THE VALUE OF TECHNOLOGY EDUCATION TO ELEMENTARY SCHOOL STUDENTS’ LEARNING OF TECHNOLOGY CONCEPTS AND PROCESSES: A QUALITATIVE INVESTIGATION OF A CONSTRUCTIVIST PERSPECTIVE

DISSertation

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

By

Kyungsuk Park, M.Ed., M.A.

* * * * *

The Ohio State University 2004

Dissertation Committee: Approved by
Professor Karen F. Zuga, Adviser
Professor Paul E. Post
Professor Raylene Kos

Adviser

College of Education
ABSTRACT

This study investigated the value of technology education to elementary school students' learning of technology concepts and processes as a result of technology education experiences. The research questions were (1) How do elementary school students learn technology concepts as a result of technology education experiences?, (2) How do elementary school students learn technology processes as a result of technology education experiences?, and (3) What are elementary school students' beliefs and attitudes toward technology and technology activities?

This study employed a qualitative research methodology. Evidence has been collected from several major sources for five months: participant observation; semi-structured interviews with students and teacher; and documents including students' journals, notebooks,
written works, and the teacher’s handouts. I presented the evidence through using inductive analysis and interpreted the evidence through the lens of the constructivist perspective.

The findings revealed that technology education provided elementary school students with a constructivist learning context. Elementary school students were introduced to meaningful hands-on activities of technology education and encouraged to involve themselves in creative problem solving processes and social interactions. In addition, they conceptualized technology as making, invention, new things, and computers and perceived technology and technology activities as fun and exciting.

This study has two major implications for educational practice and further study. First, classroom teachers’ efforts are needed to bridge the gap between elementary school classrooms and cognitive science throughout technology education activities. Second, continued examination of students’ learning of technology concepts and processes is needed in order to investigate the value of ESTE.
Dedicated to my family
ACKNOWLEDGMENTS

I would not have been able to complete this academic journey at the Ohio State University without the following individuals who have stayed with me along the way.

First of all, I would like to acknowledge my gratitude to my adviser, Dr. Karen F. Zuga. I consider myself fortunate to have worked with her during my doctoral studies. She has helped me grow personally and professionally with her guidance and support.

I wish to express my appreciation to my committee members, Dr. Kos, Dr. Post, and Dr. Scott in heaven for their professional support and encouragement.

My thanks, as well, go to the students who participated in my study and the teacher who generously allowed me to conduct research at her classroom.
I would like to extend my appreciation to Dr. Sangbong Yi. I have been deeply indebted to him for his sincere guidance and support.

I would like to extend my gratitude to my family who support me. Especially, my sincere thanks go to my Mom. I owe every wonderful thing in my life to her.

My heartfelt thanks go to my beloved daughter, Jisung Lee. I can’t find any good words to express my heart to her. She is so precious and everything to me. I love her so much and she inspires me everyday.

And, last but certainly not least, I am deeply grateful to my devoted husband, Hyonyong Lee, for his incomparable sense of humor, encouragement, patience, and belief in me. He is my best friend as well as best colleague. His love and support has made me overcome the challenging times during graduate studies. Without him, it would not have been possible for me to finish an academic journey.
VITA

August 11, 1973................. Born - Incheon, Korea

1996.............................. B.S.Ed. Technology Education, Korea National University of Education (KNUE), Chungbuk, Korea

1996 - 1997....................... Full-time Administrative Associate, Department of Technology Education, KNUE, Chungbuk, Korea

1998.............................. M.Ed. Technology Education, KNUE, Chungbuk, Korea

1998 ............................. Teacher, Joongheung High School, Bucheon, Korea

1999 - 2000...................... Graduate Research Associate, Mathematics, Science, and Technology Education Program (MSaT), The Ohio State University (OSU), Columbus, OH
2000 – 2001......................... Graduate Teaching Associate, MSaT, OSU, Columbus, OH

2001............................... M.A. Technology Education, OSU, Columbus, OH

2001 - 2002......................... Graduate Research Associate, College of Education, OSU, Columbus, OH

2002 - present..................... Graduate Research Associate, International Technology Education Association (ITEA), Reston, VA and Eisenhower National Clearinghouse (ENC), Columbus, OH

FIELDS OF STUDY

Major Field: Education
Special Area: Technology Education
Minor Field: Research Methods in Human Resource Development

Studies in Elementary School Technology Education. Dr. Karen F. Zuga

Studies in Computer Education. Dr. Paul E. Post

Studies in Qualitative Research. Dr. Raylene Kos
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>ii</td>
</tr>
<tr>
<td>Dedication</td>
<td>iv</td>
</tr>
<tr>
<td>Acknowledgments</td>
<td>v</td>
</tr>
<tr>
<td>Vita</td>
<td>vii</td>
</tr>
<tr>
<td>List of Tables</td>
<td>xv</td>
</tr>
<tr>
<td>List of Figures</td>
<td>xvii</td>
</tr>
<tr>
<td>Chapters:</td>
<td></td>
</tr>
<tr>
<td>1. INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>Statement of Problem</td>
<td>4</td>
</tr>
<tr>
<td>Significance of Study</td>
<td>6</td>
</tr>
<tr>
<td>Purpose and Research Questions</td>
<td>8</td>
</tr>
<tr>
<td>Limitations</td>
<td>9</td>
</tr>
<tr>
<td>Definition of Terms</td>
<td>11</td>
</tr>
<tr>
<td>Summary</td>
<td>14</td>
</tr>
<tr>
<td>2. REVIEW OF LITERATURE</td>
<td>16</td>
</tr>
</tbody>
</table>
Historical Efforts and Contemporary Issues in ESTE ............................................... 16

Historical Efforts in ESTE ....................... 17

European Influences: Selected Europeans
Grace Dodge and Emily Huntington ......... 21
John Dewey and Russell ...................... 23
Frederick Bonser and Lois Mossman ....... 25
After Bonser and Mossman .................. 30

Contemporary Issues in ESTE ................. 35
Integration ........................................ 35
National Standards ............................ 37

Constructivism: Theoretical Orientation of
ESTE ............................................... 42

Definition ......................................... 43
Characteristics of Constructivist Teaching and
Learning ............................................ 44
Meaningful Learning.......................... 44
Real World (Authentic) School Activities
.................................................. 45
Learning Process.................................. 47
Social Interaction.............................. 49
Active Learners................................. 51
Teachers’ Role................................. 52

Qualitative Research Paradigm: Methodological
Perspective ........................................ 54
Basic Axioms of Qualitative Research Paradigm . 56
Ontology.......................................... 57
Epistemology................................. 58

x
Transferability .................................................101
Credibility ......................................................103
   Prolonged Engagement .................................103
   Persistent Observation .................................104
   Triangulation .............................................105
   Peer Debriefing ..........................................106
   Member Checks ...........................................107
Dependability ..................................................108
Time Line .........................................................109
Summary .........................................................109

4. CONTEXT .......................................................112
   The Environment ..........................................112
   The Curriculum .............................................117
      The Technology Education Program Curriculum ...118
      The Technology Education Program Lessons ......125
   Summary ......................................................139

5. ELEMENTARY SCHOOL STUDENTS’ LEARNING OF TECHNOLOGY
   CONCEPTS AND PROCESSES, AND THEIR BELIEFS
   AND ATTITUDES TOWARD TECHNOLOGY AND TECHNOLOGY
   ACTIVITIES ....................................................141
   How Elementary School Students Learned Technology
   Concepts and Processes .....................................142
      Learning through Meaningful Learning with Real
      World School Activities .....................142
         Evidence .............................................143
         Analysis ............................................153
Learning through Problem Solving and Design
Process ..................................................161
Evidence ................................................161
Analysis ..............................................170

Learning through Social Interaction and
Collaboration .........................................175
Evidence ...............................................177
Analysis ...............................................186

What Elementary School Students’ Beliefs and
Attitudes toward Technology and Technology
Activities Were ............................................191
Evidence ................................................192
Analysis ...............................................197
Summary ................................................199

6. SUMMARY AND IMPLICATIONS.................................201
Summary ................................................201

Findings on Elementary School Students’
Learning of Technology Concepts ............202
Technology Concept: Properties of
Materials .................................................203
Technology Concept: Transportation
Technology ..............................................205
Technology Concept: Recycling and
Environment ............................................207

Findings on Elementary School Students’
Learning of Technology Processes ..........209
Technology Process: Engineering Design
Process ................................................210
## LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Historical efforts in ESTE</td>
</tr>
<tr>
<td>2.2</td>
<td>Listing of the technology content standards</td>
</tr>
<tr>
<td>2.3</td>
<td>Compendium of major topics for technology content standards for grades K-5</td>
</tr>
<tr>
<td>2.4</td>
<td>Methodological characteristics of quantitative and qualitative research paradigms</td>
</tr>
<tr>
<td>3.1</td>
<td>The brief information on participants</td>
</tr>
<tr>
<td>3.2</td>
<td>Sources of evidence collection</td>
</tr>
<tr>
<td>3.3</td>
<td>Overview of procedures employed in this study</td>
</tr>
<tr>
<td>4.1</td>
<td>Description of technology education lessons of the fifth grade required course</td>
</tr>
<tr>
<td>4.2</td>
<td>Description of technology education lessons of the fifth grade elective course</td>
</tr>
<tr>
<td>4.3</td>
<td>Description of technology education lessons of the sixth grade elective course</td>
</tr>
<tr>
<td>5.1</td>
<td>Anna’s answers on the technology log</td>
</tr>
</tbody>
</table>
5.2 Beth’s answers on the technology log ............194
5.3 Rachael’s answers on technology log ............196
6.1 Learning of the technology concept of
    properties of materials .......................205
6.2 Learning of the technology concept of
    transportation technology .....................207
6.3 Learning of the technology concept of
    recycling and environment .....................209
6.4 Learning of the technology process of
    engineering design process .....................211
6.5 Learning of the technology process of invention
    process ........................................213
6.6 Students’ concepts of technology and attitudes
    toward technology activities .....................214
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1</td>
<td>Race day.................................126</td>
</tr>
<tr>
<td>4.2</td>
<td>A game board................................128</td>
</tr>
<tr>
<td>4.3</td>
<td>Testing a barge............................131</td>
</tr>
<tr>
<td>4.4</td>
<td>A hoop glider.............................132</td>
</tr>
<tr>
<td>4.5</td>
<td>A mighty pinwheel machine................133</td>
</tr>
<tr>
<td>4.6</td>
<td>Safety cartoon............................135</td>
</tr>
<tr>
<td>4.7</td>
<td>The students wearing safety glasses........136</td>
</tr>
<tr>
<td>4.8</td>
<td>Invention sketch..........................137</td>
</tr>
<tr>
<td>5.1</td>
<td>Rachael’s sketch..........................145</td>
</tr>
<tr>
<td>5.2</td>
<td>Anna and her partner’s game board..........147</td>
</tr>
<tr>
<td>5.3</td>
<td>Anna’s cartoon.............................148</td>
</tr>
<tr>
<td>5.4</td>
<td>Spencer’s invention sketch.................152</td>
</tr>
<tr>
<td>5.5</td>
<td>Sarah’s final product.....................164</td>
</tr>
<tr>
<td>5.6</td>
<td>Beth’s final product......................167</td>
</tr>
<tr>
<td>5.7</td>
<td>Ryan’s final product......................168</td>
</tr>
<tr>
<td>5.8</td>
<td>Mike’s final product......................179</td>
</tr>
</tbody>
</table>
5.9     Kiernan’s final product........................184
5.10    Regan wearing safety glasses....................186
CHAPTER 1

INTRODUCTION

Educational reform reports have advocated the introduction of technology studies in education (American Association for the Advancement of Science, 1998; International Technology Education Association, 2000; National Council of Teachers of Mathematics, 2000; National Research Council, 1996; National Science Teachers Association, 1997). For instance, the National Science Teachers Association (1997) noted that

Children are naturally interested in the human-made (designed) objects such as toys, buildings, automobiles, bridges, can openers or door knobs. Designed objects and materials are an essential element of a child’s environment. . . The technological design process in some ways resembles scientific inquiry. . . At the elementary level, technologic design stimulates and engages children in a variety of critical thinking skills. (p. 81)
Technology education has been gaining more attention in recent years, particularly at the elementary school level in the United States. Hands-on activities are essential in elementary school classrooms since elementary school students learn more through doing something by hand than by listening to knowledge. Knowledge is not transferred from a teacher to a student, but constructed through interaction between individuals or between people and materials. As Brooks and Brooks (1999) noted, the teacher is not a disseminator of new knowledge and information but a facilitator who behaves in an interactive manner and mediates the environment for students. Therefore, technology education in which hands on activities dominate, has been highlighted in an elementary educational environment.

In this light, technology has been emphasized in a educational environment. Current notable issues, such as hands on activity, integration of school curriculum, or a constructivist approach in the classroom, are nearly the same with elementary school technology education (ESTE) educators’ ideas and philosophy.
However, ESTE, itself, is still vague as a subject in the United States even though the history of it can be traced back to European influence. As Davis, Ginns, and McRobbie (2002) stated, “Elementary school teachers and teacher educators have expressed concerns about what students learn as they engage in design and technology activities” (p. 35). That is to say, little has been documented about the value of technology education to elementary school students’ learning of technology concepts and processes as a result of technology education experiences.

In sum, it is manifest that the introduction of technology studies in the education of all students is a current educational trend (American Association for the Advancement of Science, 1998; International Technology Education Association, 2000; National Council of Teachers of Mathematics, 2000; National Research Council, 1996; National Science Teachers Association, 1997), but little research has been conducted about the value of technology education to elementary school students’ learning.
Statement of Problem

In ESTE literature, many authors have pointed out that there has not been much research conducted regarding the value of ESTE (Brusic, 1997; Foster, 1997; Zuga, 1997).

Foster (1997) stressed that what professionals in technology education should do is to conduct research to explore the evidence of the benefits of ESTE to children. Zuga (1997) suggested that “some of the major topics that need to be addressed are identifying what the value of technology education is, identifying what benefit students derive from technology education, and identifying what can be done to ease the implementation of technology education” (p. 324). Jones (1997) noted that “there has been very little published work which analyzes the findings in terms of the students’ learning of technological concepts and processes” (p. 83). Wright (1999) pointed out that “the technology education profession does not have a clear understanding about its unique contribution to children, about what it does better than anyone else in the school. There are many
claims of the benefits of ESTE to children, but no conclusive evidence to support the claims” (p. 61).


However, Davis, Ginns, and McRobbie (2002) stated that “this limited research base represents a constraint
for teachers, teacher educators, and curriculum developers who wish to capitalize on the rich and varied content of technology. Clearly, more research in this area is needed to support effective implementation of technology programs and enhance the preservice and inservice training of teachers” (p. 36).

An examination of the value of ESTE to students’ learning of technology concepts and processes is a research topic that might guide and resolve some of the current problems in technology education. In sum, the problem of this study is the lack of information about the value of technology education to elementary school students’ learning of technology concepts and processes.

**Significance of Study**

There are several reasons that support the significance of this study. First of all, there has been little research performed on the value of technology education for elementary school students. As Zuga (1997) noted, “beginning to search for the value of technology education will provide the ground for further research
and provide researchers a bit more information before testing for significance” (p. 323).

A second reason supporting this study is that there has not been enough research conducted on students’ learning of technology concepts and processes as a result of exposure to technology education. According to Liu (2000), “more research is necessary to help us understand how students develop cognitive reasoning during the learning about technology” (p. 4).

A third reason supporting this study is that there has been little research on technology education conducted by using qualitative research methods. As Wright (1999) noted, research in technology education should include a mixed methodology of quantitative and qualitative studies. In addition, he noted that qualitative research could provide useful and valuable findings and implications for exploring how elementary school students benefit from or are affected by technology education.

If we know more about the value of technology education to elementary school students’ learning of
technology concepts and processes, I believe that we could shed light on the development of ESTE.

**Purpose and Research Questions**

The purpose of this study is to investigate the value of technology education to elementary school students’ learning of technology concepts and processes. More specifically, the study aims to explore how elementary school students learn technology concepts and processes as a result of technology education experiences and what attitude they perceive toward technology and technology activities.

The research questions of this study are as follows:

(1) How do elementary school students learn technology concepts as a result of technology education experiences?

(2) How do elementary school students learn technology processes as a result of technology education experiences?
What are elementary school students’ beliefs and attitudes toward technology and technology activities?

Limitations

This study is delimited by a number of factors. One limitation might come from a cultural factor based on the researcher’s educational background. I have different educational experiences and points of view since I am most familiar with typical Korean technology classrooms. For instance, when I observe the technology classes, possible bias from my Korean cultural and educational experiences could influence and affect my field notes. Moreover, this is a self-reported study and totally relies on my interpretation of what I saw, heard, and thought.

Other limitations could be related to the research site and participants in this study. This study confined itself to observations and interviews of students at one school district and school in the Midwestern United States, where only a relatively narrow range of socioeconomic conditions are represented. Also, the
students who participated in this study were selected after the parents granted permission.

For the purpose of this study, the following variables were not considered in the synthesis:

- Views from more than one elementary school,
- Those students who did not return a signed parental permission form were not allowed to participate,
- The study area applicable only to the time period identified in the study,
- The time of year was limited, and
- Gender, race, religion, age, and so on were not considered.

Finally, the results of this study are not intended to be generalized to all applications of ESTE instruction. The students and the teacher participating in this study possessed unique characteristics that may or may not exist in other populations.
Definition of Terms

The purpose of this section is to define and clarify the terms according to how they are used in this study.

**Technology** is “human innovation in action that involves the generation of knowledge and processes to develop systems that solve problems and extend human capabilities. It is the innovation, change, or modification of the natural environment to satisfy perceived human needs and wants” (International Technology Education Association, 2000, p. 242).

**Design technology** is “a natural, intellectually and physically interactive process of design, realization, and reflection. Through the consideration of ideas, aesthetics, implications, and available resources, children become imaginative engineers, exploring alternative solutions to contextualized challenges” (Dunn & Larson, 1990, p. 5) and “the one subject directly concerned with the individual’s capacity to design and make, to solve problems with the use of materials, and to understand the significance of technology” (Eggleston, 1996, p. 23).
**Technology education** is “a study of technology, which provides an opportunity for students to learn about the processes and knowledge related to technology that are needed to solve problems and extend human capabilities” (International Technology Education Association, 2000, p. 242).

**Elementary School Technology Education** is “an educational program in which children engage in design and problem-solving, and/or constructional/manipulative activities to help them learn about themselves and the technological world around them, and in assessing the appropriateness and consequences of technological actions” (Wright, 1996, p. 4).

**Technology concepts** are “what students should know and understand about technology – how it works, and its place in the world” (International Technology Education Association, 2000, p. 14). In this study, technology concepts are considered as knowledge including properties of materials, transportation technology, recycling and environment that students learn while undertaking technology education activities.
Technology processes are “human activities used to create, invent, design, transform, produce, control, maintain, and use products or systems” (International Technology Education Association, 2000, p. 240). In this study, technology processes are considered as process skills including the engineering design process and invention process that students experience while undertaking technology education activities.

Constructivism is “a philosophy and psychology about the way people makes sense of the world. The central point is that people are always intellectually active - they do not learn passively, but go out of their way to try to make some meaning in what is taking place in their environment. Our constructions of life are conditioned and constrained by our experiences and this means that - since we all have different experiences - we are all likely to have different perceptions about ideas, actions, behaviors, incidents, situations, tasks, feelings, and so on” (Bently & Watts, 1994, p. 8).

A constructivist perspective is “an approach to cognitive development in which children discover
virtually all knowledge about the world through their own activity. It is consistent with Piaget’s cognitive developmental theory and Vygotsky’s sociocultural theory” (Berk, 2000, p. 645).

Summary

The remaining chapters attempt to provide the reader with the descriptions of the inception of this study, related literature, methodology employed, context, evidence and interpretations, and summary and implications for educational practice and further research.

Chapter 2 describes the review of literature. It introduces the 1) historical efforts and contemporary issues in ESTE; 2) constructivism that is a theoretical orientation of ESTE; 3) qualitative research paradigm that is a methodological perspective of this study, and 4) theoretical perspective of this study.

Chapter 3 discusses methodology. It includes the methodological perspective, pilot study, planning the study, participants, collecting evidence, evidence
analysis procedures, establishing trustworthiness, and time line.

Chapter 4 discusses context. It describes the environment and curriculum of the technology education program of the school.

Chapter 5 presents evidence showing elementary school students’ learning of technology concepts and processes and their beliefs and attitudes toward technology and technology activities, and interprets the evidence as it relates to the constructivist perspective.

Chapter 6 discusses the summary of this study and implications for educational practice and further research.
CHAPTER 2

REVIEW OF LITERATURE

This review of literature consists of four main parts: 1) an overview of ESTE literature pertaining to historical efforts and contemporary issues; 2) an overview of constructivism literature that is a theoretical orientation of ESTE; 3) an overview of the qualitative research paradigm that is a methodological perspective of this study; and 4) the theoretical perspective of this study.

Historical Efforts and Contemporary Issues in ESTE

This section discusses the historical efforts in the evolution of ESTE from the European influences of practical education to the contemporary issues of integration and national standards.
Historical Efforts in ESTE

The purpose of this section is to demonstrate the historical efforts in ESTE. The prominent leaders and movements in the field from European philosophers of 16th century to 1980 are discussed. It consists of the following subsections: European influences, Grace Dodge and Emily Huntington, John Dewey and Russell, Frederick Gordon Bonser and Louis Coffey Mossman, and after Bonser and Mossman.

European Influences: Selected Europeans Who Promoted Practical Education

The early influence of Elementary School Industrial Arts (ESIA) can be traced back to a strong European influence. Nelson (1981) stated that “Industrial arts had its roots in the educational philosophies and practices which evolved in several of the European countries” (p. 19).

Comenius, Rousseau, Pestalozzi, and Froebel who were western educational philosophers advocated cultural industrial education and influenced the origin and development of ESIA (Hostetter, 1974; Mossman, 1924).
John Amos Comenius (1592 – 1671), the most outstanding proponent of the sense-realism movement, as well as, a most famous educational writer, advocated the significance of words by using pictures and objects that were familiar to the students. He introduced a practical method of education and emphasized the importance of education which was cultural and objective (Bennett, 1937; Nelson, 1981). His book, *Orbis Pictus*, that was the first illustrated textbook for children, demonstrated the power of graphic representation. Bennett (1937) stated that “children learn as much as possible not from books, but from the great book of nature, from heaven and earth, from oaks and beeches. The infant school, or mother school, of Comenius was a forerunner of Froebel’s kindergarten. In this school play was utilized as a means of education” (p. 36).

Jean Jacques Rousseau (1712-1778), the author of *Emile*, emphasized that the child should have little to do with books until he had a great deal of experience in a natural environment. Being an exponent of the theory that learning is best accomplished by doing, he thought that one hour of work would be equivalent to a whole day
of verbal instruction. He saw much value in training of the senses through contact with things and activity in connection with them. His program for children included the utilization of drawing and music, the manipulation of three-dimensional materials and the use of tools in learning to develop the whole child (Bennett, 1937).

Johann Heinrich Pestalozzi (1746 – 1827), known as the father of ‘manual training’, established an industrial school for orphans and children of poverty-stricken families. His philosophy stressed the need for learning to follow the practical experience that came from involvement with things, “Doing leads to knowing” (Bennett, 1937, p. 120). Also, he developed an instructional method that used objects to motivate the student by first appealing to the sense and then stimulating the mind (Bennett, 1937). He has been regarded as an advocate of object teaching that emphasized students’ involvement in manipulation activity (Mossman, 1924). Nelson (1981) described that “his method of instruction was characterized by the use of objects, whether they were part of the natural environment or man-made objects. Perception is improved
by the use of objects, a principle that has persisted in education from the time of Pestalozzi’s experiments until the present” (pp. 26-27).

Freidrich Froebel (1783-1852), the founder of Kindergarten, stressed the importance of the use of many three-dimensional materials that he gave children to use to foster their growth and development. He was one of the first to recognize individual differences and prescribe different materials to meet individual needs (Bennett, 1937). He suggested that all people, whether they intended to spend their lives in industrial employment or not, should have the privilege of manual training in the fulfillment of the self-activity component of his plan. He included manual training in early childhood instruction, suiting the material to the age level of the child (Nelson, 1981). Like Pestalozzi, Froebel agreed with the use of objects, and he believed that “reception and reflection were interrelated with understanding coming only when the learner made application of what was perceived in the form of some self-activity” (Nelson, 1981, p. 30).
Grace Dodge and Emily Huntington

Concurrent with the time that Woodward founded the ‘manual training school’ for the purpose of general education in secondary schools, ESIA was planned as practical instruction influenced by educational sloyd that came from Europe (Zuga & Cardon, 1999). Two women, Grace Dodge and Emily Huntington, were early advocators for elementary school industrial education (Bennett, 1937).

Grace Dodge, an educational writer and philanthropist and a social reformer later helped to found Teachers’ College Columbia for the purpose of training industrial education teachers and gave the new form of kindergarten the necessary backing and publicity allowing it to spread to many other areas of the country (Bennett, 1937; Smith, 1981).

According to Smith (1981), Emily Huntington visited a kindergarten and observed the children enjoying their play with blocks, and then she “conceived the idea of substituting small-sized household furnishings and let housework become the play” (p. 177). Emily Huntington
also provided educational ideas about implementing hand
work in the schools (Bennett, 1937).

Zuga and Cardon (1999) gave the above two women
credit as female elementary school educators who
supported and helped to develop industrial arts and
technology education in the elementary school.

Some ESIA educators organized the Kitchen Garden
Association in 1880 to promote the study of practical
arts in schools through education for household
management. Even though this association had ties to the
social reform movement, it was short lived and
eventually became the Industrial Education Association
(Bennett, 1937; Smith, 1981; Zuga, 1994; Zuga & Cardon,
1999). As Smith (1981) noted, after the Kitchen Garden
Association reorganized as the Industrial Education
Association in 1884, “its major project soon became the
professional training of industrial education teachers—
the first such attempt to do so in the United States” (p.
189).
John Dewey and Russell

John Dewey (1859-1952) is one of educators who had influence on the development of manual training (McPherson, 1979). He believed that both theoretical learning and practical learning have to be connected and provided in school and emphasized the importance of learning with the materials and processes in real life. Dewey (1900) stated that “we must conceive of work in wood and metal, of weaving, sewing, and cooking, as methods of living and learning, not as distinct studies” (p. 11).

He believed that children were inherently active beings who wanted to communicate with others, to build things, and to investigate and create new things. He advocated the accommodation of these traits in the school through activities such as language, manual and household arts, nature study, dramatics, art, and music. He also advocated scientific and industrial studies as a way to make students more aware of life around them (Smith, 1981).

As Luetkemeyer and McPherson (1975) stated, “Dewey’s social education brought about integration
between the individual and society by redesigning the traditional school so that it would function as a form of community-life. He held that the great waste in schools was their lack of relating subject matter to everyday experiences and, in turn, relating daily experiences to school” (p. 261).

Russell, following Dewey’s philosophy, saw industrial arts as the basis for the elementary school program (Russell, 1912; Smith, 1981). He published the book, *The School and Industrial Life* in 1909, and recommended that humanistic, scientific, and economic studies should be included in the elementary school curriculum (Smith, 1981). Smith (1981) stated that “He advocated studies in many subjects to help understand the industries but concluded that the chief consideration in the course of study is the ordering of the industrial processes by which raw materials are transformed into things of greater value for the satisfaction of human needs” (p. 188).

Russell and his follower, Bonser (1914), stated the goals of industrial arts as general education.
Industrial studies would be the same, in the elementary school, for all children, regardless of sex or future vocation – the same for prospective doctors or lawyers as for prospective mechanics or farmers. The end point is that common knowledge, experience, appreciation, and sympathy which are necessary to effective manhood and womanhood in any life activity. As an elementary school subject, industrial arts must stand the same test, be measured by the same standards, as any other elementary school subject. (p. 27)

Russell and Bonser (1914) also helped to ensure the value of industrial arts. They stated that “This is not specifically vocational training...Values emphasized throughout are human. The end point is primarily the intelligent and efficient development of the boy and the girl, not of the industrial commodities which they are to produce” (p. 39).

**Frederick Bonser and Lois Mossman**

Bonser was considered one of the leaders of both elementary school curriculum and industrial arts (Luetkemeyer & McPherson, 1975; Volk, 1993).
He had followed Dewey’s and Russell’s social-industrial philosophy of industrial arts education (Foster, 1995; Hamilton & Pedras, 1975). He collaborated with Russell to develop a curriculum for public schools called the ‘The Industrial-Social Theory’, or ‘The Russell-Bonser Plan’.

According to Luetkemeyer and McPherson (1975), Bonser’s major contributions to industrial arts education are in the following three areas: “(1) publicizing the definition of industrial arts education; (2) organizing the first general shop (multiple activities) at both Western Illinois State Normal School, Macomb, Illinois and Teachers College, Columbia University; and (3) being responsible for the ‘Russell-Bonser Plan’ and/or ‘The Industrial Social Theory’ of industrial arts education” (p. 263).

In 1923, Bonser and Mossman published the book, *Industrial Arts for Elementary Schools*. It has been valued as a standard text on ESIA for many years (Sredl, 1964). In it, there was a definition of industrial arts.

Industrial arts is a study of the changes made by man in the forms of materials to increase
their values, and of the problems of life related to these changes. (p. 5)

Their definition of industrial arts was intended to teach students about not only industry and technology, but also the influence of industry on humans and society. Even though the social purpose of their definition has not been paid attention by many industrial arts educators, it was clear Bonser and Mossman intended to provide a social purpose throughout the study of industrial arts (Towers, Lux, & Ray, 1966). They also suggested the following content of industrial arts in their book: Foods, clothing, shelter, utensils, records, tools and machines. They seemed to insist on integration of two disciplines between manual training and home economics. Unlike the content of secondary school manual training, the content of ESIA was more comprehensive and general.

According to Scobey (1968), “probably the most influential basis for the present emerging concept of industrial arts was the work of Bonser and Mossman who were undoubtedly influenced by the writings of John Dewey” (p. 5).
Mossman set up ‘general shop’ in which students alternated through experiences in shop work, drawing, and home economics. This eventually integrated manual training, drawing, and home economics into ‘industrial arts’. She also had attempted to integrated industrial arts with other school subjects (Foster, 1995). She advocated that industrial arts in the elementary school should be included as part of social studies. That is to say, she promoted the method view of industrial arts (Mossman, 1929, 1938). In addition, she proposed the constructivist ideas that were similar to recent ideas of constructivism.

Mossman (1924) described the nature of the learning process.

The learning process is based upon self-activity. Learning comes only through the activity of the one who learns. It is the process of making new connections in the nervous system or modifying those already existing. These connections are such as to cause the individual to do certain things in given situations. This connection-forming comes about only as the learner himself is active. The drive or dynamo is in him... Hence there is going on a constant reconstruction of connections. This
continuum of activity thus results in a reconstruction of experience. To the extent that this reconstruction is guided into building up desirable connections that make for growth, the resultant is educative. (p. 53)

Mossman (1929) also proposed the importance of connecting new information with pre-existing knowledge.

The learning should be continuously articulated with kindred previous learning so that, in time, they come to have logical organization, and the various elements come to be in proper relationship to each other and to the whole. (p. 114)

Mossman (1924) had emphasized the significance of school life as a primary environmental factor. She also stated the importance of social language in the progress of students’ understanding. She described that

This school life includes doing a great variety of things which appeal to the children of the given age and environment, striving to become possessed of the skills needed for doing things as individuals and as groups, developing interests which lead into new fields of investigation,
learning to understand the activities of the outside world which concern the members of the school group, a continuous process of making life more meaningful, effective, and satisfying. (p. 55)

After Bonser and Mossman

Throughout the middle of twentieth century, there were efforts publishing books and articles and implementing the projects on ESIA. For example, there were Newkirk’s Integrated Handwork for Elementary schools (1940), Scobey’s Teaching Children About Technology (1968), Gerbracht and Babcock’s Elementary School Industrial Arts: Classroom and Laboratory (1969), Swierkos and Morse’s Industrial Arts for the Elementary Classroom (1973), Hunt’s Technology for Children (T4C) project in New Jersey (1973), and Heasley’s Technological Exploratorium, K-6 project in Northeastern Ohio (1972).

Newkirk (1940) suggested the significance of handwork in his book Integrated Handwork for Elementary Schools. He advocated handwork as an integral part of educational method in the elementary school.
Scobey published the book, *Teaching Children About Technology* (1968). It was the first textbook using technology in its title. She suggested the content descriptors of muscle power to cybernation, materials of construction, food processes, textiles and clothing, sources of power, transportation vehicles, tools of communication. Also, Scobey (1968) described that “the emerging role of industrial arts in the elementary industrials arts (1) helps children understand how technological development affects social arrangements, (2) provides opportunities for effective learning experience, and (3) provides a means of enriching and integrating the curriculum” (pp. 7-8).

Hunt (1973) introduced the *Technology for Children* (T4C) project in New Jersey. According to Hoots (1974), “this is probably one of the most widespread programs in existence. It has provided in-service instruction for many teachers and instructional packets for their use in the classroom” (p. 232).

Another project, *Technological Exploratorium, K-6*, was introduced to Ohio schools by Heasley, as the
According to Heasley (1974), the purpose of the project is

The enrichment of the elementary curriculum through the interdisciplinary involvement of students and teachers on a variety of experiences. The total involvement of all these educational variables is essential for developing understanding of man and his materials and how they shape the environment. The utilization of materials and tools, and environment in processes, projects, environment research, creative and critical planning, thinking, organizing, acting, and evaluating are vital elements in technological explorations that give new dimensions for learning both in and out school. (p. 109)

Zuga and Cardon (1999) described that “early in the twentieth century there was a trend to prepare children for work by informing them about adult work roles through study of the community. During the latter part of the century this tradition gave way to incorporating career education in the elementary school curriculum” (p. 152). Its presence has served to provide funds for teaching industrial arts and technology education in
many elementary schools at the price of teaching content about careers (Zuga & Cardon, 1999).

Career education did not begin as a part of industrial arts, but former U.S. Commissioner of Education Sidney Marland, who is often identified as having initiated the career-education movement of the 1970s, credited industrial arts pioneers James Russell and John Dewey with many of the ideas underlying career education (O’Bannon, 1975). According to Miller (1979), “the most significant shift in elementary school industrial arts resulted from an increased emphasis on career education” (p. 54).

The American Council for Elementary School Industrial Arts (ACESIA) was founded in 1962 and Elizabeth Hunt was the first president of ACESIA. Hostetter (1974) stated that the formation of the ACESIA was one of the important influences on twentieth century ESIA in the United States. ACESIA changed its name to the Technology Education for Children Council (TECC) in 1987.

Table 2.1 summarizes the historical efforts in ESTE.
<table>
<thead>
<tr>
<th>Periods</th>
<th>Historical efforts in ESTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>16C ~ 19C</td>
<td>□ The influence of European Philosophy: Comenius, Rousseau, Pestalozzi, Froebel, etc.</td>
</tr>
<tr>
<td></td>
<td>: Advocated practical education</td>
</tr>
<tr>
<td>19C</td>
<td>□ The influence of Educational Sloyd: Dodge, Huntington, and so on.</td>
</tr>
<tr>
<td></td>
<td>: Tool instruction</td>
</tr>
<tr>
<td>Early 20C</td>
<td>□ The influence of progressive educators: Dewey, Russell, Bonser, and Mossman</td>
</tr>
<tr>
<td></td>
<td>: Social reconstruction perspective</td>
</tr>
<tr>
<td>After</td>
<td>□ Newkirk: Integrated Handwork for Elementary Schools (1940)</td>
</tr>
<tr>
<td>Bonser</td>
<td>□ Scobey: Teaching Children About Technology (1968): 1st textbook using technology in its</td>
</tr>
<tr>
<td>and Mossman</td>
<td>title.</td>
</tr>
<tr>
<td></td>
<td>□ Hunt: Technology for children(T4C) project in New Jersey</td>
</tr>
<tr>
<td></td>
<td>□ Heasley: Technological Exploratorium K-6 in Ohio</td>
</tr>
<tr>
<td></td>
<td>□ Career education</td>
</tr>
<tr>
<td></td>
<td>□ The formation of the American Council for Elementary School Industrial Arts (ACESIA)</td>
</tr>
<tr>
<td></td>
<td>: Technology Education for Children Council (TECC)</td>
</tr>
</tbody>
</table>

Table 2.1: Historical efforts in ESTE.
**Contemporary Issues in ESTE**

The purpose of this section is to demonstrate the contemporary issues in ESTE. They include integration and national standards.

**Integration**

During the last two decades one outstanding tendency in school education has been to integrate science, mathematics, and technology. Several documents emphasize integrating approaches as a necessary component of national education reform (American Association for the Advancement of Science, 1993, 1998; International Technology Education Association, 1996, 2000; National Council of Teachers of Mathematics, 2000; National Science Teachers Association, 1992).

The International Technology Education Association (2000) stressed the importance of technological studies [technology education] as an integrator. Technology education is “a way to apply and integrate knowledge from many other subject areas—not just mathematics, science, and computer classes, but also liberal and fine arts” (pp. 6-7). The ways of integration by using
technology education can primarily focus upon either technology content integration, or technological process skills (e.g., problem solving skills), or both. For instance, T/S/M Integration Activities [Technology Science Mathematics Integration Activities] developed by LaPorte and Sanders (1993) expressed the idea that “technological problem solving activities may provide a practical, meaningful, and motivating learning context” (p.18). These technological activities include the application of mathematics and science principles to solve real world problems. They developed the activities that employ scientific inquiry and mathematical skills on the basis of technological process skills and contents. According to Zuga (2000), “In a technology education laboratory, including the scientific constructs and mathematical principles which relate to technology education content and activities strengthens the connections that students can make in all three subjects [science, mathematics, and technology] and in their integration” (p. 226). It is clear that technological contents (or/and technological process
skills) based hands-on activities play a leading role in integrating and connecting science and mathematics.

**National Standards**

The Technology for All Americans project in 1996, led by William Dugger of Virginia Tech, addresses the issue of establishing standards for technology education. According to Zuga and Cardon (1999), “This project may have greater credence than earlier ones because standards have evolved as an issue of great concern among contemporary educators” (p. 154).

The International Technology Education Association (2000) described the standards as

*Technology Content Standards* specifies what every student should know and be able to do in order to be technologically literate, and it offers criteria to judge progress toward a vision of technological literacy for all students. There are a total of 20 standards in this document and the individual standards fall into two types: what students should know and understand about technology, [sic] and what they should be able to do. (p. 14)
Table 2.2 depicts the listing of the technology content standards and Table 2.3 presents the compendium of major topics for technology content standards for grades, K-5.

### THE NATURE OF TECHNOLOGY

1. Students will develop an **understanding** of the characteristics and scope of technology.

2. Students will develop an **understanding** of the core concepts of technology.

3. Students will develop an **understanding** of the relationships among technologies and the connections between technology and other fields of study.

### TECHNOLOGY AND SOCIETY

4. Students will develop an **understanding** of the cultural, social, economic, and political effects of technology.

5. Students will develop an **understanding** of the effects of technology on the environment.

6. Students will develop an **understanding** of the role of society in the development and use of technology.

7. Students will develop an **understanding** of the influence of technology on history.

### DESIGN

8. Students will develop an **understanding** of the attributes of design.

9. Students will develop an **understanding** of engineering design.

Table 2.2: Listing of the technology content standards (International Technology Education Association, 2000, p. 210).
Table 2.2 (continued)

10. Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

**ABILITIES FOR A TECHNOLOGICAL WORLD**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>11.</td>
<td>Students will develop abilities to apply the design process.</td>
</tr>
<tr>
<td>12.</td>
<td>Students will develop the abilities to use and maintain technological products and systems.</td>
</tr>
<tr>
<td>13.</td>
<td>Students will develop the abilities to assess the impact of products and systems.</td>
</tr>
</tbody>
</table>

**THE DESIGNED WORLD**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>14.</td>
<td>Students will develop an understanding of and be able to select and use medical technologies.</td>
</tr>
<tr>
<td>15.</td>
<td>Students will develop an understanding of and be able to select and use agricultural and related biotechnologies.</td>
</tr>
<tr>
<td>16.</td>
<td>Students will develop an understanding of and be able to select and use energy and power technologies.</td>
</tr>
<tr>
<td>17.</td>
<td>Students will develop an understanding of and be able to select and use information and communication technologies.</td>
</tr>
<tr>
<td>18.</td>
<td>Students will develop an understanding of and be able to select and use transportation technologies.</td>
</tr>
<tr>
<td>19.</td>
<td>Students will develop an understanding of and be able to select and use manufacturing technologies.</td>
</tr>
<tr>
<td>20.</td>
<td>Students will develop an understanding of and be able to select and use construction technologies.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STANDARDS</th>
<th>GRADES K-2</th>
<th>GRADES 3-5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Nature world and human-made world</td>
<td>Things found in nature and in the human-made world</td>
</tr>
<tr>
<td></td>
<td>People and technology</td>
<td>Tools, materials, and skills</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Creative thinking</td>
</tr>
<tr>
<td>2</td>
<td>Systems</td>
<td>Systems</td>
</tr>
<tr>
<td></td>
<td>Resources</td>
<td>Resources</td>
</tr>
<tr>
<td></td>
<td>Processes</td>
<td>Requirements</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Processes</td>
</tr>
<tr>
<td>3</td>
<td>Connections between technology and other subjects</td>
<td>Technologies integrated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Relationships between technology and other fields of study</td>
</tr>
<tr>
<td>4</td>
<td>Helpful or harmful</td>
<td>Good and bad effects</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unintended consequences</td>
</tr>
<tr>
<td>5</td>
<td>Reuse and/or recycling of materials</td>
<td>Recycling and disposal of waste</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Affects environment in good and bad ways</td>
</tr>
<tr>
<td>6</td>
<td>Needs and wants of individuals</td>
<td>Changing needs and wants</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Expansion or limitation of development</td>
</tr>
<tr>
<td>7</td>
<td>Ways people have lived and worked</td>
<td>Tools for food, clothing, and protection</td>
</tr>
<tr>
<td>8</td>
<td>Everyone can design</td>
<td>Definitions of design</td>
</tr>
<tr>
<td></td>
<td>Design is a creative process</td>
<td>Requirements of design</td>
</tr>
<tr>
<td>9</td>
<td>Engineering design process</td>
<td>Engineering design process</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Creativity and considering all ideas</td>
</tr>
<tr>
<td></td>
<td>Expressing design ideas to others</td>
<td>Models</td>
</tr>
<tr>
<td>10</td>
<td>Asking questions and making observations</td>
<td>Troubleshooting</td>
</tr>
<tr>
<td></td>
<td>All products need to be maintained</td>
<td>Invention and innovation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Experimentation</td>
</tr>
<tr>
<td>11</td>
<td>Solve problems through design</td>
<td>Collecting information</td>
</tr>
<tr>
<td></td>
<td>Build something</td>
<td>Visualize a solution</td>
</tr>
<tr>
<td></td>
<td>Investigate how things are made</td>
<td>Test and evaluate solutions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Improve a design</td>
</tr>
</tbody>
</table>

Table 2.3: Compendium of major topics for technology content standards for grades K-5 (Modified from International Technology Education Association, 2000, pp. 211-214).
<table>
<thead>
<tr>
<th></th>
<th>Discover how things work</th>
<th>Use tools correctly and safely</th>
<th>Recognize and use everyday symbols</th>
<th>Follow step-by-step instructions</th>
<th>Select and safely use tools</th>
<th>Use computers to access and organize information</th>
<th>Use common symbols</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Collect information about everyday</td>
<td></td>
<td>Determine the qualities of a product</td>
<td>Use information to identify patterns</td>
<td>Assess the influence of technology</td>
<td>Examine trade-offs</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Vaccinations</td>
<td></td>
<td>Medicine</td>
<td>Vaccines and medicine</td>
<td>Development of devices to repair or replace certain parts of the body</td>
<td>Use of products and systems to inform</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Products to take care of people and their belongings</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Technologies in agriculture</td>
<td></td>
<td>Tools and materials for use in ecosystems</td>
<td>Artificial ecosystems</td>
<td>Agricultural wastes</td>
<td>Process in agriculture</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Energy comes in many forms</td>
<td></td>
<td>Energy should not be wasted</td>
<td>Energy comes in different forms</td>
<td>Tools, machines, products, and systems use energy to do work</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Information</td>
<td></td>
<td>Communication</td>
<td>Processing information</td>
<td>Many sources of information</td>
<td>Communication</td>
<td>Symbols</td>
</tr>
<tr>
<td></td>
<td>Symbols</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Transportation system</td>
<td></td>
<td>Individuals and goods</td>
<td>Transportation systems use</td>
<td>Transportation systems and subsystems</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Care of transportation products and systems</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Manufacturing systems</td>
<td></td>
<td>Design of products</td>
<td>Natural materials</td>
<td>Manufacturing processes</td>
<td>Consumption of goods</td>
<td>Chemical technologies</td>
</tr>
<tr>
<td>20</td>
<td>Different types of buildings</td>
<td></td>
<td>How parts of buildings fit</td>
<td>Modern communities</td>
<td>Structures</td>
<td>Systems used</td>
<td></td>
</tr>
</tbody>
</table>

Constructivism: Theoretical Orientation of ESTE

Constructivism has been increasingly and widely used with different meanings and different goals. Educators in a variety of fields have elaborated on constructivism as a theory of learning, a theory of teaching, and as a constructivist epistemology of a research paradigm (Freed, 1998; Matthews, 1994, 1998; Tobin & Tippins, 1993).

Constructivist theory has been built on work by cognitive psychologists who have focused on the idea of cognition, the mental process by which knowledge is acquired. The research on cognition helps to explain from where constructivist theory evolved (Freed, 1998).

Based on the works of Jean Piaget and Lev Vygotsky, it is having major ramifications for the goals teachers set for the learners with whom they work, the instructional strategies teachers employ in working toward these goals, and the methods of assessment used by school personnel to document genuine learning (Fosnot, 1996).
Definition

As the term constructivism becomes more widespread, different people tend to use it with slightly different meanings. As Bently and Watts (1994) defined it,

Constructivism is a philosophy and psychology about the way people make sense of the world. The central point is that people are always intellectually active — they do not learn passively, but go out of their way to try to make some meaning in what is taking place in their environment. Our constructions of life are conditioned and constrained by our experiences and this means that — since we all have different experiences — we are all likely to have different perceptions about ideas, actions, behaviors, incidents, situations, tasks, feelings, and so on. (p. 8)

Constructivists emphasize the importance of a preexisting conceptual structure that is used as the basis for understanding the environment and achieving higher levels of knowledge. They consider that knowledge generation is socially mediated, rather than revealed exclusively through internal logic. That is to say, constructivists believe that knowledge is constructed by
learners through interaction with physical phenomena and interpersonal exchanges (Beller, 1998; Cross, 1998; Driscoll, 2000; Scruggs & Mastropieri, 1994; Watts, Jofili, & Bezerra, 1997).

**Characteristics of Constructivist Teaching and Learning**

This section describes six characteristics of constructivist teaching and learning: (1) meaningful learning, (2) real world (authentic) school activities, (3) learning process, (4) social interaction, (5) active learners, and (6) teachers’ role.

**Meaningful Learning**

Ausubel has been known as a cognitive psychologist who introduced the concept of meaningful learning. Meaningful learning is regarded as the fundamental idea of constructivism (Ausubel, 1963). In a contemporary argument for ESTE, Dunn and Larson (1990) stated that students could get valuable and meaningful experience throughout learner-centered instruction.

Children involved in active exploration learn that they can influence their environment. They eagerly
seek answers to real problems they pose, building and testing theories, creating, and organizing reality in a way that is meaningful to them. This theory of cognitive constructivism provides a perspective for viewing the child as an engineer of personal understanding. (p. 8)

Similarly, in a historical argument Mossman (1938) also emphasized the significance of meaningful learning. She described how students build meaningful knowledge and experience.

A curriculum which can put meaning and significance into the affairs of daily life is its own justification. To build meanings and significance is to build relationships, make more connections within one’s experience. Hence, a program including much of inquiring, adventuring, exploring, and experimenting is one that gives meaning and zest to life. (p. 68)

**Real World (Authentic) School Activities**

To be a successful lesson, teachers should provide real world (authentic) school activities. If students cannot apply in-school experiences
effectively into their out-of school life, students often are not interested in experiences and activities provided by teachers in school. Teachers should bear in mind students have their own points of view and they can make decisions about what is valuable to them (Lee, 2002). Perkins (1992) described the usefulness of the connection between learning and applying it later in life.

Having and understanding knowledge and skills comes to naught unless the learner actually makes active use of them later in life – in studying other subjects, shopping in the supermarket, getting a better job, casting a vote, or whatever other context. Although other desiderata can be added to retention, understanding, and active use, it is difficult to discard any one of these. (p. 45)

Brooks and Brooks (1999) also described appropriate content of a lesson using the constructivist approach.

The constructivist approach to teaching presents these real-world possibilities to students, then helps the students generate the
abstractions that bind these phenomena together. (p. 104)

**Learning Process**

According to Lee, “constructivism makes different assumptions regarding learning process. A constructivist view of teaching and learning has proved to be a powerful model to describe how conceptual change in learners may be promoted” (p. 51). Spigner-Littles and Anderson (1999) described the learning process of how students construct new knowledge.

The theory of constructivism maintains that knowledge is acquired through an active process in which the individual continually structures and restructures experience through self-regulated mental activity . . . Students bring to the classroom setting cognitive structures based upon their unique individual experiences that have largely shaped each individual’s thinking accumulated knowledge . . . new information must be somehow tied to the learner’s goals, experiences, previous knowledge, values, beliefs, and/or socio-cultural factors. (p. 205)
Naylor and Keogh (1999) also stated the learning process based on the ideas of linking pre-existing knowledge.

The principles of this approach are that learners can only make sense of new situations in terms of their existing understanding. Learning involves an active process in which learners construct meaning by linking new ideas with their existing knowledge. (p. 93)

Constructivism considers students’ interests and previous experience and knowledge as important paramount parts of teaching and learning (Bednar & Charles, 1999; Beller, 1998; Bentley & Watts, 1994; Clements & Battista, 1990; Crowther, 1999; Scruggs & Mastropieri, 1994).

Similarly, in a historical argument for ESTE, Mossman (1938) assumed that learning depends on the active learners’ process for constructing and reconstructing their experiences. She stated that

We view the learner as active. We regard learning as a dynamic process, coming through activity. We postulate the environment as changing and different for each individual according to his sensitivities. We assume that sensitivities can be modified through experience in meeting situations... This
means learning to face one’s reality and deal with it. It means sensitivity to environing conditions, a sensitivity which learns to detect potentialities. (p. 49)

**Social Interaction**

Many educators have realized that learning is a social process. They have paid attention to the significance of the social-cultural perspectives of cognition (Clements & Battista, 1990; Jonassen, 1992; Jones, Rua, & Carter, 1998; Klein & Merritt, 1994; Lunenburg, 1998; Yager, 1991). Schlenker and Schlenker (1997) described the impact of social interaction for promoting students’ understanding.

Learners may indeed form strong conceptual frames of reference, but whether their understanding is accurate depends on the experiences they have and how they interpret these experiences. Their understanding of any concept becomes more sophisticated through their interactions with the environment; as they gain additional experience, they acquire new precepts and revise previously held ones. The result is new and deeper levels of understanding that are more sharply focused than before. (p. 15)
Brooks and Brooks (1999) stated the importance of social discourse as a way of knowing and understanding.

One very powerful way students come to change or reinforce conceptions is through social discourse. Having an opportunity to present one’s own ideas, as well as being permitted to hear and reflect on the ideas of others, is an empowering experience. (p. 108)

Similarly, in a historical argument for ESTE, Mossman (1938) had emphasized the significance of school life as a primary environmental factor. She stated that “environment is a very significant factor in the learning process, including all, both physical and social, that stirs the learner to action” (p. 157). She also described the importance of social language in the progress of students’ learning.

The awareness of the self develops along with awareness of others and both develop with some form of language. The social processes seem to be the key to understanding human growth and learning, if one is to develop personality. (p. 54)
**Active Learners**

In constructivism, learning is an active process influenced by the learner. Students are responsible for their own learning within a learning atmosphere in which teachers are facilitators not knowledge providers. Lunenburg (1998) described the learner’s role.

One foundational premise of constructivism is that children actively construct their knowledge, rather than simply absorbing ideas spoken to them by teachers. (p. 76)

Bentley and Watts (1994) also stated the learner’s active involvement in learning process as follows.

The learner is seen to be at the very center of the learning experience. The emphasis is on the child as a meaning-maker and the stress is on the elevation of the young person and the personal nature of their meaning-making, to the central focus of schooling. (p. 9)

Similarly, in a historical argument for ESTE, Mossman (1938) also described learners’ internal and external wants and needs regarding learning.
They will be built into the learner’s thinking when his needs and his views of the usefulness of techniques involved cause him to value the subject matters and seek to master them. This point of view seeks to build an organization in and through the learner’s experiences by helping him continuously to relate new with old experiences. (p. 69)

**Teachers’ Role**

To apply a constructivist theory to classroom instruction, a teacher should be a facilitator not a knowledge provider. Bentley and Watts (1994) described the teacher’s role as a facilitator.

Teachers should start where the learner is. They enable individual learning through focused experience and then use children’s range of experiences to further understandings . . . Teachers are facilitators. Teachers encourage children to explore ideas themselves rather than being directive themselves. (pp. 10-11)

Lunenburg (1998) also described the teacher’s role as follows.

The role of the teacher and other learners is to provide the setting, pose the challenges, and offer
the support that will encourage cognitive construction. (p. 77)

Similarly, in a historical argument for ESTE, Mossman (1938) has emphasized the teacher’s role as a very important responsible human factor in the environment of the learner.

The teacher must seek to know as much as possible of these environing influences, for they constitute pressures in the situations the learners face. Their demands, their questions, their ideals, their approval, and their attitudes, though unspoken, all influence the challenge to action. (pp. 58-59)

In addition, Mossman (1938) stated that the teacher must be alert to the learner’s emerging potentialities and seek to give them opportunity. Learners are, if growing normally, always alive, sensitive, active, alert to changes in their situation, and eager to do something with reference to these changes. (p. 122)
Paradigm can be defined as a worldview or set of beliefs that guide inquirers (Guba & Lincoln, 1994; Lincoln & Guba, 1985; Patton, 1990). The term, paradigm was popularized by Thomas S. Kuhn in 1970. He published the book, *The Structure of Scientific Revolutions*, which proposed that scientific findings do not prove an absolute objective truth; rather scientific findings are a changeable scientific framework or paradigm. Kuhn described how, when problems appear that a previous scientific model cannot fully explain, a discipline undergoes a process of shifts from one paradigm to another.

The quantitative research paradigm has been remarkably pervasive and used by many inquirers; therefore, to most educators, the word research connotes a traditional form of experimental research or survey. The basic axioms and methodological characteristics of these studies have been grounded in what is referred to as the positivist research paradigm (Borland, 1990).
Though the quantitative research paradigm has been the main avenue for educational inquiry, problems have arisen that challenge this paradigm. In particular, Lincoln and Guba (1987) questioned whether research can ever be free of contextual bounds, such as historical time and, if not, whether there is value in making the broad generalizations valued in a positivist paradigm. A qualitative research paradigm seeks to understand educational problems and situations by examining context specific cases, settings, and actions.

Qualitative researchers do not propose generalizing findings from one instance or setting to another. Instead, they suggest that, while similarities may exist between two contexts, the research serves us best by broadening our understanding of the range of behaviors that might occur in an educational setting. A qualitative research paradigm is frequently termed a constructivist, interpretative, or naturalistic approach (Creswell, 1994; Tashakkori & Teddlie, 1998).

This section discusses the basic axioms and methodological characteristics of qualitative research paradigm.
Basic Axioms of Qualitative Research Paradigm

As described by Patton (1990), “a paradigm is a worldview, a general perspective, or a way of breaking down the complexity of the real world. Each person’s paradigm tells him or her what is important, legitimate, and reasonable” (p. 37). Lincoln (1988) defined a paradigm as “a model which not only tells us what reality ought to be like but also tells us how to seek data from that reality, and how we ought to talk about the search for that data or knowledge” (p. 4).

In short, a person’s paradigm allows him or her to limit the number of sensory and cognitive possibilities that bombard us each day. We see and believe only those things which are congruent with our paradigm.

The most fundamental differences between quantitative and qualitative research paradigms are found on “basic axioms rather than in the methodologies applied” (Borland, 1990, p. 162). This section describes five basic axioms of the qualitative research paradigm: ontology, epistemology, purpose, cause and effect, and value.
**Ontology**

Qualitative researchers want to know about those cases in which the generalized model is not effective. Their view of reality is different from that of quantitative researchers. Qualitative researchers believe that there are multiple, subjective, and constructed realities that are contextually bound (Guba & Lincoln, 1994; Slip & Constable, 1996). They believe that each individual has a different view of reality. While two or more people may perceive many things in similar ways, more so if they share a similar paradigm, idiosyncratic aspects of a person’s paradigm are what make each person’s behaviors, responses, and language, for instance, unique. Qualitative researchers argue that reality can be studied only holistically and cannot be fragmented into variables to be studied in isolation. Furthermore, qualitative researchers believe that separating any part from the whole alters both the part and the whole (Guba & Lincoln, 1982, 1994; Neuman, 1989). Therefore, studies of classroom practice must be embedded in the complex social, cultural, historical,
and political interactions of everyday classroom experiences. One student’s perceptions of what is effective in a classroom may differ from another student’s due to diverse homes, religious beliefs, previous learning and other factors that make up a student’s personal paradigm.

**Epistemology**

In a qualitative research paradigm, a researcher and the respondents are inseparable, and they interact to influence one another. Qualitative researchers believe that interactivity between a researcher and the respondents allows them to discover or mediate a situated reality that is meaningful in the specific research context. Researchers in this paradigm make a concerted effort to acknowledge the relationships between themselves and their respondents and to provide explanations for how differing relationships may affect the research results (Guba, 1979, 1981; Guba & Lincoln, 1982; Neuman, 1989). For instance, Spradley (1979) described a research position of participant observation. In this position, a researcher not only
observed the setting and participants but also participated in the ongoing activities of the setting. An example was that of a researcher acting as a teacher while studying his or her students’ engagement in reading. The actions taken by the teacher/researcher were likely to have some effect on students’ book choices, motivation, or strategy use. In this case, the teacher/researcher would examine not only the students’ behaviors but also the researcher’s own teaching.

**Purpose**

In a qualitative research paradigm, a goal of inquiry is to develop an idiographic (particular and limited) body of knowledge in the form of working hypotheses that fit a particular situational context and describe the individual case (Borland, 1990; Creswell, 1998; Guba, 1981; Lincoln & Guba, 1985). Qualitative researchers believe that it is impossible to make nomothetic laws (time and context free rules) regarding human beings since there are always differences in context from situation to situation, and even a specific situation differs over time (Borland, 1990; Lincoln,
While reports of a research study, if richly detailed, may engender a form of psychological generalization (Donmoyer, 1988), that is, a sense of familiarity with the participants or context that may persuade a research consumer to transfer results to his or her own setting, such generalization is left to the research consumer to determine. However, this type of transfer can be an effective means of promoting change in policies and practices in educational settings.

**Cause and Effect**

Qualitative researchers believe that there can be no certain way of determining a cause-effect relationship. Human action can be understood not as being caused but as emerging from socially mediated meanings influenced by psychological, environmental, physiological, linguistic, political, and other factors. All of these factors may affect human action and views. Humans are interactive participants in the social world who shape and simultaneously are shaped by multiple factors (Guba & Lincoln, 1982, 1989; Lincoln, 1988).
Therefore, what specific factors cause a response in human behavior is not a reasonable question for a naturalistic inquirer. Instead, the qualitative researcher would ask questions concerning, for example, how students alone or within groups, manage to increase the amount of work they produced while still maintaining quality standards. The researcher would talk to students about their environment, the ways they liked to work, how they helped each other, and other similar questions. From this, the researcher would use the students’ words to mediate a meaning that made sense to the researcher and the students participating in the study. If the report from this work was richly detailed, other teachers may make psychological connections to their own students, broadening their understanding of how their students might be responding to classroom practices.

**Value**

In a qualitative research paradigm, all actions are value-bound. The researcher brings considerable evidence of his or her own values to the research study in terms of the choice of the paradigm, the choice of the
substantive theory, the choice of setting and participants, the choice of research methods, and the values that are inherent in the context (Lincoln & Guba, 1985). Therefore, a qualitative researcher is not interested in establishing a sense of objectivity; rather, he or she is concerned with how biases, interests, perspectives of the inquirer are accounted for in the study (Richardson, 2000). In addition, the researcher must show that decisions made before and during the study are consistent with a specific theoretical stance upon which the study is based or which emerges from the ongoing study. The researcher must make a continuous documented effort to find data that does not fit the theory in use as a means of confronting biases. In this way, what would be confounding variables in a quantitative research, variables that must be controlled, are considered rich data in a naturalistic inquiry. These anomalous data provide strength to the study by creating the need for further examination of the researcher’s theory and analytic processes.
Methodological Characteristics of Qualitative Research Paradigm

Within a paradigm, researchers need to specify the methodology that would be used. Qualitative research design includes, for instance, case studies, ethnographies, grounded theory studies, interviews, and action research.

This section describes the characteristics of qualitative research paradigm: research design and population selection.

Research Design

Qualitative researchers conduct inquiry in a natural setting and no attempts are made to artificially control aspects of the setting, on the other hand, in a quantitative research paradigm, a research setting is usually decided by a researcher, and it can be manipulated depending on the research’s purpose. Qualitative researchers believe that controlling for extraneous variables can obscure the multiple and interactive shapings that occur as humans interact in specific settings. They believe that the contexts in
which phenomena are studied affect perceptions of the phenomena to the extent that a change in context may substantially alter, for example, the effectiveness of an instructional strategy, the perceptions of a child about school, or the language a teacher uses with children (Borland, 1990; Lincoln & Guba, 1985; Guba, 1981). Therefore, contexts are not controlled but are richly described to develop a research consumer’s understanding of the place and time in which the study occurred. One feature for successful qualitative research is an emergent design. According to Schwandt (1997), “emergent design has no design or plan at all at the outset of study. It arises unexpectedly and it is adaptable and flexible” (p. 35). Rather than describing in advance every aspect of the design, qualitative researchers elaborate upon this detail and their evolution as part of the final report. Lincoln and Guba (1985) stated that “design of naturalistic inquiry . . . can not be given in advance; it must emerge, develop, unfold” (p. 225).

A human is considered a primary instrument in qualitative research even though other forms of
instruments may be used (Guba & Lincoln, 1989). Qualitative researchers prefer the human-as-instrument because of reasons such as their greater insightfulness, their flexibility, their responsiveness, and the holistic emphasis they can provide (Guba & Lincoln, 1982; Lincoln & Guba, 1985). Borland (1990) described that “all instruments interact with and change what they measure and the measurement context, but only the human instrument can detect and appreciate those changes” (p. 164).

**Population Selection**

Within the quantitative research paradigm, researchers attempt to select a representative sample from the population (Creswell, 1994) and try to generalize their particular findings of a sample to their population.

On the other hand, qualitative researchers are interested in a sample itself not to generalize to the population. Patton (1990) stated sampling in qualitative research as follows.
Qualitative inquiry typically focuses in depth on relatively small samples, even a single case (n=1), selected purposefully. The logic and power of purposeful sampling lies in selecting information-rich cases for study in depth. That is to say, the purpose of purposeful sampling is to select information-rich cases whose study will illuminate the questions under study. (p. 169)

In particular, attractive to the naturalist is maximum variation sampling. Moses (1994) defined maximum variation sampling as “the process of deliberately selecting a heterogeneous sample and observing commonalities in their experiences. It is a most useful method of sampling when exploring abstract concepts, such as hope, and selecting, for instance, participants from a variety of backgrounds in which hope is evidently of primary importance” (p. 229).

A descriptive summary of methodological characteristics of quantitative and qualitative research paradigms is found in Table 2.4. It is primarily based on the following researchers’ classification schemes: Creswell (1994), Fraenkel and Wallen (1996), and Gay (1996).
| Overall purposes | Explain, predict, and/or control phenomena through focused collection of numerical data. | Explain, gain insight and understanding of phenomena through intensive collection of narrative data. |
| Hypotheses | Specific, testable, and stated prior to particular study. | Tentative, evolving, and based on particular study. |
| Research setting | Controlled to the degree possible. | Natural setting. |
| Sampling | Random: Intent to select 'large', representative sample in order to generalize results to a population. | Purposive: Intent to select 'small', not necessarily representative, sample in order to acquire in-depth understanding. |
| Data analysis | Raw data are numbers. Performed at end of study, involves statistics. | Raw data are words. Essentially ongoing, involves synthesis. |

Table 2.4: Methodological characteristics of quantitative and qualitative research paradigms.
Theoretical Perspective

The theoretical underpinning of this study is constructivism. In constructivist theory, knowledge is constructed by learners as they attempt to make sense of their experiences. Learners, therefore, are not empty vessels waiting to be filled, but rather active organisms seeking meaning (Driscoll, 2000).

Constructivists consider students’ interests, and previous experience and knowledge as important paramount parts of teaching and learning (Bednar & Charles, 1999; Bentley & Watts, 1994; Clements & Battista, 1990; Crowther, 1999; Spigner-Littles & Anderson, 1999). They consider that knowledge generation is socially mediated, rather than revealed exclusively through internal logic (Beller, 1998; Cross, 1998; Scruggs & Mastropieri, 1994; Watts, Jofili, & Bezerra, 1997).

Mossman (1929), who was an elementary school industrial arts educator, proposed constructivist ideas that were similar with the recent ideas of constructivism. She stated the importance of connecting new information with pre-existing knowledge, the significance of social interaction with peers and
teachers, and a teacher’s role as a facilitator (1924, 1929, 1938).

Like constructivists and Mossman, I believe that learning depends on the active learners’ process for constructing and reconstructing their experiences in social environment. The learner should be at the center of the learning and actively engage in the process of learning. In addition, a teacher should effectively facilitate students to construct their own learning through hands-on activity, social interaction, problem solving process, and so forth.

I have tried to collect and analyze evidence through the lens of the constructivist perspective.

Summary

This chapter discusses a review of literature in four areas related to this study: 1) an overview of ESTE literature pertaining to historical efforts and contemporary issues; 2) an overview of constructivism literature that provides a theoretical orientation of ESTE; 3) an overview of qualitative research paradigm
that provides a methodological perspective for this study; and 4) theoretical perspective of this study.
CHAPTER 3

METHODOLOGY

This study is a qualitative research. Its purpose was to investigate the value of technology education to elementary school students’ learning of technology concepts and processes as a result of technology education experiences. The research questions were (1) How do elementary school students learn technology concepts as a result of technology education experiences?, (2) How do elementary school students learn technology processes as a result of technology education experiences?, and (3) What are elementary school students’ beliefs and attitudes toward technology and technology activities?

This chapter consists of eight parts: 1) methodological perspective, 2) pilot study, 3) planning the study, 4) participants, 5) collecting evidence, 6)
Methodological Perspective

The methodological stance of this study is a qualitative research paradigm. In a qualitative research paradigm, the researchers investigate a specific situational context to gain insights into phenomena of interest, and present the individual case through a thick description (Creswell, 1994; Glesne, 1999; Guba & Lincoln, 1994; Lincoln & Guba, 1985; Yin, 1994).

According to Lee (2002), “the effectiveness of research methods is closely related to the nature of the research questions and purposes of the investigation. The best research method is the one that can answer the research questions most efficiently” (p. 57). Lincoln and Guba (1985) stated that a qualitative research method is the answer if the purpose of a study is to investigate or understand what is happening in a particular setting. The qualitative research paradigm involves historical study, ethnographic study, action
research, and case study (Creswell, 1994; Fraenkel & Wallen, 1996; Gay, 1996).

According to Shaw (1978), a case study “concentrates attention on the way particular groups of people confront specific problems, taking a holistic view of the situation” (p. 2). Kos (1989) stated that “the purpose of case studies then becomes, not one of generalization, but one of expanding the experiences and possible interpretations available to the reader. This further implies that uniqueness can be viewed as a positive aspect of case studies since unique aspects of an experience have the potential to expand a person’s cognitive structures more than do the typical aspects of an experience” (p. 42). In addition, Yin stated that case study is “an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident” (p. 13).

Qualitative research methodology was employed and one elementary school classroom was selected as a case where I investigated the value of ESTE.
Pilot Study

In the Winter quarter of 2001 a pilot study, What is the Value of ESTE?, was conducted by employing qualitative methods. Its purpose was to identify the value of ESTE. The research questions were (1) how does an elementary school teacher perceive ESTE? And (2) how do elementary school students perceive technology education activities? A site was selected in a Midwestern elementary school, and entry was obtained through permission granted by the teacher and principal at the school. The participants of pilot study were one elementary school teacher and three students (two female and one male students). The curriculum domain was an interdisciplinary, integrated one with an emphasis on problem-based learning strategies in science and technology. Observation and interviews were the primary data collection methods to answer the research questions. Videotape recording was used during classroom observations and while interviewing the teacher. Evidence gathering took place for over one and half months from February to March in 2001. After I gathered evidence, I transcribed it and created coding categories
of teacher’s perception, teacher’s instructional strategies, and students’ perceptions. Then, I searched the appropriate passages for evidence that could address my research questions, and, in turn, created definitions for the codes.

After the pilot study, I felt that I could extend the findings and implications of the pilot study to the further research.

Planning the Study

This study revolves around the questions, “How do elementary school students learn technology concepts and processes as a result of technology education experiences?” and “What are elementary school students’ beliefs and attitudes toward technology and technology activities?” I describe the procedures of choosing a site, entering the field, and gaining acceptance.

Choosing a Site

As I planned this study, I began to investigate research sites which would be qualified to meet the purpose of this study. Dr. Zuga, as an academic advisor,
assisted me in choosing a research site. I initially had three potential school districts where technology education has been taught as a content, method, or process approach.

First, I asked the superintendents of three school districts to allow us to conduct research in his/her school district. After obtaining permission, I contacted the technology education coordinators in each of three school districts and requested his/her assistance in finding a teacher in whose classroom I could conduct the study.

One school district appeared to be the best possible site for the study. The technology education coordinator in that school district introduced me to two teachers in different elementary schools. One was first grade classroom and the other was fifth grade classroom. After classroom observation, I chose a fifth grade classroom since the teacher taught technology education everyday, while the other teacher taught only one or two classes a month.

After I chose the research site, prior to the first day of school, I visited the school to give the teacher
and the principal a letter explaining the purpose of the study and to obtain the signatures needed for the application to the Human Subjects Review Board at The Ohio State University (see Appendix A). Separate written consent forms were created for students and their parents or guardian (see Appendices B & C). I had received formal approval to perform my study from the Human Subjects Review Board at The Ohio State University one week before entering the field.

**Entering the Field**

When I was ready to begin my research in the field, I had a great desire to conduct a successful study since I had waited several years to do it. However, at the same time, I was concerned about how the students would think of me as a researcher from another country. I was worried about the possibility of not being accepted by the students since I look and spoke differently. I did not expect that they had much experience with someone who has an Asian culture because Caucasian students pretty much dominated. However, I found that the students accepted me as any other visitor in the
classroom. The students were interested in talking to me and finding out about my different culture. I only needed to consider how I would develop rapport with the students.

During the first week in the classroom, I observed all three periods (Period five, six, and seven) of the fifth grade required technology education course. Each period had at least twenty students. I usually found an empty seat in a back corner of the classroom and began to observe and took field notes written in short phrases, capturing a sentence or two from students and the teacher. After the first week, five days of observation, I narrowed my focus to the period five because the teacher repeated the same activities to the each period.

Fourteen female and eleven male students were in the class. The students made me feel very welcome.

At the beginning of second week, I gave students a letter explaining the purpose of my study and asked them to consider participation in my study. A similar letter was sent to the parents of the students who had agreed to participate, which requested the parents or
guardian’s written permission for me to observe and interview their children.

Since I had observed the teacher’s classes for twenty two school days prior to my study, I had already learned about the teacher, and her instructional methods, and her technology education activities.

The only concerns came from how to interact with students and gather the evidence. I slowly began to interact with students. I walked up to them quietly as they worked on their projects and stood at their side and observed what they were doing. When I approached Anna (pseudonym), she asked me “Are you Chinese?”, “Are you going to be here everyday?” and “What were you writing?” I told her that I would be here everyday and was doing research to learn about what elementary school students might learn through technology education activities. Then, I showed her my field notes written in English, as well as, Korean. I told her I took notes to remember what I saw, heard, and felt while being here. I slowly began to interact with students and approached the students on an individual basis.
Gaining Acceptance

One month of observation prior to this study helped to foster my relationship with the teacher. I felt that she believed that I understood her approach to technology education. One day, she told me “Other teachers in this building do not know what I am doing.” She is the only technology teacher. She said “We, with the science teachers, do not cooperate for lessons”. However, she has the confidence to connect the science content for teaching technology class since she taught science before she came to this school (from field notes, April 17, 2003).

My successive concern was to gain students’ acceptance. As Zuga (1982) stated, “Time is a key to part of this. Signs are also given during the course of events. Each day, interactions change and enter a new plateau of experience with each individual. Each experience is different than the others; each individual interacts in a different way” (p. 71). However, I did not have enough time to get close with the students since this class was scheduled only for five and half weeks. Nevertheless, I was able to share their
experiences on a few occasions. For instance, at the end of the first week, the students received a free white T-shirt campaigning drug abuse resistance. When I came to the classroom, they were wearing the shirts covered with many autographs. They wanted to have the teachers’ and friends’ as well as my signature on it. They made a line to get my signature and were curious about the Korean letters I wrote on their T-shirt. The next day, Isabella (pseudonym), one of the participants in my study showed me the note where she had copied my writing of Korean and said, “Hopefully, it’s correct.” (from field notes, May 12, 2003).

I was excited to observe the class, because I had finally begun a study that I had been anxious to perform. I felt that over time I was slowly getting accepted by the teacher and the students.

Participants

The Researcher: Becoming a Qualitative Researcher

As Patton (1990) stated, “because the researcher is the instrument in qualitative research, a qualitative
report must include information about the researcher” (p. 472). As an international student, I have a different educational background and research experiences from those of American researchers. Even though my research context was in the United States, I collected and interpreted the evidence with my own educational, social, and cultural points of view.

I had primary and secondary education for twelve years in Korea; six years for elementary school, three years for middle school, and three years for high school. I then had four years of undergraduate study majoring in technology education and two years of graduate study majoring in technology education. With eighteen years educational experiences in Korea, I came to the United States to pursue the Ph.D. in technology education.

I have been a full-time doctoral student specializing in technology education in the Mathematics, Science, and Technology Education Section at The Ohio State University since Autumn quarter, 1998. During the last six years, I have had different educational experiences than those in Korea, and my perspective toward education has evolved to include an appreciation
of social constructivism. I believe a different environment makes people have a chance to look back on their experiences and have different perspectives.

When I look back to my graduate studies in Korea and the United States, I find that I have gone through some changes in my perspective on educational research. I have been trained on mathematical skills and thinking since high school. In Korean, we have three tracks for high school: the humanities track, the science track, and the vocational track. I was in the science track in which students need to take more advanced mathematics and science courses. Then, most students in the science track go to the university to study engineering, natural science, or medical science. I have enjoyed mathematics and have been fascinated with mathematic logics. In addition, I was introduced to only quantitative research methodology including educational statistics during graduate studies in Korea. As I recall, there was limited qualitative research courses open to graduate students. Those experiences lead me to do quantitative research using statistics for my master’s thesis. However, while taking more research classes at The Ohio
State University, I questioned myself about what I could say and explain with the numbers produced by statistics about my study for research consumers. I became interested in qualitative research and took all of the qualitative related research classes provided by the College of Education and had two opportunities to do mini qualitative studies.

The first experience of doing a mini qualitative study was during the autumn quarter, 1999. I prepared a presentation for an ITEA conference with a colleague in the same program. At that time, I investigated how an elementary teacher integrated technology into other subjects. I employed observation and document analysis methods to gather the evidence. I learned that the observation method was not as easy as I had assumed. The second experience took place while I was taking ED P&L 966 (Practicum in Qualitative Research) in Winter Quarter, 2001. It was the pilot study of this study, and Dr. Kos, who was the instructor of ED P&L 966 as well as one of my dissertation committee members, supervised the research procedures. I observed an elementary classroom over one and half months and interviewed three students.
and the teacher to investigate a teacher’s and students’ perceptions toward technology education. As I recall that time, I was nervous about interviewing the teacher and students so that I did not ask all the questions that I prepared. I often ran out of time and struggled with how to begin the interview. This practice better prepared me for my dissertation study.

Another way I influenced this study was through the research question I have had since 1998. I wished to investigate the value of ESTE since I put my feet in this field. I could not clarify the value of ESTE, and it was vague to me. I was anxious to learn how the students benefit from exposure to ESTE. I wanted to investigate what is really happening in ESTE context and how elementary school students learn technology concepts and processes. Through taking the qualitative research courses at the Ohio State University, I realized that qualitative research could answer the question I have had.
The Students

The population of the school was multi-cultural, consisting of mostly Caucasian students, with fewer African-American, Hispanic, and Asian students.

For this qualitative study, a total of nine elementary school students (four fifth grade female students for the Recycling Unit, two fifth grade male students and one fifth grade female student for the Alternative Forms of Energy Unit, and one sixth grade male student and one sixth grade female student for the Invention and History of Technology Unit) were purposively selected as participants. Eight out of nine participants were Caucasian and one was Hispanic. They showed various personalities. For instance, Anna was a quite student, but was friendly to me and was interested in talking to me. Another student, Rachael, was a classroom leader who liked to present her works and show her opinions. The various personalities of the students helped me think about the students’ differences and needs in the technology education classroom.

The students’ willingness to participate in the study was assessed through a conversation after I
explained the overview of the study and the students’ role. When the students agreed to participate, they were asked to sign a consent form that outlined the study and made clear their option of withdrawing from the study at any time. The students’ parents or guardians were also asked to sign a consent form if they were willing to allow their children participate in this study.

The reason I restricted the number of students to two to four of each class was that I wanted to see how elementary school students learn technology concepts and processes using in-depth case study analysis. I also believed that a few students were manageable given my proposed time schedule for observations and interviews at the elementary school. Table 3.1 shows the brief information on the participants of this study.

<table>
<thead>
<tr>
<th>Race</th>
<th>Grade</th>
<th>Sex</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anna</td>
<td>Caucasian</td>
<td>5th</td>
<td>Female</td>
</tr>
<tr>
<td>Beth</td>
<td>Caucasian</td>
<td>5th</td>
<td>Female</td>
</tr>
</tbody>
</table>

Table 3.1: The brief information on participants.
Table 3.1 (continued)

<table>
<thead>
<tr>
<th>Name</th>
<th>Ethnicity</th>
<th>Grade</th>
<th>Gender</th>
<th>Course</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rachael</td>
<td>Caucasian</td>
<td>5th</td>
<td>Female</td>
<td>Recycling (Required)</td>
</tr>
<tr>
<td>Sarah</td>
<td>Hispanic</td>
<td>5th</td>
<td>Female</td>
<td>Recycling (Required)</td>
</tr>
<tr>
<td>Ryan</td>
<td>Caucasian</td>
<td>5th</td>
<td>Male</td>
<td>Alternative Forms of Energy (Selective)</td>
</tr>
<tr>
<td>Mike</td>
<td>Caucasian</td>
<td>5th</td>
<td>Male</td>
<td>Alternative Forms of Energy (Selective)</td>
</tr>
<tr>
<td>Kiernan</td>
<td>Caucasian</td>
<td>5th</td>
<td>Female</td>
<td>Alternative Forms of Energy (Selective)</td>
</tr>
<tr>
<td>Spencer</td>
<td>Caucasian</td>
<td>6th</td>
<td>Male</td>
<td>Hand Tools Safety (Selective)</td>
</tr>
<tr>
<td>Regan</td>
<td>Caucasian</td>
<td>6th</td>
<td>Female</td>
<td>Hand Tools Safety (Selective)</td>
</tr>
</tbody>
</table>

**The Teacher**

Ms. C was a new technology teacher who had two years experience in teaching technology and five and half years of experience in teaching science. She was one of two elementary school teachers across the nation who received a grant and award for her outstanding achievements in technology education in the classroom.
She was an enthusiastic teacher as well as an action researcher.

The teacher received her bachelor’s degree in sociology and anthropology, and a master’s degree in women’s studies. She has been working on the second master’s degree in technology education.

In a conversation with Ms. C, I was able to learn her philosophical perspective on technology education. She mentioned that

I’m teaching the students to think like engineers, to solve problems and think creatively. Sometimes it appears as though they are just having fun building things. But then the lights start off and you see the students grasping the concept and wanting to know more. They are learning and connecting it to the real world. That’s technology education I think. (Personal conversation, May 20, 2003)

I conducted a summer email interview with Ms. C about what and how she thinks about her technology class. The following were written answers showing her perspective on technology education activities.
July 22, 2003 (On-line interview)

Me: How do you define technology teaching?

Ms. C: Teaching students the nature of problem solving, helping students develop skills to tackle many different types of problems or challenges. Science is the study of natural, chemical, or biological things, but technology is the development of the tools needed to study the sciences.

Me: How do you define technology learning?

Ms. C: Learning how to work on a task, developing a plan and a diagram to approach a challenge, and using the given resources and developing solutions while keeping in mind the constraints.

Me: What do you consider to be the founding principles of teaching?

Ms. C: I believe that students should do research on an area and, then, the
technology application is developed from that research. Students are given a challenge, the teacher demonstrates the type of problem solving method recommend for tackling the challenge, the students then take the lead, and the teacher becomes a coach.

Me: What are three to five of the most important things that you want your students to get out of your technology classes?

Ms. C: (1) Regardless of your science background or interest, you can still come up with possible solutions to challenges, (2) Being lazy and not thinking is bad and a waste of your teacher’s time, (3) Don’t complain about the amount of time or resources that you have been give because someone somewhere got less, (4) Always make a plan before tackling a challenge, you look and sound smarter when you have first applied your brain to the task.
The following was excerpted from the article she wrote.

Technology education requires students to apply everything they have learned to generate one or more solutions to a problem. These skills are necessary for the development of technologically literate students who will someday be world leaders. By providing a fifth grade technology education class, we hope to help create leaders who have a global perspective of technology. (Excerpted from her article)

Based on interviews with Ms. C and observations of her classes, it became visible that her foci on teaching technology are problem solving and design.

The names of all students and the teacher were fictitious to help insure anonymity. I called the teacher Ms. C and named the students participating in this study as Anna, Beth, Rachael, Sarah, Ryan, Mike, Kiernan, Spencer, and Regan.
Collecting Evidence

For the purpose of triangulation and to answer the research questions, data has been collected from several major sources: participant observation, semi-structured interviews with students and the teacher, and documents such as students’ journals, notebooks, written works, and the teacher’s handouts. Multiple sources were necessary to provide for the thick description of the students’ learning of technology concepts and processes.

Participant Observation

Participant observations occurred while collecting data related to the students’ learning of technology concepts and processes. According to Patton (1990),

The purpose of observational data is to describe the setting that was observed, the activities that took place in that setting, the people who participated in those activities, and the meanings of what was observed from the perspective of those observed. (p. 202)

As Lincoln & Guba (1985) explained,
Observation is likely to take different forms at different stages of the inquiry. Early on, the observation may be very unstructured, a stage of defocusing or immersion in order to permit the observer to expand his or her tacit knowledge and to develop some sense of what is seminal or salient. Later, the observations may become more focused as insights and information grow. (p. 275)

As a participant observer, I was involved in the situation and tried to interact with students to obtain the evidence of students’ learning of technology concepts and processes. Observation data was collected in two ways: videotaping and compiling field notes.

At first, I was concerned that the videotape recorder would influence the students to act unnaturally in their school environment. However, the students seemed to not care what was recorded. This video taping entailed several technical matters: (1) where to set the camera up in the class, (2) what I need to do during the recording, (3) how to capture the voices of the teacher and students moving around during the class session and facing away from the recording machine, and so on. I found that the video recording machine required my
undivided attention to follow the dynamics of their classroom interactions. I found that placing the recorder at the back of the classroom was less intrusion to provide a clear picture of students. Then, I was free to interact with the students. However, I cautiously divided my attention to check the video recording while I was participating in the activities.

I wrote descriptive and reflective field notes during and after the observations. As Fraenkel and Wallen (1996) noted, the descriptive field notes included the description of participants and activities, physical setting of classroom, and information from things written on blackboards, and students’ work based on what I observed. On the other hand, the reflective field notes included my thoughts and beliefs toward what I observed. I tried to write the field notes during and after the classes whenever I had time, and after interviews with students (see Appendices D & E). Within a short time after an observation, I elaborated field notes and watched the video I recorded. This helped me retrieve what happened at the classroom and find the
holes where I needed to look for more evidence at the next observation.

**Interviews**

Interviewing is a meaningful qualitative research strategy because the interviewing provides an opportunity for the researcher (1) to access the participants’ thoughts, understanding, and misconceptions and (2) to look inside their minds, beliefs, and perspectives (Glesne, 1999; Patton, 1990). Thus, qualitative interviewing requires “intense listening, a respect for and curiosity about what people say, and a systematic effort to really hear and understand what people tell you” (Rubin & Rubin, 1995, p. 17).

Patton (1990) noted the advantage of an interview as

The fact of the matter is that we cannot observe everything. We cannot observe feelings, thoughts, and intentions. We cannot observe behaviors that took place at some previous point in time. We cannot observe situations that preclude the presence of an observer. We cannot observe how
people have organized the world and the meanings they attach to what goes on in the world. We have to ask people questions about those things. (p. 278)

I interviewed students to get more of a sense of how students learn technology concepts and processes as a result of technology education experiences. The interview was informal in nature. Direct quotes from students were used in the report of this study.

The interview began with very broad questions regarding their attitudes toward technology education activities, such as ‘How was your project?’, ‘Did you enjoy working with your partner?’. I eventually focused the questions more on topics related to the technology concepts and processes. Examples of these questions included ‘Did your wheel move well?’, ‘What factors seem to affect how your car runs?’, “How does recycling save our environment?’, and ‘How can alternate forms of transportation reduce pollutants that affect the environment?’ (see Appendix F).
**Document Analysis**

As Lincoln & Guba (1985) stated, documents are “a stable and rich source of information, contextually relevant, and grounded in the contexts” (pp. 276-277). The documents such as students’ journal, notebooks, and written works, which developed over time throughout this study, were carefully analyzed to explore students’ learning of technology concepts and processes. I made the assumption that students’ learning of technology concepts and processes appeared on the students’ journals, notebooks, and written works (see Appendix H). Table 3.2 summarizes the sources of evidence collection of the study.

<table>
<thead>
<tr>
<th>Evidence</th>
<th>Interviews</th>
<th>Observations</th>
<th>Document Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Students</td>
<td>Teacher</td>
<td></td>
</tr>
<tr>
<td><strong>April, 2003</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>May 7-30.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>June 2-12.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(continues)

Table 3.2: Sources of evidence collection.
Evidence Analysis Procedures

One of the significant components of a qualitative research is ongoing analysis. It helps the researcher to be aware of emerging themes. The researcher can add new components to the study or remove some parts of the study as necessary. Evidence analysis should not be postponed until the evidence gathering is finished since the researcher can come up with a new angle on the evidence or research questions during the evidence analysis and can change or extend the evidence gathering methods before it is too late.

Thus, I started preliminary evidence collection and evidence analysis and continuously worked on the post
interviews according to responses to the pre-interviews in order to get more useful information from students.

Evidence analysis began with a preliminary search through the transcriptions of interviews and observations, field notes, and documents including students’ technology log, handouts, and worksheets showing the significant evidence of a student’s learning of technology concepts and processes. The purpose of this study was not to find patterns or rules for particular categories. Rather, it was intended to describe how elementary students learn technology concepts and processes as a result of technology education experiences. Therefore, through using inductive analysis (Patton, 1990), I tried to classify and group the evidence that shows students’ learning of each technology concept and process. I then interpreted the evidence through the lens of the constructivist perspective.

Establishing Trustworthiness

According to Schwandt (1997), “trustworthiness is one set of criteria that have been offered for judging
the quality or goodness of inquiry” (p. 164). Lincoln & Guba (1985) explained trustworthiness as “how can an inquirer persuade his or her audiences (including self) that the findings of an inquiry are worth paying attention to, worth taking account of?” (p. 290).

As Guba and Lincoln (1989) stated, “it is not appropriate to judge constructivists by positivist criteria or standards or vice versa” (p. 251). The trustworthiness criteria to judge the quality of naturalistic research are transferability, credibility, and dependability (Guba, 1981; Guba & Lincoln, 1989; Lincoln & Guba, 1985).

**Transferability**

Transferability is equivalent to external validity/generalization in quantitative methodology (Lincoln & Guba, 1985). As Guba and Lincoln (1989) stated,

The positivist paradigm requires both sending and receiving contexts to be at least random samples from the same population. In a constructivist paradigm, external validity is replaced by an
empirical process for checking the degree of similarity between sending and receiving contexts. Generalization, in the conventional paradigm [positivist paradigm], is absolute, at least when conditions for randomization and sampling are met. But transferability is always relative and depends entirely on the degree to which salient conditions overlap or match. (p. 241)

One technique to establish the transferability is a thick description (Guba & Lincoln, 1989). Lincoln and Guba (1985) suggested that a qualitative research report should provide the research consumers with the widest possible range of information related to a specific research setting, site, and time through a thick description. The qualitative researchers are not interested in generalizing their results to the larger population but transferring their findings to other research site that has a similar context.

In this study, I tried to provide the thick description and rich evidence regarding my specific context and findings that could become good information for someone who would be interested in making a transfer
of my findings to his/her situation and research setting.

Credibility

Credibility is equivalent to internal validity in quantitative methodology (Lincoln & Guba, 1985). To establish credibility, prolonged engagement, persistent observation, triangulation, peer debriefing, and member checks were used in this study.

Prolonged Engagement

According to Tashakkori & Teddlie (1998), prolonged engagement is “the investment of sufficient time to build trust, learn the culture, and test for misinformation either from informants or from their own biases” (p. 90). Prolonged engagement provides the research an opportunity to make them aware of multiple contextual factors and perspective of informants at work in any given context (Lincoln & Guba, 1995; Tashakkori & Teddlie, 1998).
In this study, I was at the classroom from the first day of the new term to the last day of that term not to miss any single day of technology education classes. It was from May 7 to June 12, 2003 and from August 28 to December 18, 2003. For conducting research on the Recycling Unit, I was at the classroom everyday from Monday through Friday. It was the required subject for all fifth graders scheduled everyday. On the other hand, for the (1) Alternative Forms of Energy Unit and (2) History of Technology and Invention Unit, I only stayed two days, Thursday and Friday because those classes were scheduled for only two days as elective classes for fifth and sixth graders.

Persistent Observation

According to Tashakkori & Teddlie (1998), persistent observation is “to provide ‘depth’ for researchers by helping them to identify the characteristics or aspects of the social scene that are the most relevant to the particular question being pursued” (p. 90). Lincoln and Guba (1985) described that
“if prolonged engagement provides scope, persistent observation provides depth” (p. 304).

I strived to be there while students were engaging in a technology education activity from the beginning of an activity to the end of it.

**Triangulation**

Lather (1986) described that “Triangulation is critical in establishing data trustworthiness, a triangulation expanded beyond the psychometric definition of multiple resources to include multiple data sources, methods, and theoretical schemes” (p. 270). Kos (1989) stated that “triangulation refers to the process of verifying data through multiple sources” (p. 58). In addition, Patton (1990) explains, “one important way to strengthen a study design is through triangulation, or the combination of methodologies in the study of the same phenomena or programs. This can mean using several kinds of methods or data, including using both quantitative and qualitative approaches” (p. 187).
Patton (1990) described that there are various types of triangulation including data triangulation, investigator triangulation, theory triangulation, and methodological triangulation. In this study, I used data triangulation. My data collection methods were combinations of observations, interviews, and documents analysis. As Morse (1994) described, data triangulation allows the researcher to generate a more holistic picture of the environment and the issue. In addition, it provides cross-data validity checks and reduces possible errors and biases that might come from one particular method (Patton, 1990).

**Peer Debriefing**

Guba and Lincoln (1989) noted that peer debriefing is a process of engaging a disinterested peer in extended and extensive discussions of one’s findings, conclusions, and tentative analyses.

As Lincoln & Guba (1985) stated, there are four purposes of peer debriefing.
First, the process helps keep the inquirer honest, exposing him or her to searching questions by an experienced protagonist doing his or her best to play the devil’s advocate . . . Second, the debriefing provides an initial and searching opportunity to test working hypotheses . . . Third, the debriefing provides the opportunity to develop and initially test next steps in the emerging methodological design . . . Finally, debriefing sessions provide the inquirer an opportunity for catharsis. (p. 308)

As Guba and Lincoln (1989) noted, I discussed tentative analyses, findings, and conclusions regarding my research with two peer debriefers who took the qualitative research course with me. This feedback process was quite useful to enhance the quality of my study.

**Member Checks**

A member check is the process of “testing hypotheses, data, preliminary categories, and
interpretations with members of the stakeholding groups from whom the original constructions were collected” (Guba & Lincoln, 1989, pp. 238-239). A member check was often used both during the investigation and at its conclusion. I presented the participants with data collected such as interview and observation transcripts and asked for their ideas to confirm, add, and clarify what has been collected. Further, interpretations and conclusions were checked through the member checks process prior to drawing my conclusions.

**Dependability**

Dependability is equivalent to reliability in quantitative methodology (Lincoln & Guba, 1985). It is “the process of the inquiry and the inquirer’s responsibility for ensuring that the process was logical, traceable, and documented” (Schwandt, 1997, p. 164). In order to assess dependability, a dependability audit is one technique for documenting the logic of process and method decisions. Lincoln and Guba (1985) described that the dependability audit concerns the process of the inquiry, including the appropriateness of
inquiry decisions and methodological shifts. To establish dependability, I described the process of this study in chapter 3 for research consumers to be able to 1) consider the context of the research, 2) track the procedures used in this study, 3) understand the evidence collection and analysis methods.

**Time Line**

This study consisted of three phases. Phase I included looking for a research site, obtaining permissions from participants, and observing classes to learn how technology education lessons were conducted over a four month period of time prior to starting this study. In Phase II, I conducted the interviews, observations, and document analysis over a five month period of time. Phase III included evidence analysis and final write-up which occurred over a five month period.

**Summary**

This chapter has been a discussion of the procedures that were employed in this study. It included the methodological perspective, a pilot study, planning
the study, participants, collecting evidence, evidence analysis procedures, establishing trustworthiness, and a time line. Table 3.3 shows the overview of procedures employed in this study. It is hoped that the reader will be able to understand how the study was performed.

<table>
<thead>
<tr>
<th>Units</th>
<th>Recycling Activities</th>
<th>Alternative forms of Energy</th>
<th>Hand Tools Safety</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activities</td>
<td>(1) A paper car activity &amp; (2) A game board activity</td>
<td>(1) A barge activity, (2) A hoop glider activity, (3) A pinwheel activity, &amp; (4) A Mighty Pinwheel Machine activity</td>
<td>(1) Tool flash card activity, (2) Tool lab activity, &amp; (3) Invention of Hand Tools</td>
</tr>
<tr>
<td>Grades</td>
<td>5th</td>
<td>5th</td>
<td>6th</td>
</tr>
<tr>
<td>Participants</td>
<td>4 girls</td>
<td>2 boys &amp; 1 girl</td>
<td>1 boy &amp; 1 girl</td>
</tr>
<tr>
<td>Research time</td>
<td>May &amp; June</td>
<td>August, September, October, November, &amp; December</td>
<td>August, September, October, November, &amp; December</td>
</tr>
</tbody>
</table>

(continues)

Table 3.3: Overview of procedures employed in this study.
Table 3.3 (continued)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(43 minutes)</td>
<td>(46 minutes)</td>
<td>(45 minutes)</td>
</tr>
</tbody>
</table>

Evidence Collection
- Participant observation,
- Interviews, &
- Documents analysis (students’ journals, notebooks, teacher’s handout, etc).

Evidence Analysis
- Ongoing analysis throughout the research,
- Inductive analysis to classify and group the evidence, &
- Analyzing the evidence through the lens of the constructivist perspective.
CHAPTER 4

CONTEXT

I intend to describe the environment and curriculum of the technology education program of the school in order to provide the context of the situation.

The Environment

The school where I conducted this study was one of six elementary schools in an urban school district of a small city located near a major metropolitan area. This elementary school opened its doors in 1883 and the school is housed in modern buildings.

The following is an introduction to the environment of the technology education classroom. It is a description of the first day of observation.
April 8, 2003 (Observation)

The technology classroom is located on the third floor between a social studies classroom and a computer classroom. It seemed to be a classroom modified from a science laboratory. One side of the classroom has long black desks equipped sinks and faucets. Another side of classroom has a black board and the other two sides of classroom have closets for storage of students’ work and materials. The teacher has saved and displayed previous students’ work on the black tables. At the back corner of the classroom, there is a big recycling box.

There are ten discussion tables and about two to three students are divided into each table. There are two computers and one printer at the front of the classroom. There are 5 posters affixed on the doors of closets: (1) Think lab safety, (2) Listen quietly to all directions and ask questions if you are unsure, (3) Follow the directions and ask your teacher before you try a new idea, (4) Stay in your
I went into the classroom. It was twenty minutes before the class began. Ms. C was writing ‘Daily Quiz’ on the white board. It was “Write a definition of the word, Cheating.” She told me that one group used extra materials for the project, but that was not accepted in this class. So, she wanted to begin the class by reemphasizing the rules the students should follow. She also told me that the students needed to be warmed up prior to the main lesson.

Most of the students entered the classroom on time. They picked up their folder from the plastic drawers named ‘Period 5’, and went to the table. They took out the technology log and copied down the daily quiz Ms. C wrote on the white board. They seemed to know what they were supposed to do. They shared and helped each other to answer the daily quiz. They spent about ten minutes on the quiz. Finally, Ms. C let the students continue the project, a cardboard chair. The students looked
very excited about making a chair out of recycling materials on which they could sit.

One group was making a chair out of big empty box. One student, a girl, in the group tested the chair by sitting on it. The box did not look strong enough to hold her up. She and her partner looked around and found lots of small boxes. They filled the empty big box with small boxes and tested it again. It was successful. They wrapped the outside of the box with construction paper.

Ms. C kept walking around by the tables while the students were working on the cardboard chair project. She asked the students to clean up the working area at eight minutes before the end of the class.

The following is another observation to show the environment of the technology education classroom in this study.
April 21, 2003 (Observation)

I was the first in the classroom so I had a chance to look about the classroom. There were a couple of books on the student tables. The titles were “Transportation”, “Structures”, “Recycling”, and so forth. All of the books were related to technology. I also noticed that those books were checked out from the public library. I asked Ms. C about the books at the end of class. She told me that she often visited the public library to find good books that could introduce students to the technological world. She added that she asked the students to read the books when they had completed their project earlier than the other students. I found many books about technology or design at the back right corner of the classroom.

The following observation also shows the environment of technology education classroom where I conducted this study.
April 23, 2003 (Observation)

There were lots of big empty boxes and Styrofoam blocks on one of black tables at the back of the classroom where I usually set my video camera. Those were the boxes of computers and monitors and Styrofoam out of those boxes. Ms. C informed me that she has asked the teachers and staff to give her the empty boxes, plastic bins, Styrofoam, and so on to use in her classroom projects. I also could notice that she has saved a lot of recycled materials including plastic bags, advertising papers, drinking straws, yarn, and so on at the back of the classroom and even in the closet and under the tables placed in front of the closet.

The Curriculum

The first part of this section describes the curriculum of the technology education program and the second part explains the lessons of the technology education program.
The Technology Education Program Curriculum

The curriculum of the technology education program of the school focused on the areas of construction, energy and power, and transportation.

The school offers three technology education courses for fifth and sixth grades: One required class for fifth grade, one elective class for fifth grade, and one elective class for sixth grade. Ms. C is the only technology teacher at the school and she teaches all of the classes. The fifth grade required program’s curriculum focused on recycling, the fifth grade elective program’s curriculum focused on alternative forms of energy, and the sixth grade elective program’s curriculum focused on ergonomics, hydroponics, robotics, and pneumatics. The following is on-line interview with Ms. C, showing the curriculum of the technology education program in the school.

April 25, 2003 (On-line interview)

Me: What is the objective of the fifth grade required class?
Ms. C: The class focuses on recycling and the use of biodegradable items to create new devices.

Me: How are you going to teach this class?

Ms. C: Students will design and make a paper car, game board, and cardboard chair out of recycled materials.

Me: How are you going to evaluate students’ learning?

Ms. C: Students will complete a technology log as they progress through each step of the design process. Students will be assessed based on the performance tasks, the portfolio, the maintaining of a daily journal, and quizzes.

Me: What is the objective of the fifth grade elective class?

Ms. C: Students will investigate the positives and negatives associated
with alternative forms of energy: wind, solar, and hydroelectric.

Me: How are you going to teach this class?

Ms. C: Students will design and build wind power machines, solar powered cars, and electric-powered vehicles.

Me: How are you going to evaluate students’ learning?

Ms. C: Students will be assessed based on the performance tasks, the portfolio, the maintaining of a daily journal, and quizzes.

Me: What is the objective of the sixth grade elective class?

Ms. C: The students will be introduced to concepts of ergonomics, hydroponics, robotics, and pneumatics.

Me: How are you going to teach this class?

Ms. C: Students will research and invent useful ergonomics products,
experiment with growing plants hydroponically, and construct a functional hydraulic robot.

Me: How are you going to evaluate students' learning?

Ms. C: Based on quizzes, a daily journal, organization of folder, and a cumulative test.

Most of the units in the technology education program involve hands-on activity. There is no textbook, and Ms. C hands out the worksheets at the first day of each activity.

The following is the descriptive statement of the technology education program on the syllabus of sixth grade elective course.

The hands-on activities in this class are called performance tasks. During the performance tasks, students will work in groups to solve a particular science/technology challenge that stimulates an actual work activity. Students will be required to
maintain documentation as they proceed during each task. Later, this documentation will be gathered into an electronic portfolio. Students will also be evaluated based on vocabulary quizzes, a daily journal, organization of a folder, and a cumulative test (Syllabus of sixth grade elective course).

Ms. C prepared the syllabus and gave it to the students on the first day of the semester. She asked the students to show it to their parents and get their parent’s signature on the bottom portion of the syllabus. She also requested the students to bring it back by the end of the first week. In the following interview, Ms. C explained the reason why she wanted to get the parent’s signature on the bottom portion of the syllabus.

May 14, 2003 (Personal conversation)

Me: Why did you want the students to get the parent’s signature on the bottom of the syllabus?

Ms. C: Because I wanted the parents to read the syllabus. Last time, one of
parents in my class was not happy with their son’s grade. They asked me to show how I evaluated and what criteria I used to give him the grade because he got all As except my class. I gave him a B. Actually, he was not good at my class. He didn’t collaboratively work with his partner and didn’t finish the final product. I couldn’t give him A. So, this time I wanted to let the parents know at the beginning of the semester what I am teaching and how I evaluate the students’ work.

While talking about the syllabus, Ms. C shared her difficulty in teaching the technology education class. She stated that “most of the units in my class involve hands-on activities. People think that hands-on activity is easy, so technology class is easy” (May 14, 2003, Personal conversation). She also mentioned that “Even the counselor has sent students with learning
disabilities to this class since she believes this class is easy and not academic” (May 14, 2003, Personal conversation).

Ms. C emphasized the significance of safety in the technology education classroom. She spent the first day of each class explaining the safety rules. The laboratory safety statement of the technology education program reads as follows:

This is a hands-on class. Students will design and create different devices to illustrate the concepts learned in class. They will use tools such as hand drills and glue guns. Following the safety and conducting rules is an important requirement to ensure the safety of all students. (Syllabus of fifth grade elective course)

In sum, the curriculum of the technology education program of the school focused on the areas of construction, energy and power, and transportation and involved hands-on activities.
The Technology Education Program Lessons

The lessons in the technology education program were made up of two parts. First, the students were introduced to new hands-on activities designed to address the technology concepts and technology processes through a worksheet Ms. C prepared. She researched the teacher-guide books and related Internet sites to make the worksheet. Second, the students directly participated in hands-on activities after Ms. C went over the directions of the activities on the worksheet.

The following are the technology education lessons that I observed.

The students in the fifth grade required course began the term by making a paper car. The students came to the technology lab everyday Monday through Friday for forty three minutes for five and half weeks. They were exposed to the paper car activity for about two weeks. They were expected to learn about the properties of materials, transportation technology, and the engineering design process through participating in the paper car activity. The students designed and built a car from the recycled materials that would hold the
payload of two pink Pearl erasers as it traveled down a ramp and across a track. The students worked in a group of two or three students. They did not have a chance to rebuild after the race day.

May 22, 2003 (Observation)

It was the race day. The students looked excited to test their paper cars. Ms. C set the ramp on the one of students’ tables. One student from each group came up and tested their cars. All of paper cars slid down the slope of the ramp. None of paper cars had wheels working well.

Figure 4.1: Race day.
As shown in Figure 4.1, one student came up and tested the paper car. After the student made the paper car slide down the slope of the ramp, the teacher measured the distance from the bottom of the slope.

The second activity was a game board. After finishing the paper car activity, Ms. C motivated students to think about recycling by solving a puzzle and watching video regarding recycling.

May 23, 2003 (Observation)

It was the first day of a game board activity. Ms. C asked the students to write the definition of ‘recycling’ as the daily quiz. The students shared their definition with peers in the table. Then, Ms. C showed the students the video, “Glass Recycling.”

Ms. C passed out the worksheet of the game board to the students after watching video. The game board activity took about three weeks, fifteen school days. In the game board activity, the students invented their own board game about trash. They drew a rough sketch of
their game board and then made it out of recycled materials. The students worked in a group of two or three students. After they finished creating the game board, they played it with peers and switched the game boards with other groups.

Figure 4.2: A game board.

Figure 4.2 presents one of the game boards that one group made, titled ‘Recycle Mania’. This group used the film bin as a game piece. The game board has its own rules and directions the students decided.
Table 4.1 summarizes the technology education lessons of the fifth grade required class while I was conducting this study.

<table>
<thead>
<tr>
<th>Week</th>
<th>Activities</th>
<th>Students’ participation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A paper car activity</td>
<td>☐ Were introduced to safety rules in technology education classroom,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>☐ Made a binder that would be used throughout the term, and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>☐ Designed and made a paper car</td>
</tr>
<tr>
<td>2</td>
<td>A paper car activity</td>
<td>☐ Kept making a paper car and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>☐ Tested a paper car</td>
</tr>
<tr>
<td>3</td>
<td>A game board activity</td>
<td>☐ Watched the video, ‘Glass Recycling’,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>☐ Solved the puzzle regarding recycling, and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>☐ Designed and made a game board</td>
</tr>
<tr>
<td>4</td>
<td>A game board activity</td>
<td>☐ Kept making a game board</td>
</tr>
<tr>
<td>5</td>
<td>A game board activity</td>
<td>☐ Played a game board with peers and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>☐ Took a final exam</td>
</tr>
</tbody>
</table>

Table 4.1: Description of technology education lessons of the fifth grade required course.

The students in the fifth grade elective course began the term by making a barge. The students come to
the technology lab on Thursday and Friday for forty six minutes for one semester. In the barge activity, the students designed and built a barge that would float as many pennies as possible. The barge that held the most pennies without sinking was declared the winning design.

September 11, 2003 (Observation)
Ms. C set the plastic bin on the front table. Most of the groups succeeded in holding over twenty pennies. The students seemed to be excited to count the numbers of pennies while a peer was cautiously putting the pennies on the barge.

Figure 4.3 shows one student putting pennies on the barge he made.
After the barge activity, Ms. C showed the video entitled, ‘Energy’, and the students solved a puzzle named ‘Energy Word Search’. Then, the students participated in a hoop glider activity. The students made a hoop glider out of paper and a plastic drinking straw. They threw the hoop glider in a hallway. Figure 4.4 shows a hoop glider one student made.
After the hoop glider activity, the students were introduced to how to make a pinwheel. Ms. C handed out the pattern of a pinwheel and asked the students to make it. In the pinwheel activity, most of the students succeeded in making the pinwheel spin. After making and testing the pinwheel, the students were asked to make a mighty pinwheel machine. The students designed and made a mighty pinwheel machine that was made of three parts: base, tower, and load. They used the recycled materials.

Figure 4.5 shows the mighty pinwheel machine one group made.
As shown in Figure 4.5, one of members in this group informed me that they elicited the design idea of the mighty pinwheel machine from the windmill. They used a big cup for the base and small cup for holding the paperclips.

Table 4.2 summarizes the technology education lessons of fifth grade elective class while I was conducting this study.
<table>
<thead>
<tr>
<th>Week</th>
<th>Activities</th>
<th>Students’ Participation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>None</td>
<td>- Were introduced to safety rules in technology education classroom and - Made a binder that would be used throughout the term.</td>
</tr>
<tr>
<td>2</td>
<td>Build a Barge activity</td>
<td>- Designed and made a barge.</td>
</tr>
<tr>
<td>3</td>
<td>No Class</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Build a barge activity</td>
<td>- Kept making a barge, - Tested a barge, and - Watched the video, ‘Energy’.</td>
</tr>
<tr>
<td>5</td>
<td>A hoop glider activity</td>
<td>- Solved a ‘Energy Word Search’ puzzle and - Made and tested a glider.</td>
</tr>
<tr>
<td>6</td>
<td>A pinwheel activity</td>
<td>- Made a pinwheel</td>
</tr>
<tr>
<td>7</td>
<td>A pinwheel activity</td>
<td>- Kept making a pinwheel and - Tested a pinwheel.</td>
</tr>
<tr>
<td>8</td>
<td>A mighty pinwheel machine activity</td>
<td>- Designed and made a mighty pinwheel machine.</td>
</tr>
<tr>
<td>9</td>
<td>No Class</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>A mighty pinwheel machine activity</td>
<td>- Kept making a mighty pinwheel machine.</td>
</tr>
<tr>
<td>11</td>
<td>A mighty pinwheel machine activity</td>
<td>- Kept making a mighty pinwheel machine.</td>
</tr>
<tr>
<td>12</td>
<td>A mighty pinwheel machine activity</td>
<td>- Tested a mighty pinwheel machine.</td>
</tr>
</tbody>
</table>

Table 4.2: Description of technology education lessons of the fifth grade elective course.

The students in the sixth grade elective course began the term with a tool flash card activity. The students came to the technology lab on Thursday and Friday for forty five minutes for one semester. In the
tool flash card activity, the students looked for the photos and pictures of hand tools out of magazines, newspapers, etc and made a flashcards. The flashcards had the picture on one side and an explanation of the tool on the same side or on the backside of the card. The students made seven flashcards. Following the tool flash card activity, the students were introduced to the tool lab activity. The students practiced how to safely use hand tools and monitor each other’s behaviors to use hand tools. The tool lab activity was ended by making a safety chart and drawing a safety cartoon. Figure 4.6 present the safety cartoon one student drew.

Figure 4.6: Safety Cartoon.
Some student drew the cartoon about the safety rules and some student made a safety chart explaining each safety rules.

Figure 4.7 shows that the students were wearing the safety classes while using a glue gun.

As Shown in Figure 4.7, the students were required to wear safety glasses while working with any hand tools in the technology education classroom. Two students were in one group and monitored each other so that the partner would use the hand tools safely.
Following the tool lab activity, the students designed the tools as an invention project. They used the recycled materials to design and build a tool that actually works. Ms. C emphasized creativity. Figure 4.8 shows one student’s sketch of an initial design idea of invention project.

Figure 4.8: Invention sketch.

As shown in Figure 4.8, the students in the invention activity sketched their initial invention ideas and were requested to get Ms. C’s approval prior to making it. Table 4.3 summarizes the technology.
education lessons of sixth grade elective class while I was conducting this study.

<table>
<thead>
<tr>
<th>Week</th>
<th>Activities</th>
<th>Students’ Participation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>None</td>
<td>□ Were introduced to safety rules in technology education lab,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>□ Made a binder that would be used throughout the term, and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>□ Discussed working together.</td>
</tr>
<tr>
<td>2</td>
<td>Tool Flash Card Activity</td>
<td>□ Took a test on Hand Tools and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>□ Made a flash card</td>
</tr>
<tr>
<td>3</td>
<td>No Class</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>None</td>
<td>□ Kept making a flash card and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>□ Organized the binder they made.</td>
</tr>
<tr>
<td>5</td>
<td>Tool Lab</td>
<td>□ Practiced how to use hand tools.</td>
</tr>
<tr>
<td>6</td>
<td>Tool Lab</td>
<td>□ Made a safety chart</td>
</tr>
<tr>
<td>7</td>
<td>Invention Activity</td>
<td>□ Designed a hand tool.</td>
</tr>
<tr>
<td>8</td>
<td>Invention Activity</td>
<td>□ Designed a hand tool and presented their ideas in front of peers and the teacher.</td>
</tr>
<tr>
<td>9</td>
<td>No Class</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Invention Activity</td>
<td>□ Kept making a hand tool.</td>
</tr>
<tr>
<td>11</td>
<td>Invention Activity</td>
<td>□ Kept making a hand tool.</td>
</tr>
<tr>
<td>12</td>
<td>Invention Activity</td>
<td>□ Evaluated each other’s invention of hand tools.</td>
</tr>
</tbody>
</table>

Table 4.3: Description of technology education lessons of the sixth grade elective course.
Each lesson consisted of three parts: Daily Quiz (They called it DQ.), Warm-Up (They called it WU.), and Main Lesson (They called it ML). DQ went for about ten minutes, WU for about ten minutes, and ML for about twenty minutes. The rest of class time was for clean-up. For DQ, Ms. C introduced the students to puzzles and games related technology. For instance, the DQ on May 15, 2003 was “List 3 creative uses for a paper clip (i.e., apple peeler).” For WU, the students spent the time in organizing their folders, bringing their unfinished products from the closet, and sharing their ideas and challenges regarding the projects. Finally, they started working on the project for about twenty minutes and cleaned up their working areas before they were dismissed.

**Summary**

This chapter provided the descriptions of the environment of the technology education classroom, and the curriculum and the lesson plans of technology education. The environment was an elementary school technology education classroom in an urban school
district of a small city, in which fifth and sixth graders learned technology concepts and processes through a hands-on activity. The curriculum of the technology education program focused on the areas of construction, energy and power, and transportation. Ms. C introduced the technology concepts and technology processes through a hands-on activity. She did not use a textbook and prepared the worksheets for each activity. The students were responsible for constructing the technology concepts and technology processes by themselves through participating in the technology education activities that were designed to address the technology concepts or technology processes.
CHAPTER 5

ELEMENTARY SCHOOL STUDENTS’ LEARNING OF TECHNOLOGY CONCEPTS AND PROCESSES, AND THEIR BELIEFS AND ATTITUDES TOWARD TECHNOLOGY AND TECHNOLOGY ACTIVITIES

This chapter consists of two sections. The first section provides evidence concerning elementary school students’ learning of technology concepts and processes, and followed by an analysis of the evidence. The evidence was classified and interpreted by a constructivist learning theory. The second section presents evidence concerning elementary school students’ beliefs and attitudes toward technology and technology activities, and followed by an analysis of the evidence.
How Elementary School Students Learned Technology Concepts and Processes

While observing and interviewing the students in the elementary school, it became apparent that elementary school students learned technology concepts and processes in a constructivist learning context.

The following is a presentation of the evidence I found regarding the technology concepts and processes elementary school students learned as a result of technology education experiences, followed by an analysis of the evidence as it relates to the constructivist learning theory.

Learning through Meaningful Learning with Real World School Activities

The elementary school students in this study appeared to learn the technology concepts and processes through real world school activities. The activities I observed put meaning and significance into the students’ daily life.
Evidence

Rachael, who participated in the paper car activity, was a ten year-old girl who had been fascinated with doing a hands-on activity. She believed that “I love making things and also like using my imagination” (Personal communication, May 15, 2003). The paper car activity was designed to address transportation technology and took about two weeks. The fifth grade students come to the technology lab everyday, Monday through Friday, for forty three minutes.

On the first day of the paper car activity, Ms. C handed out the design brief that described the materials needed and the directions. According to Ms. C’s paper car activity worksheet, “Students will build a car from the recycled material supplied that will hold the payload of two pink Pearl erasers as it travels down a ramp and across a track. The distance traveled past the bottom of the ramp will judge the success of the car.” The students were asked to brainstorm the design ideas of the paper car prior to sketching it.
In an observation and an interview with Rachael, she gave me the following information about her design idea.

May 9, 2003 (Observation)
Rachael was excited to design and make a paper car. She seemed to be quite ready to design a paper car and started sketching a car on her technology log right away after Ms. C said ‘Begin’. The other students were still struggling with the design ideas.

Rachael was ready to make the paper car when she came to class on the second day. She walked around to see what other students drew on the technology log. The following evidence showed where she got the design idea of her paper car from.

May 15, 2003 (Interview)
Me: Where did you get the design idea of your car from?
Rachael: My daddy’s car.
Me: I like your sketch.

Rachael: Thanks.

Me: Why did you want to make the car like your daddy’s?

Rachael: Well, the paper car has to hold two pink pearl erasers and travel down a ramp for the final test run. So I thought the trailer could transport them safely.

Me: What a great idea! I like your idea.

Figure 5.1: Rachael’s sketch.
Figure 5.1 showed Rachel’s sketch. As she mentioned, she elicited the design idea of her paper car from her daddy’s real car. While interviewing her, she seemed to be proud of her sketch since she had finished in a short time and was eager to make it right away.

Another student, Anna, who was a ten years and six months old girl, did the game board activity. The game board activity took about three weeks, five days per week. On the first day of the game board activity, Ms. C passed out the worksheet and asked the students to invent their own game board about trash. The students worked in groups to design and create the game board. They needed to get the design approval from Ms. C prior to making the game board.

Anna and her partner designed a game board that looked like Monopoly.

May 28, 2003 (Observation)

Anna and her partner, Emily, talked about Monopoly. They came to a conclusion to modify Monopoly for their game board project.
As Figure 5.2 presented, Anna and her partner modified the real Monopoly to make the game board. They even titled it as ‘Recycoppely’.

One day, Ms. C started the class by having the students draw a cartoon illustrating the recycling in their mind.
As Figure 5.3 showed, Anna was connecting recycling and the world. She illustrated on her cartoon how recycling and the real world would affect each other. She drew the earth decorated with flowers. She seemed to consider that recycling affected our world. She wrote on her cartoon that

Recycling saves trees. If you recycle you will always have paper and clothing. If you always recycle we will always have a beautiful world.

(Excerpted from her cartoon above)
While the garbage game board activity was going on, I interviewed Anna about recycling and its significance in our life.

June 3, 2003 (Interview)
Me: Could you tell me your definition of recycling?
Anna: Something that can be reused over and over again.
Me: Could you tell me why recycling is important?
Anna: Well, everyone should recycle because it helps to keep the earth clean and not polluted with all of the landfills. We need to save landfill room.
Me: How does recycling save our environment?
Anna: We don’t use up area in our landfill. When we save room in our landfill we can put no-recyclable in its place.
Me: How can alternate forms of transportation reduce pollutants that affect the environment?
Anna: When we use other forms of transportation we do not pollute the air and harm forms of life.
Me: How has technology affected the natural world in both positive and negative ways?
Anna: When we drive a car we pollute the air and harm trees and other wild life. Positively, we can get around faster and easier.

Anna demonstrated her understanding of the significance of recycling, and how the use of technology would affect the environment in positive and negative ways. According to International Technology Education Association (2000), “in order to discern the effects of technology on the environment, students in grades 3-5 should learn that the use of technology affects the environment in good and bad ways” (p. 67).

Ms. C informed me that the students in her class were expected to differentiate the trash from garbage and she would ask them the definitions of the words, trash and garbage, on the final exam. Therefore, I asked the students the definitions of those words one week before the game board activity started, then, I compared those to what they wrote on the final exam. In an interview with Anna, I obtained the following evidence.
May 26, 2003 (Interview)

Me: Could you tell me your definition of trash?

Anna: Something off of a piece of candy or off of fast food that needs to be thrown away. Like a banana peel.

Me: Could you tell me your definition of garbage?

Anna: A whole bunch of trash in a large area of landfill.

The following were direct quotations from her answers on the final exam.

June 12, 2003

Q4: Write the definition for the word trash.

Anna: Any kind of waste that is not food.

Q5: Give two examples of how trash is different from garbage.

Anna: Ex1: trash would be an egg carton and garbage would be an apple core. Ex2: trash would be a plastic tray and garbage would be moldy cheese.

Anna seemed to gain an understanding of the difference between trash and garbage. On the final exam,
she mentioned the key word, food, to differentiate the trash from garbage.

Another student, Spencer, was an 11 year old boy who did the invention activity. The invention activity was designed for sixth grade students. This invention activity took about five weeks, two days per week.

Spencer made a double sided screw driver as his invention project. Figure 5.4 showed his invention sketch.

```
Spencer's invention sketch.
```

In an interview with Spencer, I obtained the following evidence.
November 20, 2003 (Interview)

Me: What was the main idea of your invention?
Spencer: Double sided screw driver.
Me: What a great idea! Where did you get this idea?
Spencer: Well, I thought the double sided screw drivers could be a useful tool at home. You don’t need to have two screw drivers next to you. Mine was made out of wooden sticks though.

Spencer got the invention idea from the past experience of using two screw drivers. He seemed to feel it was inconvenient to have two screw drivers and wanted to invent double sided screw drivers.

Analysis

With respect to meaningful learning with real world school activities, the elementary school students in the study were exposed to activities related to students’ daily life. Hill (2000) stated that the technology education curriculum assists students in making connections between academic learning and real world
application. According to Mossman (1938), making the connections within students’ experiences in real life builds meaningful learning.

For instance, a paper car activity provided the fifth grade students with a context in which they learned the technology concept of transportation technology through the meaningful real world activity. Transportation technology is the field of study that focuses on how people are moved, how food is delivered, how products are transported within a society, and so on, and it is a relatively familiar topic to the students (DeVore, 1992). Most of the students had their experiences playing with toy cars and some of them had a chance to assemble a car out of Lego, K’nex, and other assembly kits. In addition, they come to school everyday by transportation such as school buses, cars, bicycles, and so forth. The paper car activity introduces the students to a real world project, transportation.

Brooks and Brooks (1999) described that the constructivist learning context provides the students a real world possibility and helps them construct
concrete concepts from abstractions. According to Bonser and Mossman (1923),

Most school subjects had their origin in practical needs. Children have failed to see that in-school experience and out-of-school experience have any connection or relationship. It is very largely because of this want of connection that school experience has made so little desirable difference in the behavior of pupils outside of school and in after life. The introduction of the industrial arts, representative of so many of the practical activities and problems of daily life, offers a means of bringing most of the other subjects of study into a close and vital connection with the situations in which their subject matter is directly usable. (pp. 67-68)

As Bonser and Mossman described, the paper car activity offered meaning to students' real life beyond the school. According to Cupples (1992), “transportation technology education in the elementary school provides
opportunities to integrate learning experiences for young people. Such studies are important elements in the life-long educational experiences of citizens who will be decision makers in a technological world” (p. 128).

In the game board activity I observed, the fifth grade students were introduced to the technology concepts of environment and recycling that are real issues in our society. The students might have direct or indirect experiences in recycling the cans, bottles, newspapers, clothing, and so on even though they might not know how to recycle those products.

The garbage game activity heavily relied on manipulative recycled materials and the students were allowed to use only recycled materials such as cardboard boxes, plastic bottles, the lids from jars and containers, straws, left over yarns, and so on to create a game board. Williams and Jinks (1985) suggested that many suitable materials can be provided at no cost and used in problem solving projects in the technology classroom. According to Dunn and Larson (1990),
Children involved in active exploration learn that they can influence their environment. They eagerly seek answers to real problems they pose, building and testing theories, creating, and organizing reality in a way that is meaningful to them. This theory of cognitive constructivism provides a perspective for viewing the child as an engineer of personal understanding. (p. 8)

As Dunn and Larson described, the game board activity provided the students with the real problem, environment and recycling, and helped them learn those concepts by designing, making, and playing the game. The students gradually gained understanding of technology concepts, environment and recycling, through making the game board and playing it with peers. They swapped the game boards with other groups and played it and gave some comments on the directions and rules of the game to each other.

As for Anna’s recycling cartoon, she showed her understanding of the technology concepts of recycling and environment and their relationships. According to
Kozulin (1998), symbolic artifacts help individuals develop their own perception. Vygotsky (1978) noted that “children’s symbolic play can be understood as a very complex system of speech through gestures that communicate and indicate the meaning of playthings” (p. 108). By drawing the recycling cartoon, Anna had a chance to demonstrate her understanding of the relationship between environment and recycling.

Moreover, Anna had some understanding of the difference between trash and garbage before the garbage game activity although she was not completely correct. She defined trash as something that needs to be thrown away and garbage as a bunch of trash. She had a misconception of those two words. She differentiated them by the amount. However, at the final exam, she differentiated the two words correctly, trash and garbage.

Anna seemed to understand the difference between trash and garbage after she spent time playing the game with peers. According to Kozulin (1998), “in both Vygotskian and Piagetian systems learning is perceived in terms of a transition from action to thought. The
roots of inner cognitive schemata are sought in the actual interactive activity of children” (p. 3).

In the invention activity I observed, the sixth grade students created the inventions to be useful tools in the real world. Ms. C asked the students to think about the usefulness and improvement of the real tools around them.

According to McCracken (2000), “the creation of tools and other devices signifies a defining moment in the emergence of technology. Technology may be thought of as people using knowledge and resources to create objects to meet their needs” (p. 85).

Perkins (1992) stated that

Having and understanding knowledge and skills comes to naught unless the learner actually makes active use of them later in life - in studying other subjects, shopping in the supermarket, getting a better job, casting a vote, or whatever other context. Although other desiderata can be added to retention, understanding, and active use, it is difficult to discard any one of these. (p. 45)
As Perkins (1992) described, the invention activity was designed to address the usefulness of the connection between learning and applying it later in life.

In the activities, the paper car activity, the game board activity, and the invention activity, the students were in the center of the projects. They were responsible for their project from the beginning of the sketch through the end of the test run. According to Dunn and Larson (1990), “a child-centered approach to learning envelops the notion that interest, curiosity, and a sense of adventure and discovery are the seeds that develop into meaningful learning” (p. 9).

In summary, it was apparent that the elementary school students learned the technology concepts and processes by themselves through meaningful learning with real world school activities. The technology education activities facilitated students’ meaning-making from each individual’s point of view and the students learned the technology concepts and processes by manipulating the materials and designing, making, and playing with the products. In the paper car activity, Rachael learned the engineering design process and the concept of
transportation technology. Anna learned the technology concept of recycling and environment in the game board activity and Spencer learned the creative invention process in the invention activity.

**Learning through Problem Solving and Design Process**

The elementary school students in the study appeared to learn the technology concepts and processes through the problem solving and design process. Ms. C informed me that “learning the nature of problem solving and design process” is one of her definitions of technology education (July 22, 2003, On-line interview).

**Evidence**

Sarah, who was engaged in the paper car activity, had difficulty making the wheels spin. She struggled with her long car. In an interview with Sarah, I obtained the following evidence.

May 20, 2003 (Interview)

Me:       Okay, Um. How is your paper car activity?
Sarah:   It’s good, but we have tons of problems.
Me: What problems you have?
Sarah: One wheel barely moves.
Me: Why did your wheel barely move?
Sarah: ‘cause it isn’t a perfect shape.
Me: What do you mean “perfect shape”?
Sarah: I tried to cut out the circle, but I’m not good at cutting.
Me: Do you have two identical sides for your car?
Sarah: Sort of (pause).
Me: Do you think only shape makes the wheel barely move?
Sarah: I think the paper is not strong enough so the wheels just collapsed.
Me: What else do you think would help the wheels to move?
Sarah: Axle!
Me: Did your axle work well?
Sarah: No, Ms. C gave us 24” of scotch tape, but we ran out of tape, so the wheels barely stay together with axle.
Me: What was the material you used for the axle?
Sarah: A straw. That wasn’t strong, either.

Sarah demonstrated her understanding of the relationship between a transportation system and its efficiency and presented her lack of ability to use the
scissors and the role of strength of materials. On the final test run day, Sarah was excited to test her car. In an interview with her, I obtained the following evidence.

May 22, 2003 (Interview)

Me: Was your car stable?
Sarah: It was a little stable. But, when it went down the track it wobbles back and forth.
Me: Why do you think your car wobbled back and forth?
Sarah: Because of the wheels, I had to make sure the car is leveled on both sides and has about the same weight.
Me: What do you think are the important factors to make a car stable?
Sarah: Mostly the wheels
Me: If you were building this car to carry you, what materials would you build it out of?
Sarah: Out of metal.
Me: Why do you want to use metal?
Sarah: I can make the wheels and the frame strong out of metal.
Me: What do you mean strong?
Sarah: It is not as easy to break and you can make a lot of things with it.
Sarah demonstrated her understanding of the properties of materials and the stability of transportation.

As the part of design process, Ms. C had students write down their predictions of the results of a test run. What follows was excerpted from Sarah’s technology log.

We have the walls around the payload. So it won’t fall out. I don’t think it will go about 30 cm if we are lucky, because the wheels are not very good (Excerpted from Sarah’s technology log).

Figure 5.5 showed Sarah’s final product of paper car.

![Figure 5.5: Sarah’s final product.](image)
On the final test run day, Ms. C had the students write down the results of a final run. What follows was excerpted from Sarah’s technology log.

A small car with a lot of weight goes good. Ours went 43cm. A long car would work a lot better because Ms. C measures the front of the car. Cars need to be light weighted and make wheels that spin (Excerpted from Sarah’s technology log).

Another student, Beth, had a similar problem in the paper car activity. She demonstrated the understanding of subsystem of transportation. Apparently, she seems to understand the function of transportation subsystem.

May 23, 2003 (Interview)

Me: How was your paper car activity?
Beth: The wheels did not roll very well.
Me: Why did the wheels not roll well?
Beth: The wheels are not straight.
Me: What do you mean straight?
Beth: We tried to make the holes in the wheel, but they weren’t big enough for the axle. Also, I’d like to use different materials for wheels.
Me: What materials do you want to use?
Beth: Wood.
Me: Why do you think of wood?
Beth: It’s strong.
Me: What do you mean strong?
Beth: You can put heavy loads on it and you can make lots of stuff like chairs and tables we sit on out of wood.
Me: What problems have you discovered about your car?
Beth: I discovered that it was really important to have the wheels spin but mine did not.
Me: Why didn’t they spin do you think?
Beth: My wheels had to be taped to the car so they would stay on the car. Also, my wheels are not perfectly round and too big.

Beth demonstrated her understanding of the relationship between the transportation system and the strength of materials as well as the quality of the parts. Figure 5.6 presented Beth’s final product of paper car.
Another student, Ryan, in the mighty pinwheel machine activity had difficulty in making the pinwheel spin. In one observation, I obtained the following evidence.

October 17, 2003 (Observation)

Ryan was trying to make the pinwheel spin. The pinwheel was stuck to the straw and did not move at all. He asked Ms. C to help him, but she wanted him to figure it out by himself. He pulled out the pinwheel from the straw and made a bigger hole on
each wing of the pattern of the pinwheel. It was too big. He put the straw into the folded pinwheel, but it was loose. Ryan threw out the pattern and tried to make a new one. In the meantime, his partner was working on the base and tower.

Figure 5.7 shows the mighty pinwheel machine Ryan and his partner designed and made. Ryan did not know how to make the pinwheel spin. He tried to make a hole on the pattern and put the straw into it. In an interview with him, I obtained the following evidence.
October 17, 2003 (Interview)

Me: How’s your pinwheel machine coming along?
Ryan: The pinwheel did not spin.
Me: What’s the problem?
Ryan: I don’t know. (He showed me the pinwheel and asked for help.)
Me: How did you attach the pinwheel to the straw?
Ryan: I made a hole, but it was too small. So, I made it bigger hole, but, I threw it away. (He looked for Ms. C and told me “don’t tell her")
Me: Well, did you measure the width of straw?
Ryan: No. (He measured the width of straw, drew the circle on it with a pencil, and made the hole on the wings of the pinwheel)
Me: Does it work?
Ryan: Yep. Thanks.
Me: What’s the pin for? (I found and indicated the pin on his table).
Ryan: Ms. C gave us (Pause).
Me: How about using the pin for attaching the pinwheel to a straw?
Ryan: Well… I’m done. (He did not want to use the pins)
**Analysis**

With respect to learning through the problem solving and the design process, the fifth grade students in the paper car activity were introduced to the technology concepts of transportation technology, the stability, the properties of materials, as well as, the technology process of engineering design.

Wadsworth (1996) explained that problem solving is a higher-order intellectual ability and is central to the learning process in a constructivist theory. The students in technology class gained a basic working knowledge of materials and processes while performing in problem solving situations (Berkemer, 1989). Problem solving methodology is basic to understanding technology (Daugherty, 2003) and has been a part of technology education curriculum (Waetjen, 1989). As Daugherty (2003) stated, “design is regarded by many as the core problem-solving process of technological development” (p. 29).

As the students worked with the activities in this study, Ms. C stressed problem solving and the design process as the keys to developing a successful solution.
to the requirements for each project. While designing and making the paper car, the elementary school students continually met the problems and challenges, negotiated the possible solutions with peers or by themselves, and made decisions to solve the problems.

For instance, Sarah gained an understanding of the efficiency of transportation through the problem solving and design process. She figured out how a wheel and axle connected to work functionally after several trials and failures. She seemed to understand that if a subsystem of transportation is not working, transportation may lose its efficiency. She believed that the shape of the wheels was the reason it did not function well. In addition, she seemed to understand the relationship of concepts of strength of materials and efficiency of the system. She believed that the paper was not strong enough to make wheels and expressed her lack of ability to deal with the materials to create an efficient system such as wheels.

In relating Sarah’s understanding of stability and the properties of materials, she demonstrated an understanding of the stability of transportation by
referring to some of the component parts of the vehicle and to the way in which they work together as a system. She also explained the strength of the materials by the concept of not breaking and suggested that she could use the stronger materials for her project. As in the Davis et. al. (2002) study the students in this study were able to use paper to build a model car and to extrapolate to real cars the materials needed to build them. Cajas (2001) noted that technology projects can be a context in which students learn about the different properties of the materials they select and how these properties affect their project.

In the evidence regarding Ryan, he clearly did not know what to do in order to attach the pinwheel to the straw. He had some knowledge of the properties of materials and the technology process of folding the pinwheel pattern, but lacked the knowledge and experience in problem solving necessary to find a solution. He asked me for help. I did not give him the answer and helped him to think of a possible solution. He experienced the problem solving process through the
hands-on paper car activity.

According to Sanders (1995),
Our methods have been characterized by hands-on activities and individualized instruction supported by a general laboratory that allowed students countless options for creative problem-solving. We must be sure that others understand that there is no better substitute for this hands-on approach to technological problem-solving. (p. 3)

As Sanders described, students in the study engaged in hands-on activities such as the paper car activity, the mighty pinwheel machine activity, and so on, that gave them problem-solving experiences.

In relating the design process, the students in the study experienced designing, making, evaluating the products, and presenting the results. The design process is one of many problem solving skills (Daugherty, 2003). According to the International Technology Education Association (2000),
In order to comprehend engineering design, students in grades 3-5 should learn that (1) the engineering design process involves defining a problem, generating ideas, selecting a solution, testing the solution(s), making the item, evaluating it, and presenting the results, (2) when designing an object, it is important to be creative and consider all ideas, and (3) models are used to communicate and test design ideas and processes. (p. 102)

For instance, the students in the mighty pinwheel machine activity defined the problem, generated design ideas, made the pinwheel machine, and tested it. According to Daugherty (2003),

While completing design activities, students have the opportunity to prove that they understand the content, work as a member of a design team, and demonstrate technology ability. The best design activities extend and apply learning related to the given technological concept. (p. 29)
Daugherty (2003) described that the students learned the technology concepts and process through the design based activity.

In summary, it was manifest that the elementary school students learned the technology concepts and processes through the problem solving and design process. In the paper car activity, Sarah and Beth learned the technology concepts of transportation technology, the properties of materials, stability, as well as, the technology processes of engineering design through the problem solving and design process. Ryan learned the technology process of engineering design in the mighty pinwheel machine activity.

**Learning through Social Interaction and Collaboration**

It was apparent that the elementary school students in this study learned the technology concepts and processes through social interaction with peers. The activities I observed in this study were basically designed for students to work in groups. Ms. C emphasized students working together. On the second day of technology class, Ms. C began the class with DQ that
was “Aliens have landed at our school. They are taking notes on what it means to be a good partner. Write two to three sentences to explain how to be a good member of a group.” Here was Anna’s answer excerpted from her technology log.

I think what it means to be in part of a group is to work together and try to get things done. You must work together like a team because one person can not do it all alone. Even if you do not like to work with a person, try to get along to get the work done together (Excerpted from Anna’s technology log).

Ms. C emphasized the significance of cooperation throughout the class. She said “team work is one of the main concepts in the technology education activities. The students should learn how to work with a partner” (July 22, 2003, On-line interview).
Evidence

Mike was an eleven year-old boy in the barge activity. Ms. C introduced the students to the barge activity as an introductory project of the alternative forms of energy unit. She handed out the worksheet that described the challenge and rules. The students were given the construction supplies: 2 pieces of aluminum foil, each 6” square, 10 plastic soda straws, 1 measured lump of modeling clay, and 24 inches of masking tape. Ms. C asked the students to use the only materials she offered, but she encouraged them to use those materials in a variety of ways that the students wanted.

In an interview with Mike, I obtained the following evidence.

September 18, 2003 (Interview)

Me: How was the barge activity?
Mike: It was a challenge to design and build it. I like designing but not cutting. But, I like this activity because our barge held more pennies than we expected.
Me: What factor seems to affect how your barge floats?
Mike: The clogged straws.
Me: Why is that?
Mike: The water doesn’t get in it and weight it down.

I observed Mike and his partner as they came to a conclusion about using the clay.

September 18, 2003 (Observation)
Mike and his partner, Christy, had different ideas about using the clay. Mike wanted to use it to clog the straws, but Christy wanted to use it to attach the aluminum foil to straws. Mike said to Christy:

September 18, 2003 (Interview)
Mike: (talking to his partner) The folded aluminum foil would stay along with the straw without clay. I would use the clay to clog the straws so that the water doesn’t get it.
Partner: Well. (Christy does not seem to agree with him)
September 18, 2003 (Observation continued)

Mike and his partner clogged one straw and came up to the tank Ms. C set for testing the barge, and floated it. They came back to their table and Mike started clogging all the straws they had. Christy cut the aluminum foil and straws.

Mike and his partner negotiated their ideas and came to the conclusion they could use the clay to clog the straws. Figure 5.8 shows Mike’s final product of the barge that had the clogged straws.

Figure 5.8: Mike’s final product.
In an interview with Mike, I obtained the following evidence.

September 19, 2003 (Interview)

Me: How many pennies did you expect that your barge would hold?
Mike: 20
Me: How many pennies did your barge hold?
Mike: 38. I got past the number of pennies hoped.
Me: If you have one more chance to build a barge, how would you make it to hold as many pennies as possible?
Mike: I would make it wider to hold more pennies.
Me: What did you learn through this barge activity?
Mike: Working together. Working with a partner made it easy.

Mike and his partner collaboratively worked on the barge activity.

Another student, Kiernan, was a twelve years old girl doing the mighty pinwheel machine activity. Ms. C provided the students with the recycling materials for making the mighty pinwheel machine. One student from
each group came up by the recycling box which Ms. C set in front of the blackboard and grabbed the materials for ten seconds. Ms. C counted to ten. The students were not allowed to use extra materials. In an interview with Kiernan, I obtained the following evidence.

October 2, 2003 (Interview)

Me: Where did you get the design ideas of your pinwheel machine from?
Kiernan: From the materials. Michelle wasn’t good at grabbing the materials this time so we changed a bit of our initial design. We don’t have any good one for a base. Jordon’s group got the plastic container. That looks good for the base.

Me: So, are you going to redesign the mighty pinwheel machine?
Kiernan: Yep. (She doesn’t look happy with the recycled materials her group got.)

Kiernan and her partner were given limited materials and had to redesign the pinwheel machine. In an observation, the following evidence was found.
October 3, 2003 (Observation)

Kiernan and her partner redesigned the pinwheel machine. They got the recycled paper cup holder, strings, some recycled papers, straws, etc. They explored the materials they got and tried to consider ideas about how to use those materials well. Kiernan was responsible for making the base and tower, and her partner for making pinwheel and filling out the worksheet.

On the last day of the mighty pinwheel machine activity, I interviewed Kiernan and found the following evidence.

November 13, 2003 (Interview)

Me: How was the mighty pinwheel activity?
Kiernan: It was hard because our mighty pinwheel machine wasn’t working. I liked building it, but didn’t like the testing as much.

Me: How does your mighty pinwheel machine work?
Kiernan: The pinwheel turns around and the string wraps around the tower. I mean when you
blow on the pinwheel, it takes the string up the rod.

Me: How many paperclips did you expect that your mighty pinwheel machine would hold?
Kiernan: 10
Me: How many paperclips did your mighty pinwheel machine hold?
Kiernan: 3

I found the following evidence that showed Kiernan and her partner collaboratively worked together to figure out how to hold the paperclips.

November 13, 2003 (Observation)
Kiernan and her partner, Linda, came back to their table. Linda wanted to take the basket out from the string. She explained to Kiernan the lighter it is the more it will hold. Kiernan wondered how to hold the paperclips without the basket. Linda tried to attach the lid of a plastic bottle and blow the pinwheel. But it didn’t even move. Linda and Kiernan came up to the recycling box set at the back corner of the classroom and asked Ms. C if they could use some materials in that box. They got
the film box, and tried it. But it didn’t work, either. They looked around to see how other groups were doing. At one point, Kiernan asked Linda, “How about the scotch tape?” Kiernan attached the tape around the string and tried to affix the paper clips on it. It worked.

Figure 5.9 shows the Kiernan’s final product of mighty pinwheel machine.

![Kiernan's final product](image.jpg)

Figure 5.9: Kiernan’s final product.

Another student, Regan, was a twelve year-old girl in the safety activity. Ms. C emphasized the significance of safety in the technology education
classroom. In one observation, I obtained the following evidence.

September 26, 2003 (Observation)
Ms. C set the five simple machine stations placing hand drills, clamps, saws, glue guns, and hammers, and asked the students to monitor each other while the partner practiced how to appropriately use the simple machines. After they finished rotating the five stations, they came back to their table and shared what they monitored with each other. They shared what behaviors met the safety rules and what other behaviors looked dangerous.

Figure 5.10 shows that Regan was wearing safety glasses while using the glue gun. Her partner was monitoring her behavior.
Analysis

The elementary school students learned the technology concepts and the engineering design processes through social interaction and collaboration. With respect to social interaction, the students worked in pairs to design, build, and test products. The Vygotskyan social constructivist standpoint is that children can always benefit from learning from other people. Wadsworth (1996) stated that
Social interaction and collaboration among children in school are essential for the development and learning of children. Social interaction is the source of learning cooperation as well as a source of cognitive conflict and disequilibrium. (p. 152)

As Wadsworth described, the students in the study learned the technology concepts and process through social interaction and collaboration. For instance, Mike and his partner had different points of view using the material, clay. Mike wanted to use it to clog the straw and his partner wanted to use it for affixing aluminum foil to straw. They tested Mike’s idea by floating one clogged straw and came to the conclusion to clog all of the straws. Negotiating and communicating between peers took place, and Mike’s idea became the group’s idea. According to Lewis, Petrina, and Hill (1998), “among the most important insights from constructivism is the issue of paying attention to students’ cognition and their interaction with each other” (p. 11). In addition, Wadsworth (1996) stated that “when students attempt to
communicate their points of view, tutors learn to clarify their thinking and tutees often experience cognitive conflict from being exposed to the views of peer tutors” (p. 153). Mike clarified his idea of why they had to clog the straws and his partner accepted Mike’s point of view.

In the evidence regarding Kiernan in the mighty pinwheel machine activity, she learned the technology concept of the properties of materials and the engineering design process through social interaction. Kiernan and her partner produced the design idea from the materials they got as they worked in groups. They shared their own design ideas and negotiated the final design. They used sketching and discourse to express their ideas. Brooks and Brooks (1999) stated that

One very powerful way students come to change or reinforce conception is through social discourse. Having an opportunity to present one’s own ideas, as well as being permitted to hear and reflect on the ideas of others, is an empowering experience. (p. 108)
As Brooks and Brooks noted, Kiernan and her partner presented their design idea by explaining the ideas and sketching it.

In relating communication with social interaction, drawing was one of the forms of communication. The students drew the initial sketch to conceptualize what they would like to build. As Kimbell, Stables, and Green (1996) noted, “sketching allows us to ‘talk through’ ideas with ourselves or with others. The language of technology is indisputably a concrete one—of images, symbols and models. Without this language it is just not possible to conceive of technological solutions” (p. 23). In addition, Mossman (1938) stated the importance of social language in the progress of students’ understanding. She stated that “The awareness of the self develops along with awareness of others and both develop with some form of language. The social processes seem to be the key to understanding human growth and learning, if one is to develop personality” (p. 54).

In the evidence regarding Regan, she learned the safety rules by monitoring her partner’s behaviors using the tools. As Herschbach (1998) stated,
When students work together in ways that foster cooperative learning, an additional source of feedback is provided. Students share knowledge, help each other to grasp important concepts, and monitor each other’s performance. (p. 53)

As Herschbach described, the students in the safety activity learned the safety rules through monitoring each other’s performance. The students used the tools as a mediator between the human hand and the object of action and experienced how to use simple machines and the function of those machines.

Wadsworth (1996) stated that

Fully accurate knowledge of physical objects cannot be acquired directly from reading, looking at pictures, or listening to what people say - these are all forms of symbolic representation - but only through actions on objects. Objects permit us to construct their properties only to the extent that we act on them. (p. 23)
In summary, the activities observed in this study tended to require students’ cooperation. Some students took on primary responsibility for design and construction, and others for evaluation and testing. On the other hand, the students in some groups took on the responsibility together for all the processes. The students learned the technology concepts and processes through the social interaction and collaboration.

What Elementary School Students’ Beliefs and Attitudes toward Technology and Technology Activities Were

As Jones (1997) noted, “It is crucial to explore teachers’ and students’ concepts of technology to understand the way these will influence the learning of technological concepts and processes” (p. 85). Students’ positive attitudes toward technology remain to influence their life and career decision (Boser et al., 1998). I explored students’ concepts of technology. The following excerpt shows how a fifth grade student conceptualizes technology.
**Evidence**

Ms. C asked students to write down the differences between science and technology. Table 5.1 shows Anna’s answers excerpted from her technology log.

<table>
<thead>
<tr>
<th>Science</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doing experiments</td>
<td>Making useful items</td>
</tr>
<tr>
<td>Hypothesis</td>
<td>Design</td>
</tr>
<tr>
<td>Laboratory</td>
<td>Working in groups</td>
</tr>
</tbody>
</table>

Table 5.1: Anna’s answers on the technology log.

Anna seemed to consider science as doing experiments with an hypothesis in a laboratory environment. On the other hand, she seemed to consider technology as making some useful item in a group work environment or design.

During the last week of technology class, I had a meeting with Anna to ask about how she conceptualizes technology and how she feels about technology education class.
June 10, 2003 (Interview)

Me: Could you tell me what technology means to you?

Anna: Working with materials and other tools to make and create useful items.

Me: What are useful items do you think?

Anna: Electricity and stuff like that.

Me: Do you think electricity is useful?

Anna: Yes (no hesitation).

Me: OK. Can I think your definition of technology is making useful items with materials and tools?

Anna: Yes (a short pause). Building things with our hands or making something that will change our world.

In summary, Anna was conceptualizing technology as making and building. I asked her what she thought about this technology education class.

June 10, 2003 (Interview)

Me: What do you think about this class?
Anna: (no hesitation) I like it. I like doing something I’ve never done before.

Me: Why do you like to learn with technology activities?

Anna: Because it makes me think of ways to work out problems in my mind.

Anna: I am able to do things quicker and easier.

The following excerpt shows another student, Beth’s answers regarding the differences between science and technology.

<table>
<thead>
<tr>
<th>Science</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural world</td>
<td>Tools</td>
</tr>
<tr>
<td>Experiments</td>
<td>Labor</td>
</tr>
<tr>
<td>Lab reports</td>
<td>Design</td>
</tr>
</tbody>
</table>

Table 5.2: Beth’s answers on the technology log.

Beth seemed to consider science as doing experiments in a lab and studying the natural world. On the other hand, she seemed to consider technology as designing and using tools and laboring.
The following interviews show how Beth conceptualizes technology.

June 11, 2003 (Interview)
Me: Could you tell me what technology means to you?
Beth: Exploring things and building new things that no one has ever seen before. Like invention
Me: What does invention mean?
Beth: It means advancement in everyday stuff.
Me: Do you mean technology means advancement?
Beth: If we did not have technology we would not have a lot of things that I like today like gameboy, trampoline, and books.

In sum, she was conceptualizing technology as invention. In addition, I asked her what she thought about this technology education class.

June 11, 2003 (Interview)
Me: What do you think about this class?
Beth: It’s going to be fun because I like computers and inventions and knowing how
things work and how they go together. I like to use my brain.

The following table shows another student, Rachael’s answers regarding the differences between science and technology.

<table>
<thead>
<tr>
<th>Science</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project</td>
<td>Design</td>
</tr>
<tr>
<td>Nature</td>
<td>Computer</td>
</tr>
<tr>
<td>Experiments</td>
<td></td>
</tr>
</tbody>
</table>

Table 5.3: Rachael’s answers on technology log.

Rachael seemed to consider science doing a project and studying nature. On the other hand, she considered technology as design and as computers.

The following excerpts show how Rachel conceptualizes technology.

June 12, 2003 (Interview)

Me: Could you tell me what technology means to you?

Me: Do you like them?
Rachael: I like using computers and making new things.

In sum, she was conceptualizing technology as new modern things. In addition, I asked her what she thought about this technology class.

June 12, 2003 (Interview)

Me: What do you think about this class?
Rachael: I think it’s cool. It helps me be a better computer person. I like to work with computers.

Analysis

With respect to the students’ beliefs and attitudes toward technology and technology activities, the students had a variety of concepts of technology; making, building, invention, design, computers, and so forth and seemed to have positive attitudes toward technology and
technology activities. In the context of the hands-on technology education activity, the students took pride in his or her unique contribution to the project and had a satisfying emotional experience. As LaPorte (2000) stated

Artifacts in the form of take home projects have been a part of the programs that preceded technology education for decades. Not only did these projects naturally lead to emotional involvement by the student; they served as artifacts of the learning experience that could be shared by others, engaging them in the emotion of the experience as well. When done successfully, they embodied the pride of their creator and exemplified accomplishment. (p. 83)

In addition, Zuga (1992) noted that attitudes about school, subjects, and learning “may be related to the quality of their experiences and affect the future quality of their experiences at school” (p. 199).
In sum, the elementary school students in this study conceptualized technology as making, building, invention, design, and computers, and perceived technology and technology activities as fun and exciting.

Summary

In this chapter, I presented the evidence of how elementary school students learned the technology concepts and processes as a result of technology education experiences, and what beliefs and attitudes they perceived toward technology and technology class. The findings revealed that the elementary school students learned the technology concepts and processes through a constructivist learning theory. They learned the technology concepts of transportation technology, the properties of materials, and stability of transportation and the technology process of engineering design process, invention process, and safety through the meaningful hands-on activity, problem solving process, design process, and social interaction and collaboration. In addition, the students had various concepts of technology such as making, building,
invention, design, and computers. They regarded technology as exciting and cool.
CHAPTER 6

SUMMARY AND IMPLICATIONS

In this chapter, I summarize findings related to elementary school students’ learning of technology concepts and processes as a result of technology education experiences. Following the summary, I discuss implications for educational practice and further research.

Summary

The purpose of this study was to investigate the value of technology education to elementary school students’ learning of technology concepts and processes as a result of technology education experiences.

As I observed and interviewed nine elementary school students in a Midwestern elementary school over a period of about five months, I was able to answer the
research questions of this study. Evidence indicated that elementary school students learned technology concepts and process in a constructivist learning context.

The summary includes the following three findings: (1) Elementary school students’ learning of technology concepts, (2) Elementary school students’ learning of technology processes, and (3) Elementary school students’ beliefs and attitudes toward technology and technology activities.

*Findings on Elementary School Students’ Learning of Technology Concepts*

The first research question of this study was how elementary school students learned technology concepts as a result of technology education experiences. Through observing and interviewing the students, I became aware of the fact that technology concepts were learned through hands-on activity, the problem solving process, and social interaction with peers. The elementary school students in the study learned the following technology concepts: properties of materials, transportation
technology, and recycling and environment as a result of technology education experiences.

**Technology Concept: Properties of Materials**

With respect to the technology concept of the properties of materials, firstly, elementary school students had a variety of experiences to select and use the materials for their projects and used a limited amount of recycled materials for each project. The students were able to identify appropriate materials for their project through selecting and handling the materials by themselves. They directly experienced the properties of materials by making and testing the products. Dunn and Larson (1990) stated that “direct experience allows the child to observe properties and functions of materials” (p. 8).

Learning of the technology concept, the properties of materials, could be summarized through three characteristics of the constructivist theory. First, through meaningful learning of hands-on activity, the students designed and made the models such as paper car and game board out of recycled materials. While working...
on materials, they gradually constructed understanding of the properties of materials.

Second, through problem solving process, the elementary school students explored the properties of materials. For instance, they met the challenge in building the paper car. They gained understanding of the properties of materials through solving the problems and making efficient transportation, a car. Dunn and Larson (1990) stated that “wise selection of materials and forms may solve particular design problems” (p. 40).

Third, the elementary school students gained understanding of the properties of materials through social interaction with peers. They were exposed to various materials and free to use those materials for each part of project. They had discourse with peers and selected the appropriate materials. Dunn and Larson (1990) stated that “selecting materials for a design is a fitting opportunity to engage children in discussion about their choices and conservation of resources” (p. 40). Table 6.1 shows the summary of how elementary school students learned the technology concept of the properties of materials.
The properties of materials

| Learning through meaningful hands-on activity | Designed and made the models such as a paper car, game board, barge, mighty pinwheel machine, and simple tools and 
| Learning through problem solving process | Explored and selected the materials to solve the design and building problems and 
| Learning through social interaction and collaboration | Understood the relationship between the properties of materials (strength) and the stability of transportation 
| | Engaged in discussion about selecting and using the materials. |

Table 6.1: Learning of the technology concept of properties of materials.

**Technology Concept: Transportation Technology**

Regarding the technology concept of transportation technology, the elementary school students gained understanding of transportation subsystems,
transportation efficiency, and stability of transportation.

Learning the technology concept of transportation technology in this study could be summarized as follows. First, through meaningful hands-on activity, the elementary school students were introduced to the paper car activity designed to address transportation technology that is a relatively familiar topic to the students. The students connected their experiences and knowledge to the paper car activity. For example, Rachael elicited the design idea of the paper car from her father’s real car, which has a trailer.

Second, through problem solving process, the students figured out the relationship of the concepts of the strength of materials and the efficiency of the transportation system.

Third, through social interaction with peers, the students collaboratively worked on designing, making, and testing the paper car. Table 6.2 shows the summary of how elementary school students learned the technology concept of transportation technology by participating in the paper car activity.
Table 6.2: Learning of the technology concept of transportation technology.

<table>
<thead>
<tr>
<th>Learning through meaningful hands-on activity</th>
<th>Transportation technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elicited the design idea of the paper car from the father’s real car and worked with manipulative materials rather than textbook.</td>
<td></td>
</tr>
<tr>
<td>Learning through problem solving process</td>
<td>Understood the relationship between a transportation system and its efficiency.</td>
</tr>
<tr>
<td>Learning through social interaction and collaboration</td>
<td>Worked in groups from the initial design to the final test.</td>
</tr>
</tbody>
</table>

Technology Concept: Recycling and Environment

The elementary school students in this study were introduced to the technology concept of recycling and environment. They were provided recycled materials for projects throughout the school year. Also, they learned the environmental issues and recycling in the game board activity.

Learning of the concept of recycling and environment could be summarized as follows. First, through meaningful hands-on activity, the elementary
school students created the game board about trash and garbage. For example, Anna and her partner modified the real Monopoly game to make a game board with recycled materials.

Second, through problem solving process, the game board activity required students to create the game board and introduced the concepts of recycling and environment. That was a challenge to them and they came to a conclusion introducing those concepts by modifying the real game board or creating a new one by themselves.

Third, through social interaction with peers, the students designed and created the game board. In addition, they played it with peers and gradually gained an understanding of the concepts of recycling and environment. Table 6.3 presents the summary of how elementary school students learned the technology concept of recycling and environment by the game board activity.
**Recycling and Environment**

| Learning through meaningful hands-on activity | Modified the real Monopoly game to make a game board and Worked with manipulative materials rather than a textbook |
| Learning through problem solving process | Needed to make the game board that introduces the concepts of recycling and environment |
| Learning through social interaction and collaboration | Worked in groups to design and create the game board. |

Table 6.3: Learning of the technology concept of recycling and environment.

**Findings on Elementary School Students’ Learning of Technology Processes**

The second research question of this study was about how elementary school students learned the technology processes as a result of technology education experiences. The elementary school students practiced technology processes: engineering design process and the invention process as a result of technology education experiences.
Technology Process: Engineering Design Process

With regard to the engineering design process, the elementary school students learned the engineering design process by participating in a hands-on activity, which was designed for the students to practice the process of engineering design. They became industrial designers, as well as, engineers. They designed, made, and tested the products.

Learning of the technology process, the engineering design process, could be summarized as follows. First, through meaningful learning hands-on activity, the elementary school students were introduced to the design projects such as a paper car, barge, mighty pinwheel machine, and so on. They went through the process of engineering design from design ideas to a final test.

Second, the elementary school students learned the engineering design process through problem solving process. From the beginning of the projects, they met the problems such as selecting the materials, solving the technical challenge of the products, improving the design, and so on.
Third, through social interaction and collaboration, the elementary school students learned the engineering design process. They worked in groups to make decisions of selecting and using the materials, modifying the design idea, making the products, testing the products, and so on. Table 6.4 depicts the summary of how elementary school students learned the technology process of engineering design.

<table>
<thead>
<tr>
<th>Engineering design process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning through meaningful hands-on activity</td>
</tr>
<tr>
<td>Were introduced to the design projects from design ideas to a final test through the paper car activity, barge activity, and mighty pinwheel machine activity.</td>
</tr>
<tr>
<td>Learning through problem solving process</td>
</tr>
<tr>
<td>Met the problems and challenges while making and testing the products.</td>
</tr>
<tr>
<td>Learning through social interaction and collaboration</td>
</tr>
<tr>
<td>Worked in groups from the beginning to the end of the projects.</td>
</tr>
</tbody>
</table>

Table 6.4: Learning of the technology process of engineering design process.
Technology Process: Invention Process

The elementary school students were asked to create useful tools for the real world. Ms. C encouraged them to take enough time to think about the real tool and its usefulness. The students creatively designed and created useful tools. They gave a presentation on their design ideas and explained why their inventive tools would be useful in front of their peers and teacher. They took questions from their peers and clarified their ideas while answering and sharing the ideas.

Learning of the technology process, the invention process, could be summarized as follows. First, through meaningful hands-on activity, the elementary school students learned the invention process. They created the hand tools to be useful in the real world. They were encouraged to improve the existing tools or invent a new one.

Second, the elementary school students learned the invention process through problem solving process. The invention project itself was the challenge to the students. They should improve or invent the hand tools.
Third, through social interaction, the students learned the invention process. They shared their initial design ideas with peers and Ms. C and got the approval from her. They clarified their ideas while explaining the invention ideas and answering the questions from the peers and Ms. C. Table 6.5 shows the summary of how elementary school students learned the technology process of invention.

<table>
<thead>
<tr>
<th>Invention process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning through meaningful hands-on activity</td>
</tr>
<tr>
<td>Learning through problem solving process</td>
</tr>
<tr>
<td>Learning through social interaction</td>
</tr>
</tbody>
</table>

Table 6.5: Learning of the technology process of invention process.
Findings on Elementary School Students’ Beliefs and Attitudes toward Technology and Technology Activities

With regard to the third research question of the study, elementary school students conceptualized technology as making, invention, new things, and computers. Their beliefs and attitudes toward technology and technology activities appeared to be positive.

Boser, Palmer, and Daugherty (1998) stated that “Students will experience a lifetime of technological change and adaptation, but hopefully positive attitudes developed through technology education will remain to influence life and career decisions” (p. 17).

Anna Beth Rachael

<table>
<thead>
<tr>
<th>Definition of technology</th>
<th>Anna</th>
<th>Beth</th>
<th>Rachael</th>
</tr>
</thead>
<tbody>
<tr>
<td>Making</td>
<td></td>
<td></td>
<td>New</td>
</tr>
<tr>
<td>Invention</td>
<td></td>
<td></td>
<td>Computer</td>
</tr>
<tr>
<td>New Computer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attitudes toward technology class</td>
<td>Like it..</td>
<td>It’s fun..</td>
<td>It’s cool...</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>It helps me be a better computer person.</td>
</tr>
<tr>
<td>Like/dislike technology activities</td>
<td>Was exciting. I like building and am good at it.</td>
<td>Was fun, the challenge was hard though. I love a challenge</td>
<td>Was exciting. It was kind of easy.</td>
</tr>
</tbody>
</table>

Table 6.6: Students’ concepts of technology and attitudes toward technology activities.
Table 6.6 is shown as a means of presenting different and similar facets of elementary school students’ concepts of technology and attitudes toward technology activities.

The findings of this study may be summarized as follows:

1. Technology education provides elementary school students with a constructivist learning context.

2. Elementary school students in this study learned technology concepts of the properties of materials, transportation technology, and recycling and environment through meaningful hands-on activity, problem solving process, and social interaction with peers and collaboration.

3. Elementary school students in this study learned technology processes of the engineering design process and the invention process through meaningful hands-on activity, problem solving process, and social interaction with peers and collaboration.

4. Elementary school students in this study learned the technology concepts and processes through self-
regulated learning process with minimal help from the teacher.

5. Elementary school students in this study conceptualized technology as making, invention, new things, and computers.

6. Elementary school students in this study perceived technology and technology activities as exciting and fun.

Conclusively, technology education in the elementary school is primarily based on a constructivist learning theory. The elementary school students are introduced to meaningful hands-on activities of technology education and encouraged to involve themselves in creative problem solving processes, and social interaction and collaboration. Therefore, based on the findings of this study, the value of technology education could be described as follows:

1. Provides the rich learning context in which elementary school students learn technology concepts and processes.
2. Facilitates elementary school students’ positive attitudes toward school experience
a. Allows elementary school students to create meaning.

b. Allows elementary school students to become excited about learning.

c. Allows elementary school students to learn actively rather than passively.

3. Serves as a mediator between practical and theoretical learning.
a. Allows elementary school students to relate personal real life experiences to school activities.

b. Allows elementary school students to relate theoretical knowledge (concepts) to practical knowledge (processes).

**Implications**

This section discusses the implications of this study in two subsections. The first subsection discusses the implications for educational practice and the second subsection describes the implications for further research.

**Implications for Educational Practice**

The initial reflection I had about Ms. C was of her confidence that she taught students’ valuable knowledge and facilitated students’ learning. As observed in this study, she provided the students with meaningful hands-on activities that encouraged students’ social interaction, collaboration, and higher thinking skills.
such as creative problem solving. The findings revealed that technology education provides a valuable learning context in which elementary school students construct new technology knowledge and skills. Elementary school teachers could consider including technology education activities in their curriculum to provide the students with a rich learning context.

Second, Ms. C’s viewpoints regarding technology teaching and learning are relatively congruent with a constructivist theory. The evidence obtained in this study indicated that hands-on learning, problem solving, and cooperative learning methods made the curriculum more effective. Elementary school teachers could consider bringing constructivist teaching ideas into their instruction through technology education activities.

Third, most of the students in this study learned the technology concepts and processes through self-regulated learning process with minimal teacher’s help. This often happened to the students participating in a hands-on activity based learning context. However, this study indicated that the students benefited from a
hands-on and student-centered activity itself. In order to enhance the students’ learning of technology, elementary school teachers could consider bringing the ideal teacher’s role as a facilitator into their instruction in teaching hands-on technology activities.

**Implications for Further Research**

Several findings in this study have implications for further research. First, little empirical research has been conducted to investigate the value of ESTE in practice. More qualitative and quantitative research should be conducted regarding the value of ESTE to students’ learning. From the evidence in this study, real-world related technology education activities could benefit students’ learning of technology concepts and process. More research-based information and evidence needs to be gathered regarding the value of real-world technology education activities to students’ learning of technology concepts and processes.

Second, ESTE may have a positive effect on students’ academic achievement. There has been limited research on the effects of ESTE on students’ academic
achievement and performance. It would be of interest to conduct a comparison study by using a standardized test to evaluate students’ achievement in an ESTE classroom compared to a non-ESTE classroom.

Third, the duplication of this study in different grade levels or other schools, where teachers are employing ESTE, is needed. The fifth and sixth grade students in this study encountered only a few technology concepts: the properties of materials, transportation technology, and recycling and environment due to time limitations. The study of different grade levels and of other technology concepts such as communication technology or construction technology may help to confirm the evidence found in this study.

Fourth, continued examination of students’ conceptual development of each technology concept and process should be explored. This may assist curriculum developers in the elementary education and technology education field to develop the curriculum.

Fifth, technology education in elementary schools is not as accepted as science, math, or language arts. Most of elementary school teachers are not comfortable
with teaching technology education and are limited by a lack of information on teaching technology. The research on what information elementary school teachers need to implement technology education should be conducted. This practical information may help reduce elementary school teacher’s efforts to implement technology education in their classroom and feel comfortable teaching technology education.

Conclusively, the purpose of this study was to investigate the value of technology education to elementary school students’ learning of technology concepts and processes. This study revealed the value of ESTE through the constructivist perspective. However, further research on the examination of the value of ESTE needs to be conducted to confirm the evidence found in this study.
LIST OF REFERENCES


APPENDIX A

HUMAN SUBJECTS APPROVAL LETTER
<table>
<thead>
<tr>
<th>Principal Investigator</th>
<th>Co-Investigator</th>
<th>Co-Investigator</th>
<th>Source of Funding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name: Karen F. Zuga</td>
<td>Name: Kyungsuk Park</td>
<td>Name:</td>
<td>None</td>
</tr>
<tr>
<td>University Title:</td>
<td>University Status:</td>
<td>University Status:</td>
<td></td>
</tr>
<tr>
<td>Professor</td>
<td>Faculty</td>
<td>Faculty</td>
<td></td>
</tr>
<tr>
<td>Associate Professor</td>
<td>Staff</td>
<td>Staff</td>
<td></td>
</tr>
<tr>
<td>Assistant Professor</td>
<td>Graduate Student</td>
<td>Graduate Student</td>
<td></td>
</tr>
<tr>
<td>Instructor</td>
<td>Undergraduate Student</td>
<td>Undergraduate Student</td>
<td></td>
</tr>
<tr>
<td>Other. Please specify.</td>
<td>Other. Please specify.</td>
<td>Other. Please specify.</td>
<td></td>
</tr>
<tr>
<td>Campus Address (room, building, street address):</td>
<td>Campus Address (room, building, street address) or Mailing Address:</td>
<td>Campus Address (room, building, street address) or Mailing Address:</td>
<td></td>
</tr>
<tr>
<td>1100 Kinnear Road, Suite 100 CAMPUS</td>
<td>681 Stark Court Columbus OH 43210</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zuga</td>
<td>Park</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date: 2/20/03</td>
<td>Date: 9/20/03</td>
<td>Date:</td>
<td></td>
</tr>
<tr>
<td>Signed:</td>
<td>Signed:</td>
<td>Signed:</td>
<td></td>
</tr>
<tr>
<td>Karen F. Zuga</td>
<td>Kyungsuk Park</td>
<td>Kyungsuk Park</td>
<td></td>
</tr>
<tr>
<td>1/27/03</td>
<td>9/20/03</td>
<td>9/20/03</td>
<td></td>
</tr>
</tbody>
</table>

Protocol Title: The value of technology education to gifted elementary school students’ understanding of technology concepts: A qualitative investigation of a constructivist perspective.

For Office Use Only

☐ Approved. Research has been determined to be exempt under these categories: __________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________
APPENDIX B

INFORMATION LETTER FOR PARENT/GUARDIAN
Dear Parent/Guardian:

We are writing to request your permission, and that of your child, to participate in a study titled "The value of technology education to elementary school students' learning of technology concepts and processes: A qualitative investigation of a constructivist perspective". This research has received the approval of Mr. , principal of School, and Ms. , a teacher.

We are interested in studying how elementary school students learn technology concepts and processes as a result of technology education experiences. Dr. Karen F. Zuga, a Professor in the Technology Education Program at The Ohio State University and Kyungsk Park, a Ph. D candidate in the Technology Education Program at The Ohio State University will be conducting this study.

This research requires no changes in the curriculum of Ms. 's classes. We will not give students extra assignments or be involved in determining their grade for the class. The whole class will be observed and taped on video and audio, but 3 – 5 students will be focusing on and be asked to participate in interviews about what they are learning through a technology education activity. Our involvement in the class will last from May to December, 2003.

The information gathered in this research will remain confidential. Students participating in this study will not be identified by name in any oral or published reports of the study. Pseudonyms will be used in all written documents resulting from this research for any individual named, the teacher, and the school in which this study is conducted.

Your child may withdraw from participation in the study without penalty by contacting any of the people listed below or Ms.
We will explain the purpose of this study to your child in a class and describe what their participation in the study might require. If you are willing to grant permission, and if your child is willing to participate, please sign the Student Agreement Form attached to this letter and return it to Ms. (initials) by the end of next week. It is necessary that both you and your child sign the form in the spaces indicated. If you have any questions about this study, feel free to contact Dr. Karen F. Zuga or Kyungsu Park at the phone numbers or e-mail addresses below.

Sincerely,

Karen F. Zuga, Ph.D.
1100 Kinnear Road, Suite 100
Columbus, OH 43212
614.292-7471
zugak1@osu.edu

Kyungsu Park, Ph.D. Candidate
1100 Kinnear Road, Suite 100
Columbus, OH 43212
614.292-7471
park.392@osu.edu
APPENDIX C

STUDENT AGREEMENT FORM
Student Agreement Form
School Students
2002–2003 Academic Year

Dr. Karen F. Zuga and Kyungsuk Park in the Technology Education Program at The Ohio State University are interested in studying how elementary school students learn technology concepts and processes as a result of technology education experiences. We invite you to participate in a study titled "The value of technology education to elementary school students' learning of technology concepts and processes: A qualitative investigation of a constructivist perspective".

In order for us to conduct this study, we would like to be in the classroom to observe lessons during your regular class. We may be talking to you and collecting videotape recording of your discussions as you participate in the technology activities Ms. has planned for you. We will not give you extra assignments or be involved in determining your grade for the class. Our involvement in the class will last from May to December, 2003.

We would very much appreciate your agreement to participate in this study. You may end your participation in the study at any time by telling any of the people listed below or Ms. , your teacher.

If you agree to be in the study, please sign your name on the left line below and ask your parent or guardian to sign on the right. This form should be returned to Ms. by the end of next week. If you have any questions about this study, feel free to contact Dr. Karen F. Zuga or Kyungsuk Park at the phone numbers or e-mail addresses below.

______________________       _______________________
Student’s Signature       Parent or Guardian’s Signature

Office of Academic Services: 614-292-2332
Integrated Teaching and Learning: 614-292-0135
Mathematics, Science, and Technology Education: 614-292-8785
Language, Literacy, and Culture: 614-292-0711 or 614-292-2445
Information for Parent or Guardians

- This study has the approval of Mr. , principal of School.
- No student will be identified in any documents or publications resulting from this study.
- The study will occur throughout the rest of the 2002 – 2003 academic year.
- We will evaluate no student for the purpose of assigning grades and we will not influence grades given by a teacher.
- A copy of the results of this study will be made available to School.
- Both signatures, from you and your child, are required.

Sincerely,

Karen F. Zuga, Ph.D.
1100 Kinnear Road, Suite 100
Columbus, OH 43212
614.292-7471
zugal@osu.edu

Kyungsook Park, Ph.D. Candidate
1100 Kinnear Road, Suite 100
Columbus, OH 43212
614.292-7471
park.392@osu.edu
APPENDIX D

SAMPLE OF FIELD NOTES TAKEN AFTER OBSERVATION
May 00, 2003 (Period 5)

The students have been working on the invention activity since May **. The students at Table D, one student was the participant of my study, were playing with small pieces of cardboard and looked bored. Today I could closely observe Table D since one of the participants of my study at Table G was absent.

I came by Table D and looked at their projects. They were still on the process of making invention tools. One student who was not a participant of my study was playing with wooden sticks and making a tower. But, his initial sketch was about the hammer having a soft head. He did not seem to care what he was supposed to do. He kept making the towers and breaking them down. I also noticed that he had a problem in writing. On the technology log on which he needed to draw the initial sketch and write the procedure of invention, he made many mistakes on spelling and even grammar.

The other student at the table D who is the participant of my study has looked excited to make an invention tool. He was proud of his invention idea when
he presented his initial sketch in front of peers and Ms. C. Ms. C complimented his idea. When I interview him two week ago, he had a clear explanation on his idea and showed his desire to make it.

But, today, he did not look excited any more. He was making a saw not working out of cardboard and taped the outside with masking tapes. I noticed that he met the challenge to make a sense to tell us the depth that the saw goes. He did not have supplies he needed for his project, gave up his initial invention idea, and made a saw out of paper. He did not want to keep working on his invention project.

I thought something blocked his growing creativity and invention ideas. The saw not working but looking a toy that he created made me think about the problems and challenge that the students might meet throughout the process of invention activity. “Was Ms. C supposed to let him change his initial invention idea when he presented his idea? Because Ms. C could not supply the sense.”

In fact, today I was frustrated in observing Table D. I thought the problems the students in Table D were
not from only their inability or laziness, but some from other factors.

Today’s observation made me consider what a teacher in technology education should provide as a facilitator and a helper. I also wondered what the students in Table D learned from the invention project.

I’m going to ask the participants of my study what they learn from the invention activity at next week’s interview.
APPENDIX E

SAMPLE OF FIELD NOTES TAKEN AFTER INTERVIEW
May 00, 2003 (Period 5)

Anna was the first interviewee. She has been so nice to me and was willing to be interviewed. We schedule the interview 20 minutes before the class since she told me it’s convenient time for her. We had an interview at the classroom. It was the lunch time so Ms. C was not at the classroom.

When the time for interviewing came I got a little bit nervous. I was worried about that I could not finish interview on time or I might not be able to ask the questions that I prepared asking.

She came a little bit late and explained the reason why she was late. I felt she was really sorry for me. She was quite ready to answer the questions. She started asking me “what are the questions I need to answer?” She was smiling at me.

When I started interviewing, no fear left as I was amazed at the flow of the interview and at the conversation with Anna. In fact, I asked all the questions I prepared and she sincerely answered.
I began the interview by asking her feeling about a paper car activity and then further asked about her understanding of the concepts of transportation technology.

What I felt from her answer was that she didn’t gain clear understanding of the technology concept of transportation technology. She just thought the paper car activity as a fun project. She seemed to pretty much enjoy designing and making the paper car, but did not have a chance to think about the function of the subsystems of transportation such as wheels and axles while participating in the activity. Even though I tried to get her answer that shows her understanding and learning of technology concept of transportation technology, she couldn’t answer well.

I thought Anna might need some help during the class to connect the design project of the paper car to the technology concept of transportation technology. Or she probably was not much encouraged to consider the technology concepts beyond designing and making the paper car.
Today’s interview with Anna was pretty good and made me think about effective instruction of elementary school technology education to help the students construct the learning of technology concepts by themselves.
APPENDIX F

INTERVIEW PROTOCOL USED WITH STUDENTS
Date: May and June, 2003

How do you feel about your paper car?

Where did you get your ideas (your design) from?

What kind of paper will make the best car?

What problems have you discovered about your car? What factors seems to affect how the car runs?

Tell me 2 - 3 suggestions for how the paper car could be improved.

What can you learn from other groups that might help you make better cars?

If you were building this car (chair) to carry (support) you, what material(s) would you build it out of and why?

Is this car stable? If not, explain how you would make it more stable.

How do the changes you have suggested make this car (chair) more stable?

How does the car work?

Could you tell me the definition for the word “Trash”?  
Could you tell me the definition for the word “Garbage”?  
Could you tell me the definition for the word “Recycling”?

Date: September, October, November, December, 2003

How do you feel about your barge activity?

Where did you get your design ideas from? (Barge)
What factors seem to affect how your barge floats?

How many pennies did you expect that your barge would hold?

How many pennies did your barge hold?

If you have one more chance to build a barge, how would you make it to hold as many pennies as possible? Tell me 2 ~ 3 suggestions for how your barge could be improved.

What did you learn through this barge activity?

If you were building this barge to support you, what material(s) would you build it out of? And why?

How do you feel about your pinwheel activity?

Did your pinwheel spin?

If your pinwheel didn’t spin well, what were the problems?

What did you do to solve the problems your pinwheel had?

Did your two pinwheels calibrate?

If your pinwheels didn’t calibrate, what were the problems?

What did you do to solve the problems your pinwheel had?

What can you learn from peers that might help you make better mighty pinwheel machine?

Tell me 2 ~ 3 suggestions for how your pinwheel machine could be improved.

How do you feel about your “Hand Tools Unit including hand tools flash card, 7 illustrations of safety rules,
creating a song, story, or poem, and design a hand tool” activity?

What was the main idea of your invention?

Where did you get your invention idea?
APPENDIX G

INTERVIEW PROTOCOL USED WITH TEACHER
Date: April, 2003 (On-line interview)

What is the objective of the fifth grade required class?

How are you going to teach students in fifth grade required class?

How are you going to evaluate students’ learning in fifth grade required class?

What is the objective of the fifth grade elective class?

How are you going to teach students in fifth grade elective class?

How are you going to evaluate students’ learning in fifth grade elective class?

What is the objective of the sixth grade elective class?

How are you going to teach students in sixth grade elective class?

How are you going to evaluate students’ learning in sixth grade elective class?

Date: July, 2003 (On-line interview)

How do you define technology teaching?

How do you define technology learning?

What do you consider to be the founding principles of teaching?
What are three to five of the most important things that you want your students to get out of your technology classes?
APPENDIX H

SAMPLES OF STUDENTS' WORKS
Grade: Fifth grade  
Activity: A paper car activity

<table>
<thead>
<tr>
<th>Sketch</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Sketch" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Final Product</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Final Product" /></td>
</tr>
</tbody>
</table>
Grade: Fifth grade
Activity: A Barge activity

Sketch

Final Product
Grade: Fifth grade  
Activity: A mighty pinwheel activity

<table>
<thead>
<tr>
<th>Sketch</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Sketch Image]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Final Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Final Product Image]</td>
</tr>
</tbody>
</table>
Grade: Sixth  
Activity: Invention activity

<table>
<thead>
<tr>
<th>Sketch</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Sketch Image" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Final Product</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image2" alt="Final Product Image" /></td>
</tr>
</tbody>
</table>