ATTITUDES TOWARD TECHNOLOGY AND DEVELOPMENT OF TECHNOLOGICAL LITERACY OF GIFTED AND TALENTED ELEMENTARY SCHOOL STUDENTS

DISSERTATION

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By

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ABSTRACT

Understanding how the universe works is fundamental to human nature, but needing to know has become essential for safely managing our future. It is our charge as educators to produce students with greater scientific and technological literacy and to encourage highly competent, ethically responsible young scientists and engineers. The International Technology Education Association urges the implementation of the Technology Content Standards in K-12 in all schools to ensure technological literacy for all students. Research is needed to explore ways to promote positive attitudes toward technology and develop technological literacy in all students.

The purpose of this study was to examine the use of specific technology activities and experiences in an elementary school classroom of gifted and talent fifth-grade students. A mixed methodology was used to explore the three primary research questions: (a) what are student attitudes and perceptions related to technology, (b) what are student attitudes and perceptions related to robotics, and (c) what student technological literacy outcomes are related to the use of technology education activities and experiences? Gender differences related to each of these primary research questions were also investigated.
A principal component analysis identified four subscales: Girls and Technology, Interest in Technology, Ability to Do Technology, and Value of Technology. In three of the four subscales, there were gender differences related to changes in student attitudes and perceptions. Girls perceived that girls were equally capable of participating in technology. Boys perceived that it required more ability to do technology and perceived less value related to technology. All students who engaged in technology education activities demonstrated more positive attitudes and perceptions related to interest in and value of technology compared to students without these activities. Girls also displayed more positive attitudes and perceptions related to robotics. Focus group interviews confirmed these findings and identified additional gender issues associated with roles and work habits. Both girls and boys demonstrated proficiency in the targeted Technology Content Standards and identified key technology features, including problem solving, programming, connections to mathematics and science, and teamwork.
Dedicated to my husband
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II. Special Area: Technology Education
TABLE OF CONTENTS

Abstract ........................................................................................................................................ ii
Dedication ...................................................................................................................................... iv
Acknowledgments .................................................................................................................. v
Vita ........................................................................................................................................ vii
List of Tables ........................................................................................................................ xii
List of Figures ........................................................................................................................ xv

Chapters:
1. Introduction ........................................................................................................................... 1
   Rationale for the study ......................................................... 11
   Statement of the problem .................................................. 15
   Research questions of the study ....................................... 17
   Data collection and analysis overview ............................ 18
   Assumptions of the study ................................................ 19
   Definition of terms .......................................................... 20
   Limitations of the study .................................................. 21

2. Review of the literature ....................................................................................................... 24
   Introduction .................................................................................. 24
   Historical background: Elementary school technology education (ESTE) ............................. 27
      European influence on practical education ....................... 27
      Early American efforts in elementary school technology education .................................. 29
   Constructivist pedagogy and elementary school technology education .................................. 36
      The philosophy of John Dewey ............................................. 36
      Children’s natural instincts .................................................. 36
      The role of work and play in the curriculum .................... 36
The meaning of the occupations and their implementation in an ESTE classroom............................ 39
Problem-based learning (PBL) ................................................... 42
Constructivism............................................................................. 44
Social reconstruction – the progressive perspective ...... 44
Constructivist ideas related to ESTE........................................ 48

A conceptual framework for elementary school technology education .................................................. 53
Contemporary understanding of the concept of technology.... 56
    Contemporary understanding of technology
    education: the British view .............................................. 57
    Contemporary understanding of education: the
    North American view .................................................... 58

A conceptual framework for technology education ...................... 60
Content standards for students in a technological world:
technology across the curriculum ............................................... 63
    The technological process ............................................. 67
    The design process ..................................................... 67
    Technological literacy ............................................... 68
    The technological method model ................................ 69
Contemporary understanding of elementary school technology education .............................................. 74
Impact of technology education on student outcomes................. 76
    Student attitudes and perceptions about technology.... 83
    Student conceptual understanding of technology ....... 99
Technology education and the educational needs of gifted students ................................................................................. 103
    Gifted female students .............................................. 109
    Gifted at-risk students ............................................ 110
Summary.................................................................................................. 111

3. Methods .............................................................................................................. 112

    Introduction.............................................................................................. 112
    Subjects of study...................................................................................... 112
    Context of study........................................................................................ 113
    Classroom procedures and timeline for technology education activities ........................................................................... 119
    Research design ........................................................................................ 132
        Rationale for a mixed methodology ................................................. 132
        Data collection and analysis ......................................................... 138
        Quantitative methodology ......................................................... 138
        Qualitative methodology ......................................................... 144
4. Results

Quantitative results

- Student Attitudes Toward Technology (SATT) survey
- “Robotics” semantic differential

Qualitative results

- Focus group interviews
- Technology education: gender roles
- Technology education: gender and work habits
- Technology education: student literacy outcomes

Observations of student performance related to technology content standards

Summary of results from the quantitative and qualitative data analysis

Quantitative results: attitudes and perceptions related to technology

Qualitative results: attitudes and perceptions related to technology and robotics

5. Conclusions and discussion

Research question 1: attitudes and perceptions related to technology

Girls and technology subscale

Interest in Technology subscale

Value of Technology subscale

Ability to Do Technology subscale

Research question 2: attitudes and perceptions related to robotics

Research question 3: technological literacy outcomes

Implications for classroom practice

Implications for future research

Summary

List of references
Appendices

A  Student Attitudes Toward Technology survey. ...................................................245
B  Recoded Student Attitudes Toward Technology survey.....................................248
C  Attitudes and perceptions related to robotics semantic differential............... 251
D  Recoded attitudes and perceptions related to robotics semantic differential....... 253
E  Observations of Student Performance Related to Technology Content Standards.............................................................................................................. 255
## LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>Research subjects</td>
</tr>
<tr>
<td>3.2</td>
<td>Technology standards related to TE activities and experiences</td>
</tr>
<tr>
<td>3.3</td>
<td>Instructional objectives and technology standards for LEGO DACTA® sets: gears, pulleys, and levers</td>
</tr>
<tr>
<td>3.4</td>
<td>Instructional objectives and technology standards for activity #2: View and discussion of the video <em>Robots</em></td>
</tr>
<tr>
<td>3.5</td>
<td>Instructional objectives and technology content standards for robotics in the classroom</td>
</tr>
<tr>
<td>3.6</td>
<td>Timeline of technology activities and experiences</td>
</tr>
<tr>
<td>3.7</td>
<td>Sample items from the instrument Student Attitudes Toward Technology</td>
</tr>
<tr>
<td>3.8</td>
<td>PATT-USA</td>
</tr>
<tr>
<td>3.9</td>
<td>Sample items from the semantic differential for robotics</td>
</tr>
<tr>
<td>3.10</td>
<td>Focus group interview questions</td>
</tr>
<tr>
<td>3.11</td>
<td>Sample items from student profile Observations of Student Performance Related to Technology Education Standards</td>
</tr>
<tr>
<td>3.12</td>
<td>Data collection and analysis summary</td>
</tr>
<tr>
<td>4.1</td>
<td>SATT principal components summary</td>
</tr>
<tr>
<td>4.2</td>
<td>Items loading on the Girls and Technology subscale</td>
</tr>
</tbody>
</table>
4.3 Items loading on the Interest in Technology subscale .................................................155
4.4 Items loading on the Ability to Do Technology subscale .........................................156
4.5 Items loading on the Value of Technology subscale ................................................158
4.6 Internal consistency reliability (Cronbach’s Alpha) for SATT subscales ..............159
4.7 Univariate analysis of variance with repeated measures for Value of Technology subscale by test time by gender .......................................................160
4.8 Means and standard deviations for the Value of Technology subscale by test time by gender ...........................................................................................................161
4.9 Univariate analysis of variance with repeated measures for Girls and Technology subscale by test time by gender .................................................................162
4.10 Means and standard deviations for the Girls and Technology subscale by test time by gender .........................................................................................................163
4.11 Univariate analysis of variance with repeated measures for Ability to Do Technology subscale by test time by gender .........................................................164
4.12 Means and standard deviations for the Ability to Do Technology subscale by test time by gender ..............................................................................................165
4.13 Univariate analysis of variance for Girls and Technology subscale by class by gender ...............................................................................................................167
4.14 Means and standard deviations for the Girls and Technology subscale by class by gender .........................................................................................................168
4.15 Univariate analysis of variance for Interest in Technology subscale by class by gender ...........................................................................................................169
4.16 Means and standard deviations for the Interest in Technology subscale by class by gender ..............................................................................................170
4.17 Univariate analysis of variance for Value of Technology subscale by class by gender ...........................................................................................................170
4.18 Means and standard deviations for the Value of Technology subscale by class by gender .........................................................................................................171
4.19 Internal consistency reliability (Cronbach’s alpha) for the pretest and posttest semantic differential to measure attitudes and perceptions related to robotics .................................................................172

4.20 Univariate analysis of variance with repeated measures for attitudes and perceptions related to robotics by test time by gender .................................................................173

4.21 Means and standard deviations for attitudes and perceptions related to robotics by test time by gender .....................................................................................................174

4.22 Summary of results ..................................................................................................................208

5.1 SATT Girls and Technology subscale compared to PATT-USA..............................................212

5.2 SATT Interest in Technology subscale compared to PATT-USA .............................................215

5.3 SATT Value of Technology subscale compared to PATT-USA .............................................217

5.4 SATT Ability to Do Technology subscale compared to PATT-USA ...............................220
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>A structure for the study of technology – The universals</td>
<td>73</td>
</tr>
<tr>
<td>4.1</td>
<td>Scree plot for posttest SATT</td>
<td>152</td>
</tr>
<tr>
<td>4.2</td>
<td>Test time by gender interaction for the Value of Technology subscale</td>
<td>161</td>
</tr>
<tr>
<td>4.3</td>
<td>Test time by gender interaction for the Girls and Technology subscale</td>
<td>163</td>
</tr>
<tr>
<td>4.4</td>
<td>Test time by gender interaction for the Ability to Do Technology subscale</td>
<td>165</td>
</tr>
<tr>
<td>4.5</td>
<td>Class by gender interaction for the Girls and Technology subscale</td>
<td>168</td>
</tr>
<tr>
<td>4.6</td>
<td>Test time by gender interaction for attitudes and perceptions related to robotics</td>
<td>174</td>
</tr>
<tr>
<td>4.7</td>
<td>Student performance profiles related to the technology content standards following technology education activities</td>
<td>198</td>
</tr>
<tr>
<td>4.8</td>
<td>Student performance profiles related to the technology content standards following technology education activities by gender</td>
<td>200</td>
</tr>
</tbody>
</table>
We've arranged a global civilization in which most crucial elements profoundly depend on science and technology. We have also arranged things so that almost no one understands science and technology. This is a prescription for disaster. (Sagan, 1996, p. 457). Dr. Sagan’s message is a plea to educators to dedicate ourselves to meeting the challenge of providing better public understanding of science and technology as a gift to the future.

Wanting to understand how the universe works is fundamental to human nature, but needing to know has become essential for safely managing our future. Our world today is so complex and rapidly changing wherein the impossibilities that seemed to be only in the realm of science fiction, such as the cloning of animals, becomes very real. Much of what we now know will be obsolete in just a few years. In just the past 20 years, our world has seen such remarkable changes. Computers were only used by scientists and engineers at universities; now more and more households in America have and use computers daily. The Internet was only an idea just a scant few years ago and DNA fingerprinting was just a hope in the minds of researchers (International Technology Education Association [ITEA], 1996). It is our charge as educators
to provide our students with greater scientific and technological literacy, and to encourage highly competent, ethically responsible young scientists and engineers.

Future engineers, scientists, and architects will undoubtedly study technology. Others may never learn much about technology if not in school, and since it is such an important force in our economy, anyone can benefit by being familiar with it. An entire country’s economic well-being may well be affected by how technologically literate its citizens are. In the complex world economy, since technology is responsible for almost all new products, the countries whose citizens are best versed in technology should have a competitive advantage. At the individual level, technology education helps consumers better assess products and make better buying decisions (ITEA, 2000).

Technology such as the Internet, genetic engineering, and cloning open up possibilities for humankind that have never existed before -- almost limitless access to information, the ability to engineer living organisms to our specifications, and the capability to make multiple identical copies of an animal or a human. This power will bring hard choices such as: Should there be limits on the flow of information? What should we do if we create an unwelcome new species? Should humans be cloned? Should carbon dioxide emissions be cut back sharply to attempt to slow down global warming?

Our world will definitely be different. We have no choice about that, but we do have a choice whether we go into it with our eyes open, deciding for ourselves how we want it to be, or whether we let it push us along ignorant and helpless to understand where we’re going or why. A technology education will make a difference for all the world’s citizens (ITEA, 1996).
The second millennium brings with it an imperative that challenges educators to engage students in authentic science and engineering activities, and lead them to current resources and experts in the field for the latest and most up-to-date information to answer their questions. Shirley Malcolm (1997), as head of the Directorate for Education and Human Resources Programs of the American Association for the Advancement of Science (AAAS), speaks to educators about this issue emphasizing that the “new generation of science means that we must both connect students to the questions that scientists bring and connect scientists to the questions that students bring” (p. 118). Neal Lane (1997), as Director of the National Science Foundation, addresses the need to explore the possibilities of new partnerships between research and education at the primary and secondary levels.

It is not clear how to do this successfully. But this is the only way we can expect to produce the finest scientists and engineers for the 21st century, raise the scientific and technological literacy of all Americans, and continue to lead all nations in scientific and technological progress. (p. 9)

The public understanding of the meaning of technology education (TE), particularly elementary school technology education (ESTE), remains an unclear concept for many, although authors in the field have supplied various definitions. The question has been raised whether or not technology is simply activity-based applied science or the result of research from science, technology, and society endeavors (Wright, 1999). In order to forge ahead in becoming a literate citizenry in science and technology, educators, students, and their parents need a clearer picture of the meaning of technology, one that illuminates their understanding of its place in the elementary school curriculum.
In *Technology for All Americans: A Rationale and Structure for the Study of Technology* (ITEA, 1996), technology is defined as “human innovation in action” (p. 16). Wright, Israel, and Lauda (1993) consider technology to be “a body of knowledge and actions, used by people, to extend the human potential for controlling and modifying the natural and human-made (modified) environments” (p. 3). Savage and Sterry (1990) view technology as “a body of knowledge and the systematic application of resources to produce outcomes in response to human needs and wants” (p. 7). Although the definitions for technology education may vary, a consistent thread runs through them that reflect the original conception of Industrial Arts posited by Bonser and Mossman (1923), perhaps as a precursor of TE, albeit more narrow in scope, i.e., “a study of the changes made by man in the forms of materials to increase their value, and of the problems of life related to these changes” (p. 5).

Wright (1999) presents a useful synthesis of the most accepted definitions of technology, one in line with this study, indicating that technology consists of

the knowledge, processes, and ingenuity that have enabled humans to conceive, design, and create tools and products as well as the systems that support them. Artifacts are made because people have needs or wants. They are made from a variety of materials, both natural and synthetic, dependent on their uses. They comprise the “built environment” in contrast to the “natural environment.” (p. 2)

Wright emphasizes that in today’s technology-based society, it is imperative that students understand this built environment -- its social and environmental impacts, consequences, and by-products -- as soon as they begin their school years.

In the *Technology for All Americans Project*, the ITEA (1996) states that the main goal for the field of technology education is to promote technological literacy. However, experts have had a difficult time coming to a consensus about what the concept of
technological literacy entails. As cited in Boser, Palmer, and Dougherty (1998), Dyrenfurth, Hatch, Jones, and Kozak explain technological literacy to be a multi-dimensional concept which includes the ability to use technology (the practical dimension), the ability to understand the complex issues raised by the use of technology (the civic dimension), and the appreciation for the role of technology in society (the cultural dimension). ITEA (1996) defines technological literacy as “the ability to use, manage, and understand technology” (p. 6).

To achieve the broad and encompassing goal of technological literacy for students, technology educators must prepare students to understand, control, and use technology (Boser et al., 1998). All students need to be able to adapt to the changes brought about by technology, identify and solve problems, and make appropriate decisions to deal with the various forces that have the potential to influence and control their lives and futures (Waetjen, 1985; Wright, 1999). A vision for what students need to know and are expected to do in order to be technologically literate is being shaped by educators and professionals. Educators need to provide and sustain a relevant education for students who are now living in a technological world. The International Technology Education Association (ITEA, 2000) is urging the implementation of the Technology Content Standards in K-12 in all schools to ensure technological literacy for all students. It is clear that they recommend technology education should be recognized as an essential core field of study in the schools.

In his summary of the conference themes and papers of the PATT9 conference, de Vries (1999) recants the recent claims of technology researchers and educators who advocate technology education as the core subject of the school curriculum that integrates
the knowledge and skills from the other content areas. These claims emphasize the importance of teaching technology to all future citizens, since technology is the basis of our modern economy and because people living in a modern technological society need to become technologically literate citizens. Technology education would bring this essential literacy to all students.

However, the field of technology education needs to conduct research to explore the evidence of the benefits of elementary school technology education (Foster, 1997a). Johnson and Liu (2000) reported little research has been conducted on students’ conceptual understanding of technology as a result of learning in a technology education class or course. Zuga (1997) suggests that researchers need to address what the value of technology education is, what outcomes children attain from technology education, and how to ease its implementation in the classroom.

Meanwhile, many paradigms for teaching technology education are being recommended. Some authors such as Gloeckner (1990) and Thode (1989) suggest that self-paced modular instruction best accommodates diversity in learning styles and learning levels. Others recommend an interdisciplinary approach that shows students the connection between mathematics, science, technology, social studies, and English (Illinois State Board of Education, 1992; Wicklein et al., 1991). Problem-based instruction is suggested by DeLuca (1992) and James (1991) as an authentic way to develop student higher-level cognition. Regardless of the techniques chosen for instruction, the main goal for technology education is to produce technologically literate citizens (ITEA, 1996). Like other literacy efforts, such as language literacy and
numeracy, technological literacy will require knowledge and practice over time (Boser et al., 1998).

While the concept of technological literacy has been a difficult one to define operationally or attempt to measure (Boser et al., 1998), various researchers have described techniques they have tried to observe gains in students’ technological literacy. Variations on the portfolio method have been used, since there is no widely accepted standardized instrument to assess the broad scope of technology education. As reported by Boser et al., Daiber, Litherland, and Thode described analyzing one-on-one and focus group discussions with similar topics at the beginning and end of a specific technology education course or program. They observed student involvement during problem-solving activities, evaluated the results of hands-on activities, used pencil and paper exercises in a pretest/posttest design, and developed a technology achievement test that included the main objectives of the course.

The British technological literacy framework for teachers to assess the performance of their students in design and technology programs includes the following criteria asking teachers to (a) indicate clearly what a student needs to do to complete the work; (b) encourage students to be more interested in the constructive feedback about assignments rather than the grade; (c) acknowledge strengths and identify weaknesses so students become aware of what they need to focus on to make progress; (d) engage students in meaningful activities; (e) use appropriate modes of working such as group work; (f) refrain from using examinations because they fail to mirror real-life situations; (g) refrain from using short-term memory recall since it is not deemed an important aspect of technological capability; (h) measure students’ ability to engage in very specific
activities; and (i) give students opportunity to work on longer tasks that demonstrate their ability to research, communicate, and analyze (Ager, 1992). This framework suggests that teachers, who have worked with students for long periods of time, can most accurately assess the technological capability of the individuals. These assessment methods use a formative assessment strategy which is very time consuming and limited to the content and concepts of the specific curriculum (Boser et al., 1998).

As an alternative, some researchers have used the affective domain from which to select measures to assess student technological literacy (Ager, 1992; Bame, Dugger, Jr., de Vries, & McBee, 1993; Raat & de Vries, 1986). Historically, instruments designed to measure cognitive objectives have been favored in the educational arena over those that measure affective objectives. However, new evidence challenges this position that is based upon the belief that personality characteristics develop relatively slowly and can only be appraised over long periods of time. Popham (1994) suggests that affective behaviors are subject to much more sudden transformations than cognitive behaviors. According to Krathwohl, Bloom, and Bertram (1964), students with a positive attitude toward a subject are more often engaged in active learning both during and after instruction. Accordingly, if they exhibit a positive attitude toward technology, they will be more likely to attain technological literacy through technology instruction (Bame et al., 1993).

Raat and de Vries (1985) developed an instrument to investigate the attitudes of middle school students toward technology called the Pupils’ Attitudes Towards Technology (PATT). The instrument was used to determine students’ attitudes toward and conceptual understanding of technology in order to develop course materials in a
physics curriculum that could apply technological concepts and practices. The conclusions they drew were that students had a vague understanding of the concept of technology; students, particularly girls, had a very obscure understanding of the relationship between physics and technology; and that girls are less interested in technology and deem it less important than boys.

In order to assess middle and junior high school student attitudes toward and conceptual understanding of technology, Bame and Dugger, Jr. (1989) revised, tested, and validated the PATT questionnaire to use in the United States (PATT-USA). Bame et al. (1993) administered the PATT-USA to 10,000 thirteen- and fifteen-year-old students enrolled in technology education/industrial arts classes in seven states. Their hope was that the PATT-USA could measure attitudinal changes in perceptions toward technology which might be linked to enhancing technological literacy.

The five subscales of the PATT – USA that measure attitudes and perceptions include: (a) general interest in technology, (b) attitude toward technology, (c) technology as an activity for boys and girls, (d) consequences of technology, and (e) technology is difficult. The subscale items measuring conceptual understanding of technology relate to students’ understanding of the impact of technology in shaping the world. Findings from the PATT-USA study indicate age and gender differences in students’ interest in and perceptions of technology. Findings show attitudinal influences related to parental professions and home experiences. Results indicate attitudinal differences exist between students who have experienced technology classes and those who have not. Also, student conceptual understanding of technology and its importance differed between students in the United States and other industrial countries.
With no accepted or standardized cognitive measures of technological literacy, Boser et al. (1998) initiated research using the PATT-USA, as a standardized attitude measure, to see if it would provide insight into effective teaching approaches to positively affect students’ attitude toward technology. Supported by research from the affective domain, Boser et al. hypothesized that students who have a positive experience in a technology education program will develop a positive attitude toward technology and that a positive attitude toward technology would lead to interest in studying about technology and interest in pursuing technological careers. Consequently, students would become more technologically literate. “The attitude measure may then be one indicator of effective teaching approaches for technology education” (Boser et al., 1998, p. 4).

Boser et al. (1998) examined four instructional approaches used in technology education: (a) industrial arts approach, (b) integrated approach, (c) modular approach, and (d) problem solving approach. Their data indicated that after a 9-week instructional period, in three of the four approaches, responses of girls and boys were significantly different on three of the five attitude subscales. Students’ interest in technology was not altered significantly, but boys were more positive than girls. Students’ belief in the difficulty in working with and studying technology was reduced, but boys were more positive than girls. Girls had more positive attitudes toward technology as an activity for both boys and girls. Students in the study expressed narrow concepts or misconceptions of what technology entailed on the pretests and posttests. There were no positive changes in students’ technological literacy as measured by the Concept of Technology subscale. There was no clear direction of change in student attitudes that could be attributed to an
instructional approach. Lastly, students’ attitudes toward technology and their concept of technology were in line with other PATT and PATT-USA studies.

Although some change in attitude was observed, the data did not provide evidence of a significant change in students’ Concept of Technology that would point to increased levels of technological literacy. The researchers (Boser et al., 1998) suggest that the treatment period could have been too short or the instrument might need to be tailored to the specific curriculum to be useful. They encourage further assessment in the affective domain that would measure attitude changes attributable to a particular instructional method or curriculum. They maintain that attitude measures may demonstrate some correlation with technological literacy eventually, but the profession needs to develop an acceptable procedure or instrument that will measure students’ technological literacy. Finally, they suggest that the field needs to develop curriculum materials and activities that will foster the interest and technological needs of girls as well as boys.

Rationale for the Study

The rationale for the current study focusing upon elementary school technology education (ESTE) is supported by the literature. There is a scant amount of research conducted in the area of ESTE (Foster, 1997b; Zuga, 1997). Researchers need to address this deficiency in research and build a body of knowledge that can serve as groundwork for testing the significance of particular methods and strategies in teaching technology. Zuga (1997) and Downs (1974) established a database of doctoral, master’s, and non-degree research related to ESTE through 1993. The classified studies fell into two major categories of curriculum and student achievement. Zuga found that many studies in the
curriculum area were status studies providing historical information or benchmarks of the profession. The curriculum research was limited in its value for today’s researchers and curriculum developers since they were limited to specific points of time of public school practice and teacher training programs.

Indeed, several authors in the ESTE literature have suggested the need for research studies identifying the value of technology education, the benefits students derive, and what can be done to facilitate the implementation of technology education (Brusic, 1997; Foster, 1997b; Wright, 1999; Zuga, 1997). Foster said the field is in need of a clear research agenda, and offered one based upon the preferences of selected leaders and researchers. His agenda paralleled that of Zuga, both of them viewing technological literacy and effectiveness of instructional techniques as top research priorities.

The direction of this research is in line with the research agenda recommended by leaders in the field of technology education. The American Association for the Advancement of Science Technology Education Research Conference (AAAS, 1999) brought together 35 scholars and researchers from science education, technology education, and cognitive science to discuss the research agenda for technology education. The papers presented by conference participants reflect on the issues of research in technology education. Although a tremendous amount of research is needed and the researchers are few, the participants proposed recommendations for a research agenda that will improve the efforts of technology education. They recommend research that identifies how students learn the key ideas and skills that are necessary for technological literacy, as identified in the Standards for Technological Literacy: Content for the Study of Technology (ITEA, 2000). They suggested that research is needed to assist teachers in
using effective instruction. Research is needed that explores how specific curriculum materials and classroom instruction actually promote student learning of ideas and skills that have been identified for technological literacy.

The Second AAAS Technology Education Research Conference (AAAS, 2001) continued the discussion building upon the high-priority research issues identified at the first conference. Researchers from across the globe came together to promote research on how students learn the ideas and skills identified for technology education, and to discuss research priorities and the conditions needed to establish a coherent and productive research agenda for the field. The proceedings of the two conferences are published online by Project 2061, the science education reform initiative of AAAS (http://www.project2061.org/meetings/technology/default.htm).

A series of conferences entitled Pupils’ Attitudes Towards Technology (PATT) have been held around the world, supported by an international organization based in the Netherlands that promotes research in technology. There have been 14 PATT conferences providing an international forum for the discussion of issues, research, and development related to the global promotion of technological literacy. The PATT conferences are often held in conjunction with the ITEA Annual Conferences. The proceedings of the PATT conferences include papers from leaders in the field of technology education. PATT conference proceedings can be found online at http://www.iteawww.org/D4c.html.

The rationale of this study is additionally supported because there has been very little research on technology education using either quantitative or qualitative research methods (Wright, 1999). He recommends research that includes qualitative methods or a
mixed methodology of quantitative and qualitative methods. A mixed methodology may reveal considerable insight related to the benefits and effects of using technology education with elementary school students.

Another rationale for this research lies in Welty’s (1999) suggestion that future research needs to focus on how teachers can best use their precious time to engage young people in journeys (engaging activities) that reach predetermined destinations (the attainment of standards). Welty says that research should focus on what students are learning from rich technological activities and how students learn the deep understandings and essential skills for technological literacy. Similarly, at the AAAS Technology Education Research Conference, Kolodner (2001) encouraged technology education researchers to consider Ann Brown’s research model on design experiments.

Brown (1992) emphasized that learning scientists should strive to conduct research that attempts to establish innovative educational environments while conducting experimental studies of those innovations, referred to as design experiments. Other experts are urging research that will help educators understand how best to introduce learning environments that use a problem-solving approach to teach technology and how those learning environments can help students excel in technological processes, such as planning, designing, constructing, programming, testing, redesigning, and evaluating (Crismond, 2001; Lee, 1996).

Finally, this study is supported by the need to understand the value of technology from the student’s point of view. In our quest to reach the goal of developing technological literacy for all, researchers need to examine students’ attitudes and perceptions. Zuga (1984, 1989) discusses that elementary school technology education is
not simply providing hands-on/minds-on activities for students. Rather, it is a program that engages students in the development of their curriculum. That is, it begins with where the student is in his/her understanding of a concept. It is a student-centered approach based on fostering a learning environment in which students can question, discover, explore materials, create, and evaluate. The curriculum becomes personally relevant for the student. Context gives meaning to school knowledge and work is important for technology in the real world.

While research on student attitudes toward technology education has been conducted (for example, Bame & Dugger, Jr., 1989; Bame et al., 1993; Becker & Maunsaiyat, 2002; Boser et al., 1998; Doppelt & Barak, 1999; Raat & de Vries, 1985; Volk, 1999; and Volk, Yip, & Lo, 2003), research is needed to assess changes in attitude as the result of students’ participation in a technology education program. Since teachers use such a wide range of instructional methods and techniques to deliver technology education, it is important to explore student attitudes toward and development of technological literacy in the context of specific technology education activities and experiences.

Statement of the Problem

This study is designed to address the lack of information in the literature on how to create a technology-rich learning environment in the elementary school classroom. The intent of this environment is to engage children in authentic, real-world problem-solving and provide opportunities for students to access science and engineering experts in the field for the latest and most current information related to their questions to
promote positive attitudes toward and greater understanding of technological literacy.

Wright (1999) points 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)

Although the Standards for Technological Literacy: Content for the Study of Technology (ITEA, 2000) has been disseminated, research is needed to indicate the type of educational activities that will enable teachers in the classroom to meet the technology content standards. Teachers need to know how to connect the standards with what they teach. They need to know the type of educational activities and experiences that could be used to ensure student development of technological literacy.

The purpose of this study is to explore the relationship between the use of technology education activities and experiences and affective and cognitive outcomes related to technological literacy of gifted and talented fifth-grade students. The affective and cognitive outcomes are based upon the Technology Content Standards (ITEA, 2000). Examples of the technology education activities and experiences include Wright Patterson Air Force Base Robotics in the Classroom and FIRST™ LEGO® League Robotics Challenge.

The current study is modeled on research synthesized from the studies of Bame et al. (1993) and Boser et al. (1998). These studies reflect research efforts to assess and compare various instructional strategies in technology education, despite the lack of standardized measures of technological literacy. Since assessing students’ cognitive ability resulting from various instructional approaches is difficult, measuring students’
attitudes toward technology may reveal the teaching approaches that relate to positive attitudes toward technology. Based upon the posited link between positive attitudes and improving cognitive outcomes, assessment in the affective domain of attitude change may indicate instructional methods that may be effective in developing technological literacy. Moreover, developing a student profile related to technology education outcomes may provide a tool to identify cognitive outcomes.Hopefully, this study will add to the body of knowledge about developing technological literacy in an elementary school classroom and will serve to enlighten technology education teachers about their own teaching practice.

Research Questions of the Study

The specific questions to be addressed in this study are:

1. What are the attitudes and perceptions related to technology of gifted and talented fifth-grade students in an elementary school classroom? Are there gender differences in student attitudes and perceptions related to technology?

2. What are the attitudes and perceptions related to robotics of gifted and talented fifth-grade students in an elementary school classroom? Are there gender differences in attitudes and perceptions related to robotics?

3. What technological literacy outcomes of gifted and talented fifth-grade students in an elementary school classroom are related to the use of
technology education activities and experiences? Are there gender differences in student technological literacy outcomes?

Data Collection and Analysis Overview

This investigation is framed within a mixed methodological research perspective of both quantitative and qualitative procedures. Two quantitative instruments were used to collect data from gifted and talented fifth-grade students in a self-contained elementary school classroom who engaged in technology education activities and experiences. First a Likert-type survey, Student Attitudes Toward Technology (SATT), was administered using a pretest and posttest design to assess students’ attitudes and perceptions related to technology and to assess students’ conceptual understanding of technology. Secondly, students were asked to respond to a pretest and posttest semantic differential to identify student attitudes and perceptions related to “Robotics.”

Using qualitative interview methods, students were asked to participate in focus group discussions related to robotics and technology education activities and experiences. Focus group interviews included questions to reflect the three primary research questions as well as potential gender differences. A profile, Observations of Student Performance Related to Technology Content Standards, was developed to identify student literacy outcomes related to the technology content standards, and to create a student profile of technological literacy developed during the technology education activities and experiences.

Posttest data related to the SATT was also collected from students in another gifted and talented fifth-grade classroom, a regular fifth-grade classroom, two gifted and
talented fourth-grade classrooms, and a regular fourth-grade classroom. None of these students had engaged in technology education activities and experiences.

Statistical procedures using the Statistical Program for the Social Sciences (SPSS Version 12.0 for MS Windows) were used to analyze responses to the Student Attitudes Toward Technology (SATT) survey and the semantic differential to measure attitudes and perceptions related to robotics. For the SATT, the following statistical procedures were computed: (a) principal component analysis, (b) reliabilities, (c) multivariate analysis of variance, and (d) univariate analyses of variance. For the “Robotics” semantic differential the following statistical procedures were computed: (a) reliabilities and (b) univariate analysis of variance.

Qualitative procedures, including systematic coding and categorization via content analysis and ethnographic summary, were used to analyze student responses to the focus group interview questions. Student profile scores based on the Observations of Student Performance Related to Technology Content Standards were aggregated and averaged across students and by gender.

Assumptions of the Study

Several assumptions are made that frame this study. Students are excited and intrigued about their learning when they feel that they are in touch with worthwhile endeavors. They learn more when they feel their learning is making an impact or is valuable to society in some way. If students tend to act positively toward a subject such as technology or robotics projects, they will have more of an interest in that subject (Bame et al., 1993; Popham, 1994). Technological activities and experiences can provide
a useful vehicle to develop technological literacy and can be easily incorporated into a teacher’s repertoire of teaching/learning strategies.

**Definition of Terms**

The purpose of this section is to define and clarify terms used in this study. Some of these terms mean different things to different people. The operational definitions shown here are meanings specific to this research.

**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. (Bentley & Watts, 1994, p. 8)

**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).

**Elementary School Technology Education (ESTE)** 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, 1999, p.4).

**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” (ITEA, 2000, p. 242).

Technology Content Standard is “a written statement that specifies the knowledge (what students should know) and process (what students should be able to do) students should possess in order to be technologically literate” (ITEA, 2000, p. 242).

Technological Design (Engineering Design) is “the systematic and creative application of scientific and mathematical principles to practical ends such as the design, manufacture, and operation of efficient and economical structures, machines, processes, and systems” (ITEA, 2000, p. 238).

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” (ITEA, 2000, p. 242).

Technological Literacy is “the ability to use, manage, understand and assess technology” (ITEA, 2000, p. 242).

Limitations of the Study

This study has several limitations. In this design, history is one of the uncontrolled rival hypotheses, as any changes may be due to events that occurred between the administrative times of the pretest and the posttest in addition to the classroom “treatment” activities. The variable of time threatens the internal validity of this study since the pretest and posttest were administered at the beginning and the end of the school year, respectively. The longer the time that elapses between the two
observations, and the more participants for which specific events happen collectively, the more plausible history becomes a rival hypothesis (Campbell & Stanley, 1963).

Other rival hypotheses include the participants maturing (physically or psychologically) between the pretest and posttest, or possibly the participants responding more favorably on the posttest as a result of taking the pretest (testing). If the participants scored atypically on the pretest, they may have regressed toward the mean naturally (statistical regression), without any influence of the treatment (Huck & Cormier, 1996). The student samples were not randomly selected. The samples were convenience samples from individual self-contained classrooms. The context of the study involves one school and one school district in which only a relatively narrow range of socioeconomic conditions is represented along with little ethnic diversity.

The context of the study is limited to the use of a specific set of technology education activities and experiences with students who are identified with superior cognitive ability by state standards (i.e., gifted and talented) and whose daily instruction is within a fifth-grade self-contained elementary classroom. Since the study does not meet representativeness criteria, it is in essence, a test of statistical interaction. The teacher of the students is also the researcher/educator in the field of ESTE as well as gifted education. The findings are limited to the experiences of these students and readers are cautioned to view findings as limited to this specific classroom situation, transferring only what is useful to their situations. Therefore, the results from the study can not be generalized beyond the persons, time, and setting of the study.

The review of the literature in Chapter 2 provides a brief historical backdrop for the development of elementary school technology education, the fundamental
philosophies and pedagogies that support it, and a conceptual framework that defines it. An overview of the standards is presented as well as research on technology education and on student affective and cognitive outcomes related to the technology content standards. Finally, literature related to technology education and gifted and talented students is reviewed. Throughout the literature review, gender differences are identified.
CHAPTER 2

REVIEW OF THE LITERATURE

Introduction

Technology is certainly reshaping our society and will be pushing it for the rest of the history of mankind. Moreover, the technological revolution has wrought changes in our children (Strommen & Lincoln, 1992). They are raised in a world of instant accessibility to knowledge, and in a world where vivid images supply information formerly presented only through text. Although they are accustomed to an environment in which they can control the flow and access of information (e.g., TV remote controls, video game controllers, computer mice, cell phones), the educational environment students encounter daily is dramatically dated. This has caused a significant rift between the interactive ways children learn within the home and in society at large and in the teaching and learning that goes on at school (David, 1990; Kolderie, 1990), producing estrangement of the schools from society and its children. The negative impact on children is pronounced as they are caught awkwardly between moving toward the future while their educational institutions are locked in rigid, uninteresting, and even alienating ways of the past (Strommen & Lincoln). Soloway (1991) proposes that drastic reform in
American education is needed to resolve this divergence between students and schools so that children are empowered to embrace the future.

All people must be technologically literate to some degree; that is, understanding what technology is, how it is developed, how it is used, and how it affects and is affected by the society as a whole so that we may understand our modern world and be able to function adequately in it (ITEA, 1996; Raizen, Sellwood, Todd & Vickers, 1995. The best place to get those lessons is in the primary and secondary schools, in conjunction with the other learning that prepares a student for life as an adult (ITEA). In fact, understanding technology and its impacts and consequences should start as soon as students begin school and continue throughout their elementary education, to provide a necessary foundation for developing technological literacy (Wright, 1999).

Experts are recommending putting technology education in our schools -- experts from the American Association for the Advancement of Science, the National Science Foundation, and the National Aeronautics and Space Administration -- and they agree about the value and importance of teaching about technology (American Association for the Advancement of Science [AAAS], 1990; ITEA, 1996; National Aeronautics and Space Administration [NASA], 2004). Yet, still only a few school districts have a complete technology education program in place, and only a handful of states have developed content standards. Students are graduating with little or no understanding of the most powerful force shaping society today. The back-to-basics push emphasizes competency in traditional courses, but technology education has never been a basic part of education. The growing emphasis on standardized competency tests has encouraged educators to teach to those tests, which have few substantial questions to gauge
technological literacy. Schools see technology education as a luxury, and really less important. To many, it is a new field evolved from the old industrial arts programs devoted to woodworking, metalworking, and drafting. True technology education has little to do with industrial arts, but it has not established itself as a field of study yet in the public eye (ITEA, 1996).

Some say technology is little more than applied science, but science is the study of the natural world; technology is the creation of a human-made world (Wright, 1999). Scientific thinking is reductionist, reducing a problem to its component parts and analyzing each separately; technological thinking is holistic, constantly focused on how the different pieces interact. The philosophical basis for science is realism, that is, the belief that the world has an underlying reality; the philosophical basis for technology is pragmatism rooted not in any ultimate reality, but in what works. Science searches for absolute answers, things that are true and independent of any human desires or beliefs; technology involves a choice among many possible answers, with human values often a part of the equation.

In keeping with the goals of this study to evaluate instructional materials that may develop elementary school student outcomes related to technological literacy, this literature review will examine: (a) historical background of elementary school technology education (ESTE), (b) constructivist pedagogy and ESTE, (c) conceptual framework for ESTE, (d) characteristics and educational needs of gifted students, and (e) student attitudes and perceptions about technology.
Historical Background: Elementary School Technology Education (ESTE)

*European Influence on Practical Education*

Nelson (1981) traces the early influences of elementary school industrial arts back to the educational philosophies and practices of several European countries. Comenius, Rousseau, Pestalozzi, and Froebel, western educational philosophers of their time, promoted the development of cultural industrial education and elementary school industrial arts (Hostetter, 1974; Mossman, 1924).

An educational writer of the 17th century, Comenius initiated the sense-realism movement, a practical method of education emphasizing the importance of a cultural and objective education. He described the impact of using familiar pictures and objects on the development of student language (Bennett, 1937; Nelson, 1981). He demonstrated the power of graphic representation in his book, *Orbis Pictus*, which was the first illustrated textbook for children. Bennett reflecting Comenius’ view states “Children learn as much as possible not from books, but from the great book of nature, from heaven and earth, from oaks and beeches” (p. 36). Bennett goes on to say that “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).

Swiss-French philosopher of the 18th century and author of *Emile*, Rousseau thought that learning is best accomplished by doing, and that experiencing activity in a natural environment trains the senses (Concise Columbia Encyclopedia, 1991). To develop the whole child, he emphasized that children’s learning environments should provide a great deal of time to manipulate three-dimensional materials, and use tools, drawing, and music. He believed children should have ample experience in this type of
learning environment before ever being presented with learning from books (Bennett, 1937).

In the 19th century, Pestalozzi established an industrial school for orphans and children from poverty-stricken families, and became known as the father of manual training. He believed that doing led to knowing, and stressed the importance for learning to follow the practical experience that comes from involvement with things. His instructional methods for children emphasized using objects to motivate the students by appealing first to their senses, followed by stimulating their minds (Bennett, 1937). Mossman (1924) considered him to be the main advocate of object teaching that stressed students’ involvement in manipulative activities.

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. (Nelson, 1981, pp. 26-27)

Froebel, the founder of kindergarten in the 19th century, stressed the importance of fostering children’s growth and development through using many three-dimensional materials. Bennett (1937) reports Froebel was a forerunner in recognizing individual differences and prescribing different materials to meet those individual needs. He agreed with Pestalozzi that using objects was fundamental in early childhood learning since he believed that reception and reflection produced understanding. He explained that this was accomplished only when the learner could engage in some self-activity to make application of what was perceived. He believed that all people deserved the privilege of manual training in the fulfillment of the self-activity component of the learners’ plans, whether or not they intended to spend their lives in industrial employment. He included
manual training in early childhood education, with materials suitable to the age level of the student (Nelson, 1981).

According to Zuga (1996, ¶ 4), the word “industrial was not meant to indicate the trades or a study of industry per se, but as a term equated with being industrious or occupied.” To clarify the use of the term, the second annual report of the Industrial Education Association opened with the following statement:

There is an industrial training which is neither technical nor professional, which is calculated to make better men and better citizens of the pupils, no matter what calling they may afterward follow; which affects directly, and in a most salutary manner, the mind and character of the pupil, and which will be of constant service to him through all his life, whether he be wage worker or trader, teacher or clergyman. The training of the eye and of the hand is important and essential elements in all good education (Gladden as cited in Bennett, 1937, pp. 413-414)

Early American Efforts in Elementary School Technology Education

Belief in the value of an industrial arts education for underprivileged children developed during the 19th century. Elementary school industrial arts (ESIA) came into being with Woodward’s (1898) founding of the “manual training school” in private secondary schools to provide a foundation for further liberal arts education. As Froebel’s kindergarten ideas gained in popularity, elementary school industrial education and manual training programs grew side by side and were a precursor for the beginning of industrial arts education. Zuga (1996) reports that educators criticized early manual training programs as being too rigid because of the influence of the Russian System of Tool Instruction (Bennett, 1937). The programs were considered thoughtless because they had their origins in kindergartens (Dewey, 1916c). ESIA emerged from Swedish and British educational approaches, such as educational “Sloyd” or handicrafts, which were
meant to be used as part of a well-rounded curriculum to develop eye-hand coordination and a sense of form rather than the development of a specific skill or trade (Zuga & Cardon, 1999).

Two early advocates for elementary school industrial education during the late 19th and early 20th centuries were Emily Huntington and Grace Dodge. Emily Huntington was the founder of the “kitchen-garden” program of industrial education, and provided educational ideas about implementing hand work in the schools (Bennett, 1937; Milbank Memorial Library, 2004). She sought to instill in impoverished girls a love of work by teaching them housekeeping skills that would earn them wages if they went into domestic service jobs. However, she observed that the girls saw the work as humiliating and tiresome. By chance, Huntington visited a well-run kindergarten and was inspired to adapt Froebel’s kindergarten principles and procedures to train her students in housekeeping skills. “After visiting a kindergarten and observing the children enjoying their play with blocks, she conceived the idea of substituting small-sized household furnishings and let housework become the play” (Smith, 1981, p. 177). Huntington coined the term “kitchen-garden” to reflect the influence of Froebel’s kindergarten. Her ideas to prepare children of the poor to become house-keepers valued for their efficiency by their parents and future employers were widely adopted. She was convinced that the kitchen-garden system was the necessary ingredient for training older girls in cooking.

Grace Dodge, an educational writer, a philanthropist, and a rich social reformer, along with a group of women colleagues, administered the Kitchen Garden Association (KGA). They soon realized, however, that their organization had outgrown its original mission to teach poor girls the basics of domestic service. With growing support of the
manual training movement among social reformers and educational leaders during her time, Dodge redesigned the KGA, which was renamed the Industrial Education Association (IEA) in 1884.

The aim of the IEA was to provide instruction in the industrial arts for elementary school boys and girls of all socio-economic classes and make the industrial arts (including the manual arts and the domestic arts) a vital and integral part of public education. Industrial education for elementary schools originated in kindergarten classrooms and incorporated a broad range of laboratory-based activities, such as block building, drawing, book making, embroidery, crocheting, paper folding, and construction (Bennett, 1937). Dodge provided the financial backing and publicity the IEA needed to spread to many areas of the country (Bennett; Smith, 1981). With her help, the IEA evolved five years later into New York College for the Training of Teachers, for the purpose of training industrial education teachers, which then became Teachers College, Columbia in 1892.

These two women are recognized as female elementary school educators who supported and helped develop industrial arts and technology education in elementary school (Zuga & Cardon, 1999). Their contributions provided a liberal rather than vocational education emphasis and purpose for what they called industrial education (Bennett, 1937).

In The School and Industrial Life, written in 1909, Bertrand Russell recommended that the elementary school curriculum should include humanistic, scientific, and economic studies (cited in Smith, 1981). Furthermore, Smith (1981) explains that although Russell advocated many subjects to help understand the industries,
he 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” (Bertrand Russell cited in Smith, p. 188). Clearly, Russell viewed industrial arts as the basis for the elementary school program.

With his follower, Frederick Bonser, Russell helped to ensure the value and goal of industrial arts. “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” (Russell & Bonser, 1914, p. 39). They defined the goals of industrial arts as a 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, experiences, 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)

Thus, they stressed the importance of students studying manufacturing concepts as well as the economic and social influences of industries on an industrial society (Luetkemeyer & McPherson, 1975, Snyder, 1992).

Bonser continued to become a leader who influenced both elementary school curriculum and industrial arts (Foster, 1995b; Luetkemeyer & McPherson, 1975; Smith, 1981; Volk, 1993). Together with Russell, he developed a curriculum for public schools referred to as the Russell-Bonser Plan. His goal was to establish the purpose of industrial arts in terms of its social or general behavior values and as the development of abilities
that would promote desirable conduct (Russell & Bonser, 1914). Hennes (1921) reflected a similar goal:

There are certain social ideals and skills absolutely necessary in order to live unselfishly and helpfully in society with their fellows. Our children must learn how to cooperate. They must learn the spirit of mutual helpfulness. They must come to appreciate fair play, and thus become unselfish in their dealings with others. They must, in particular, learn to be truthful. (p. 137)

Bonser and Mossman (1923) published a book called Industrial Arts for Elementary Schools which became the standard text on elementary school industrial arts for many years. Influenced by Dewey, perhaps by their association with him at Teachers College, Columbia, they defined industrial arts as

those occupations by which changes are made in the forms of materials to increase their values for human usage. As a subject for educative purposes, 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. (Bonser & Mossman, p. 5)

Their intention was to establish that the aim of industrial arts was to teach students not only about industry and technology, but also about the influence that industry has on humans and society. Even though their intention clearly was to provide a social purpose throughout the study of industrial arts, their intention has been basically ignored by industrial arts educators (Towers, Lux, & Ray, 1996). Zuga (1996) explains further that Bonser and Mossman (1923) suggested the content of industrial arts as well. They included foods, clothing, shelter, utensils, records, tools, and machines. Integration of the two disciplines of manual training and home economics runs throughout their book. The content of elementary school industrial arts (ESIA) differed from the content of secondary school manual training in that ESIA was more comprehensive with respect
Mossman developed the first “general shop” in which students worked through experiences in shop work, drawing, and home economics alternately that led eventually to the integration of manual training, drawing, and home economics into what is known as industrial arts (Foster, 1995a). Her vision was to include industrial arts in the elementary school as part of social studies. She endorsed a method view of industrial arts (Mossman, 1929, 1938). She advocated a large volume of constructivist ideas. “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 understand human growth and learning, if one is to develop personality.” (Mossman, 1929, p. 54) “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.” (Mossman, 1929, p. 114)

Bonser and Mossman (1923), influenced by the work of Dewey, defined the purpose of industrial arts as the study of "problems of citizenship as to share in the regulation of industry" (p. 7). General life skills were the skills of concern in elementary industrial arts and were considered of greater purpose than merely specific prevocational skill training (Zuga, 1996). Elementary industrial arts was a vehicle for the study of the occupations that encouraged the integration, acquisition, and application of practical knowledge to current social problems. As Dewey (1916c) said, "The most direct road for elementary students into civics and economics is found in the consideration of the place and office of industrial occupations in social life" (p. 201). Dewey promoted these ideas
for older students as well. Luetkemeyer and McPherson (1975) sum up the major contributions from Bonser and Mossman as:

(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)

According to Hostetter (1974), the philosophy of Dewey and the formation of the American Council for Elementary School Industrial Arts (ACESIA) by the American Industrial Arts Association were the two most important influences on 20th century elementary school industrial arts in the United States. Foster (1997a) says that “probably due to the formation of ACESIA and the popularity afforded by career education, elementary programs began to garner attention in the industrial arts press in the late 1960s and early 1970s” (p. 24). He goes on to say that during that period, “career education, which was a popular general education program, provided a vehicle for elementary school industrial arts to realize resurgence in popularity in the industrial arts profession” (p. 23). John Dewey and James Russell, industrial arts pioneers, have been given credit for many of the ideas underlying career education by the former U.S. Commissioner of Education, Sidney Marland, who is identified as having initiated the career-education movement of the 1970’s.

During the 1980’s, the term “technology education” (TE) began to be used by most major institutions in the industrial arts field for their programs. Likewise, the field’s elementary school program became known as elementary school technology education (ESTE).
Constructivist Pedagogy and Elementary School Technology Education

The Philosophy of John Dewey

During the progressive movement of the early 20th century, Dewey (1916b) planted the roots of constructivist pedagogy, a theory of cognitive growth and learning that frames Elementary School Technology Education (ESTE) and provides the theoretical underpinnings of this study. Dewey appealed to teachers to organize instruction around children’s natural inclination to be engaged in investigation, acquire knowledge, and use a constructive imagination. For education to be effective, Dewey (1916c) says that teachers must look at ordinary life situations that cause reflection as models for formal education. “They give pupils something to do, not to learn; and the doing is of such a nature as to demand thinking, or the intentional noting of connections; learning naturally occurs” (p. 2). The review of Dewey’s philosophies of occupations and constructivist ideas will be discussed with regard to their direction and relevance for providing quality learning experiences for students in the ESTE classrooms of today.

Children’s Natural Instincts

Dewey (1916c) said there are four basic instincts in children.

1. The social-conversational instinct – this instinct describes the free and active social dialogue between peers and teacher about points of interest and of value to the student in the conversation; statements are made, inquiries raised, topics discussed, and meanwhile the student continually learns.
2. The making or constructive instinct – this instinct describes the impulse to use his/her hands and manipulate materials. The student engages in problem-solving activity in the process of making plans and using tools.

3. The inquiry instinct – the instinct of investigation seems to grow out of the combination of the constructive impulse (the instinct of making) with the conversational instinct (the child’s instinct to find expression first in play, in movement, gesture, and make-believe) and precedes abstract investigations. Children like to just do things and watch to see what happens. This instinct can be directed to give valuable results.

4. The expressive or aesthetic instinct – this instinct refers to the child’s desire to make something and to give it a social motive, something to tell, a work of art.

The Role of Work and Play in the Curriculum

In the climate of Dewey’s day, characterized by educational reform and increased interest in child psychology, the curriculum was undergoing considerable modification. Dewey (1907, 1916c) discussed the necessity of starting from and with the student’s experience and capabilities when introducing new concepts. He said that the forms of activity during play and work that children engage in outside of school should be the models of activity in the classroom. Dewey (1915) was definite in his ideas about the place of “active occupations” in education, a concept that includes both play and work. Active occupations represent things to do, not to study; their educational significance consists in the fact that they may typify social situations.
He explained that both work and play involve anticipation of accomplishing a result or affecting an outcome. Both involve the selection and adaptation of materials and processes designed to affect expected results. The directing idea gives meaning to the successive acts of both work and play. The difference between them is largely one of time-span. That is, when the anticipated results require persistent effort for their accomplishment, play activities gradually pass into work. While both work and play signify purposeful activity, work differs from play because it takes a longer course of action to obtain a result. Dewey (1916c) said that there is a greater demand for continuous attention to the activity and more intelligence must be demonstrated in selecting and shaping the means to accomplish the results. As activities grow more complicated, they gain added meaning by greater attention to the specific results achieved. Work consciously includes regard for consequences as a part of its nature.

Dewey explained that there are no exclusive periods of play activity and work activity for young children. Even very young children try to achieve purposeful results. Children are eager to share the occupations of adults or older children. They want to “help” with such things as washing dishes, setting the table, baking, and making toys. As they mature, those activities that do not produce tangible and visible achievement cease to be interesting to them. Results enable them to get a sense and measure of their own abilities. As children play, their attitude is often one of being completely and seriously absorbed in what they are doing. When the activity ceases to be adequately stimulating, that positive attitude cannot be maintained. Dewey (1916c) held that,

Work is psychologically simply an activity which consciously includes regard for consequences as a part of itself; it becomes constrained labor when the consequences are outside of the activity as an end to which activity is merely a
means. Work which remains permeated with the play attitude is art -- in quality if not in conventional designation. (p. 130)

The Meaning of Occupations and Their Implementation in an ESTE Classroom

From 1896-1904, Dewey worked as Director of the Laboratory School at the University of Chicago. According to Luetkemeyer and McPherson (1975) “Dewey’s Psychology of Occupation as the basis for the elementary school curriculum was an outgrowth of his work as Director of the Laboratory” (p. 189). Inherent in Dewey’s definition of occupations, are the experiences a student has outside the school and includes activities that are familiar and common to the student in his/her home and surrounding environment (Luetkemeyer & McPherson). Since children are inherently active beings who want to communicate with others, build things, investigate, and create, Dewey advocated that school should accommodate these traits through activities such as language, manual and household arts, nature study, dramatics, art, and music. He recommended scientific and industrial studies that would make students more aware of life around them (Smith, 1981).

From Dewey’s standpoint, redesigning the traditional school to function as a form of community-life would bring about integration between the individual and society. He thought it a great waste that schools did not relate subject matter to a student’s everyday experiences and daily experiences to school (Luetkemeyer & McPherson, 1975).

Dewey (1916c) defines the occupations as “… a mode of activity on the part of the child which reproduces, or runs parallel to some form of work carried on in social life” (p. 132). The child’s simulation of adult occupations is the medium that integrates
the child’s instincts with the development of the mind. These simulations are intrinsically appealing to children and when they are joined to the child’s instincts, they embody the thinking process. Unlike adult work that is for pay, the simulations of occupations are “an end in themselves” with the purpose to develop the child’s “mental and moral states (as well as) the growth involved in the process of reaching a result” (p. 134).

Dewey (1916c) said that occupations grow out of natural instincts and are therefore interesting to the child. As the child plays to reproduce social occupations, that play gives an outlet to the instincts and repeats the continuous struggle of the race to master the forces of nature “through the getting of food to maintain life, securing clothing to protect and ornament it, and thus finally, to provide a permanent home” (p. 136). The intersection of the instincts and the simulation of occupations represent humankind’s relationship to the world. The exercise of these instincts leads to the student’s classroom simulation of adult occupations (Palermo, 1992). Dewey (1916c) was convinced that when exercises which are prompted by these instincts are a part of the regular school program, the whole pupil is engaged, the artificial gap between life in school and out is reduced, motives are afforded for attention to a large variety of materials and processes distinctly educative in effect, and cooperative associations which give information in a social setting are provided. (p. 195)

In other words, assigning a definite place for play and active work in the curriculum are a matter of intellectual and social growth, not merely temporary and momentary happiness. Effective learning happens when the acquisition of knowledge is an outgrowth of activities having an end of their own, instead of simply being a school task. Dewey states that play and work correspond, one for one, with the initial stages of knowing; that is, in
learning how to do things and in becoming acquainted with the things and processes in the doing.

Furthermore, Dewey (1916c) noted, “Experience has shown that when children have a chance at physical activities which bring their natural impulses into play, going to school is a joy, management is less of a burden, and learning is easier” (p. 194). He did not advocate, however, using plays, games, and constructive occupations just for a relief from the tedium and stress of “regular” schoolwork. Rather, he said that children’s natural tendencies to explore, manipulate tools and materials, and construct and give expression to their emotions of joy and happiness were fundamentally worthwhile for their mental and emotional growth. Classroom simulation of occupations does two things:

1. gives children experience in working together on a task that is interesting and that demands practical thinking, and converts lifeless subject matter into a living reality; and

2. places children in simulated roles that accurately portray a picture of the adult world and human progress.

According to Dewey (1916a), the educator is charged with engaging pupils in activities in such a way that education, intellectual outcomes and formulating a socialized disposition, are the primary goals of the activity. Secondary to education is manual skill, technical efficiency, immediate satisfaction found in the work, and preparation for future usefulness that is gained in the activity. This principle rules out activities which have a definite prescription or direction, and that do not permit the use of judgment in selection and adaptation. It also rules out activities that don’t allow students to learn from making their own mistakes.
The devotion to developing efficient skill without regard to present purpose results in devising exercises isolated from a purpose. Dewey (1916b) tries to enlighten us by calling us to realize that the functional development of a situation constitutes a sense of “wholeness” for the purpose of mind. In other words, for the person, the purpose of using a material, tool, or process is the simple thing. Each element in the making or doing is unified by the purpose for which those elements are done. Each element takes on a definite meaning of its own in the process and serves the purpose. Then to the expert, the elements become the simple things. Educators need to be watchful that they don’t take on the standpoint of the expert for whom the elements exist, isolate them from purposeful action, and then present them to beginners as the simple things.

*Problem-Based Learning (PBL)*

Dewey (1916c) indicated that children learn best by doing and by thinking through problems. Barrows and Tamblyn (1980) define problem–based learning (PBL), as learning that occurs from the process of working toward understanding or resolving a problem. Teachers who use problem-based learning recognize that in the world outside of school, adults build their knowledge and skills as they solve real problems or answer important questions. Students, who are taught through problem-based learning, become self-directed learners with the desire to know and learn. They develop the ability to formulate their needs and goals as learners, and the ability to select and use the best available resources to satisfy or accomplish them.

Barrows and Tamblyn (1980) summarize the steps in PBL as: (a) students encounter the problem before any preparation or study is done; (b) the problem situation
is presented to the students as it would present itself in reality; (c) students work with the
problem using their ability to reason and apply knowledge to be challenged and evaluated
on a level of learning appropriate to the individual; (d) as students work with the
problem, needed areas of learning are identified and used as a guide for individualized
study; (e) the skills and knowledge that students acquire by this study are applied back to
the problem, to evaluate the effectiveness of learning and to reinforce learning; and (f)
the learning that has occurred as students work with the problem and in individualized
study is summarized and integrated into the students’ existing knowledge and skills.

Students must develop habits of thinking, researching, and problem solving to
succeed in the rapidly changing world of the 21st century. PBL requires students to
demonstrate an understanding of the material they study and use advance knowledge.
Since PBL is an active instructional technique and is student-centered, it readily motives
students, builds critical thinking and reasoning skills, furthers creativity and students’
independence, and helps them have a sense of ownership of their own work. Students
initiate and manage many of their own activities. The teacher serves as a facilitator of
learning while students increase their independence, thinking and problem-solving skills,
and build their own creative learning strategies. Textbooks serve as only one of many
valid information sources. PBL gives students an active role in the classroom through
problems that connect to their lives. The process requires them to find the needed
information, think through a situation, solve the problem, and develop a final presentation
(Barrows & Tamblyn, 1980).

PBL provides many student outcomes. It enables students to learn a body of
essential knowledge (core information) to deal with problems that are as close to real-life
situations as possible, developing effective use of their knowledge and understanding.
PBL promotes students’ active engagement with learning – learning becomes the act of discovery as students examine the problem, research its background, analyze possible solutions, develop a proposal, and produce a final result. Students develop the ability to extend or improve knowledge, and to develop strategies for dealing with future problems (active use of knowledge). PBL promotes an interdisciplinary approach requiring students to read and write, research and analyze, think and calculate. The problems frequently cut across disciplines and lend themselves to interdisciplinary courses.

PBL requires students to make choices about how and what they will learn and promotes collaborative learning as students build teamwork skills, learn from each other, and work together to solve the problem. PBL helps raise the quality of education; teachers shift to higher standards and require greater performance calling for the development of advanced cognitive skills, research skills, and problem-solving skills. As students connect with the community and the larger world outside the classroom, and participate in the civic life of their community, they become better equipped to succeed in the adult world.

*Constructivism*

*Social Reconstruction – The Progressive Perspective*

Zuga (1996) explains that the curriculum orientation of Dewey and the other progressives from his era was that the school was separated and isolated from society, placing students in learning situations that were not reflective of real life or associated with the problems of society (Bode, 1933; Counts, 1932; Cremin, 1976; Dewey, 1916b;
Dewey & Childs, 1933). The progressives argued that students were shortchanged and unprepared to recognize and understand the values and issues they would encounter as adults (Dewey & Childs). Dopp (1902) reflected that Dewey's social reconstruction ideas were an influence on elementary school industrial arts educators. Wiecking (1928) mirrored Dewey's perspective as well. He states:

> Intelligently planned and directed, the field of manual training and industrial education may change attitudes and foster appreciation of great moments in the child's life. With a background of actual participation in manual activity there may come to the child a point of view about our civilization which is bound to affect his future behavior toward questions arising in industrial life. (p. 268)

Because of Dewey’s influence on educators during the first part of the 20th century and because of the established practices in industrial education in the elementary schools, the position of industrial arts was elevated in the schools (Zais, 1976). Zuga (1996) mentions that industrial arts facilitated the study of the occupations which permitted the integration, acquisition, and application of practical knowledge to current social problems. She reminds us that elementary and kindergarten laboratory schools developed at places such as The Ohio State University, while the public schools, in turn provided laboratories to provide genuine real-life experiences for every student (Publications Committee, 1935). Zuga (1996) says:

> While social reconstruction was the direction and intention of many elementary school and industrial arts educators of the time, their influence was not the mainstream direction taken by the industrial arts community as it moved forward into the twentieth century. Most of the voices advocating social reconstruction in industrial arts curriculum gradually became silent as industrial arts curriculum theorists focused on identifying better ways to teach skills (Fryklund, 1956; Selvide, 1923; Selvide & Fryklund, 1946) and unique content for industrial arts (Towers, Lux, & Ray, 1996). School practice became more vocational, with a curriculum of woodworking, metalworking, and drawing. (Schmidtt, 1963, ¶18)
In summary, Dewey's occupations technique seems to be tailored for the postmodern era (Palermo, 1992). As calculators, computers, and word processors teach the 3R’s and television and the Internet tell children all about the world, these aids have once again isolated children and made them passive. The tedious work of long division or editing sentences to be grammatically correct is passed on from the student to the computer. The work of obtaining knowledge is often reduced to printing out a web document. It seems logical then to return to Dewey’s occupations technique. The simulation can deliver practical, social, and moral experience as the lesson is lived by the student directly.

In our hyper-real society, the teacher who uses Dewey’s occupations technique can interpret Dewey’s philosophy as “We learn by doing!” (Palermo, 1992). Dewey’s simulations of the occupations are complete unto themselves. Without a current referent in today’s world, the occupations technique signifies itself only. That is, for today’s teachers, Dewey’s pedagogy of occupations is caught in a continuous loop of its own. If one wants to implement Dewey’s occupational simulation in the schools of today, the first task is to seek how these pedagogical techniques reflect the real world (Palermo). Teachers who subscribe to Dewey’s theory of the occupations practice student-centered methods based on children’s natural instincts. In such a classroom centered on their natural instincts to explore, children can experience the joy of discovery and solving challenges (Dewey, 1916c).

Constructivism as a theory of teaching and learning and as a research paradigm has become increasingly popular over the last three decades (Freed, 1998; Matthews, 1998; Tobin & Tippins, 1993). Research in cognition, the mental process by which
knowledge is acquired, has led to the evolution of constructivist theory (Ausubel, 1963, 1978; Piaget, 1964, 1969, 1970; Vygotsky, 1978). Piaget, often considered the father of modern constructivism, explains that children use their own understanding of nature to interpret their world; learning results from the learner’s own individual constructions (Crowther, 1999; Popkewitz & Brennan, 1998; Wadsworth, 1996). Similarly, Ausubel (1968) says that “the most important single factor influencing learning is what the learner already knows” (p. vi). Additionally, he writes that “the learner is able effectively to exploit his existing knowledge as an ideational and organizational matrix for the incorporation, understanding, and fixation of large bodies of new ideas” (p. 58). The term constructivism has taken on slightly different connotations and is used rather loosely to mean different pedagogical, psychological, or philosophical positions (Bettencourt, 1993). Constructivist ideas are defined by Bentley and Watts (1994):

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)

Fosnot (1996) explains:

Constructivism is a theory about knowledge and learning; it describes both what “knowing” is and how one “comes to know.” Based on work in psychology, philosophy, and anthropology, the theory describes knowledge as temporary, developmental, nonobjective, internally constructed, and socially and culturally mediated. Learning from this perspective is viewed as a self-regulatory process of struggling with the conflict between existing personal models of the world and discrepant new insights, constructing new representations and models of reality as a human meaning-making venture with culturally developed tools and symbols, and further negotiating such meaning through cooperative social activity, discourse, and debate. (p. ix)
From a constructivist perspective then, pre-existing knowledge is used as a basis for understanding and learning. Knowledge is actively constructed by learners as they attempt to make sense of their experiences, through interaction with physical phenomena and interpersonal exchanges (Beller, 1998; Cross, 1998; Driscoll, 2000; Scruggs & Mastropieri, 1994; Watts, Jofili, & Bezerra, 1997).

**Constructivist Ideas Related to ESTE**

Recent trends in educational reform have their basis in constructivism (Fosnot, 1996). For instance, the principles and ideas of constructivism are reflected in current national standards such as the *National Science Education Standards* (National Research Council, 1996); the *Principles and Standards for School Mathematics* (National Council of Teachers of Mathematics, 2000); and the *Standards for Technology Literacy: Content for the Study of Technology* (ITEA, 2000). Teaching strategies and approaches in an ESTE classroom are compatible with constructivist ideas.

Doolittle and Camp (1999) suggest that since constructivist theory addresses higher-order thinking, problem solving, and collaborative work skills, which are fundamental to modern day technology, it may provide a valid framework in which to organize and synthesize the knowledge and concepts within technology education. The authors propose that cognitive constructivism, as a basic learning theory, serves the new mission, curriculum, and pedagogy of technology education in the 21st century very well. With the changes and development for technology education, other authors have called for a new look at the theoretical framework for technology education (Doty & Weissman, 1984; Lynch, 1996, 1997; Osborne, 1996).
Constructivism as a theory of learning maintains that learners are actively engaged in constructing their own knowledge and meaning from their own experiences (Fosnot, 1996; Steffe & Gale, 1995).

A constructivist pedagogy acknowledges the learner's active role in the personal creation of knowledge, the importance of experience (both individual and social) in this knowledge creation process, and the realization that the knowledge created will vary in its degree of validity as an accurate representation of reality. These four fundamental tenets provide the foundation for basic principles of the teaching, learning, and knowing process as described by constructivism. (Doolittle & Camp, 1999, ¶17)

While the literature on constructivist theory portrays a way of learning, it does not outline a way of teaching (Fosnot, 1996). Doolittle and Camp (1999) examined constructivist pedagogy. They suggested that in order to merge the need for learning the core knowledge and skills of technology education with the constructivist framework that emphasizes adaptability, knowledge construction, and self-monitoring, theorists in technology education need to acknowledge and embrace five central concepts. These five concepts provide a framework within technology education that recognizes the value of “domain-specific knowledge, future innovation and change in domain-specific knowledge, and the thoughts and perspectives of the individual student and teacher:

1. All teaching within career and technical education must begin and end with an appreciation of the student's understanding.

2. The student must be facile with a core set of currently accepted knowledge and skills within career and technical education.

3. Career and technical knowledge and skills are dynamic; thus students must have the skills necessary to adapt.
4. Student's idiosyncratic understandings of career and technical knowledge and skills must be valued, as these understandings may lead to new discoveries, insights, and adaptations.

5. The goal of career and technical education must be an occupationally self-regulated, self-mediated, and self-aware individual. (Doolittle & Camp, 1999, ¶56)

Doolittle and Camp (1999) presented essential factors of a constructivist pedagogy that may lay a foundation for the teaching strategies and approaches in an ESTE classroom. They proposed that authentic, real-world environments be the setting for learning; content and skills addressed should have personal relevance for the student and taught with regard to the learner’s prior knowledge; assessments should provide information for teachers on which they can develop future learning experiences; students should be taught and encouraged to have a role in assessment of their progress and learning; teachers should serve as mentors, facilitators, and guides to students rather than merely instructors; and teachers should teach students to view content from multiple viewpoints and perspectives.

Vygotsky (1978) explains the need for teachers to facilitate the social and learning environment in which they can guide and mentor their pupils toward mastery. Glassman (2001) reminds educators of the power and importance of everyday activities in their attempt to create a better constructivist classroom. Many teachers may be uncomfortable with a constructivist approach to teaching and learning. Bentley and Watts (1991) claim a significant distinction exists between the theoretical version of what constructivism
involves and the practice of constructivism which many teachers implement in their classrooms.

Although teachers may be committed to a constructivist approach in principle, they may have misunderstood the constructivist principles explained by researchers; or possibly the model of constructivism that works for researchers has not been aligned with management methods that work for teachers in typical classrooms. Keogh and Naylor (1996) believe that a number of significant issues about how to make constructivism applicable to classrooms have not yet been fully addressed. They suggest that although teachers may want to plan activities on the basis of what the learner already knows and understands, they face the problem of the sheer practicality of attempting to do that with a class of 30 or 40 students.

Based on the study of cognition, Jerome Bruner (1966) framed instruction within constructivist theory. According to him, learning is an active process whereby learners construct new knowledge, ideas, and concepts that are based on their past knowledge and experiences. He says that instructors should lead students to the discovery of ideas and principles through active discussion and Socratic learning. According to him, the instructor’s task is to organize the curriculum so that it spirals continually, building upon what students have already learned. Herein lies more challenge for the teacher who wants to implement a constructivist environment.

To give children the education they need to succeed in the global, technologically-intense world, teachers must build the classroom learning environment upon children’s native learning abilities and their existing technological competence.
To address curricular concerns, many in the field of technology education have argued that creative problem-solving activities are the heart of technology education. Moreover, they argue that problem solving is the core content and teaching method to foster technological literacy and encourage projects exploring new effective approaches in technology education with the intention of broadening the opportunity for creative problem-solving (DeLuca, 1992; Lee, 1996; McCormick, 2001; Raizen et al., 1995; Williams, 1996; Wu, Custer, & Dyrenfurth, 1996).

With problem-solving as the heart of technology education, LaPorte (2001) suggests that the soul of technology education is “doing.” According to LaPorte, this is the essence of technology that sets it apart from science, mathematics, and other core school subjects. The point LaPorte makes is that a hands-on teaching method is not just a matter of sound pedagogy for technology education. Instead, the “doing” (or practice) forms the core of the content of the field.

In regard to the knowing and doing discussion, Kenneth Welty (1999) laid out a challenging metaphor that examined the difference between an “adventure” and a “journey.” An adventure in technology education was characterized as an exciting and potentially rewarding activity that is initiated without any specific intellectual expectations for students. The merits of this approach tend to surface during reflections on the experience. A journey, on the other hand, was described as an activity that has a specific destination in mind. From his perspective, the destination should be the mastery of a profound idea or the development of an essential skill. Welty purports that technology teachers have an affinity for adventures that are launched without sufficient thought about how the student will be different when they are completed. With
adventures, the attainment of specific goals tends to occur more by default than by design. Technology education will become more valued, Welty claims, when its activities are designed as journeys toward well-specified outcomes. He respects the value of adventures with technology, but also values the finite amount of time that is available in the curriculum.

A Conceptual Framework for Elementary School Technology Education

The purpose of this section of the literature review is to offer a meaningful definition of Elementary School Technology Education for teachers and children. Many elementary school teachers and educators understand technology education to mean instructional technologies for communication and information; that is, the knowledge and skills needed to use technology to enhance student learning. Their understanding does not embrace teaching students about technology in general but how teachers can use technology in educational settings, such as computers, distance education, audio and videotapes, laser disks, and other technologies to teach mathematics, language arts, and other subjects. This is a limited understanding of technology education and must be broadened.

What sets the study of technology apart from other branches of knowledge are the core concepts that help to unify the field and give students a way to understand the designed world. The core concepts of technology defined in the Technology Content Standards are “systems, resources, requirements, optimization and trade-offs, processes, and controls” (ITEA, 2000, p. 32). It is recommended that since these concepts are the cornerstones for the study of technology, they should be taught at every opportunity as an
integrated component of the learning content. The core concepts are interspersed throughout the standards.

1. Systems. A systems approach to thinking includes an understanding of a whole in terms of its component parts, how the parts are interrelated to each other, and how the parts are related to the whole system itself. Systems occur in many areas of human life, such as political systems, computer systems, the solar system, civil systems, and technological systems (informational, physical, and biological). Simple and complex systems need to be studied in terms of their contexts, design, troubleshooting, and operations. Analyzing a malfunctioning system requires considering how the parts affect the whole system.

2. Resources. Basic resources are required to accomplish a technological job, such as a) tools and machines to extend and enhance human potential; b) natural, synthetic, and modified natural items; c) information and organization of data to operate systems and products; d) applied and converted energy to do work; e) capital to support the development and use of new innovations and inventions; f) effective time management; and g) people, who are the most important of all the resources.

3. Requirements. Every newly developed product or system has requirements and parameters. The requirements include safety needs, physical laws, available resources, cultural norms, and use of criteria for desired elements and features, and constraints, involving design limitations.
4. Optimization and Trade-off. “Optimization is a process or methodology of designing or making a product, process, or system to the point at which it is the most fully functional, effective, or as near perfection as possible” (ITEA, 2000, p. 33). The whole process of creating something new should include optimization. Trade-off represents the choices or exchanges that are made for one quality over another.

5. Processes. “A process is a systematic sequence of actions used to combine resources to produce an output” (ITEA, 2000, p. 33). Design, modeling, maintenance, management, and assessment are processes used in technology.

6. Controls. To cause systems to change, control mechanisms or activities that use specific information must be used. Controls often do not work properly, so understanding how to use information about the output of a system (feedback) or to regulate the inputs to a system is needed, whether it is a social, civil, or technical system.

To frame a meaningful definition of Elementary School Technology Education (ESTE), a discussion of the overall understanding of the concept of technology will be presented followed by a discussion of the concept of technology education and, in particular, elementary school technology education. Finally, a useful definition of ESTE as it relates to teachers and children will be presented.

As long as there have been people, there has been technology. Indeed, the techniques of shaping tools are taken as the chief evidence of the beginning of human culture. Technology is an intrinsic part of a cultural system and it both shapes and reflects the system’s values (Meyer, 1967; Mumford, 1962).
Many have tried to formulate a definition of technology that would become a satisfactory one for the field. One possible definition explains the concept of technology as the knowledge and study of human endeavors in creating and using tools, techniques, resources, and systems to manage the man-made and natural environment for the purpose of extending human potential and the relationship of these to individuals, society, and the civilization process. (Snyder & Hales, 1981, p. 2)

More simply put, technology consists of those human endeavors to modify and change the environment and the lives of humans. In the document *Technology for All Americans: A Rationale and Structure for the Study of Technology*, ITEA (1996) defines technology:

Technology is human innovation in action. It involves the generation of knowledge and processes to develop systems that solve problems and extend human capabilities. As such, technology has a process, knowledge, and context base that is definable and universal… Processes, knowledge, and context, then, are the universals of technology, and must be the foundation of the structure for the study of technology. (p. 16)

In today’s world, technology is a complex social enterprise that includes not only research, design, and craft, but also finance, manufacturing, management, labor, marketing, and maintenance (AAAS, 1993). Therefore, it is important to understand technological changes. The history of humankind is the story of inventions and innovations and of people developing and using tools and materials to extend human capabilities in their quest to make their lives easier and more enjoyable (ITEA, 1993).

*Contemporary Understanding of the Concept of Technology*

In its broadest definition then, technology education is the oldest discipline among all of the school subjects (AAAS, 1993; Zargari & MacDonald, 1994). Technological knowledge arises from, and is embedded in, human activity (Herschbach, 1995). The
International Technology Education Association, the association for technology education teachers, technologists, and other professionals of technology education, describes technology education as “... an educational program that helps people develop an understanding and competence in designing, producing, and using technology products and systems, and in assessing the appropriateness of technological actions” (Wright et al., 1993, p. 4).

Technology education is a school subject that should be taught to all students, K-12, to develop technological literacy, with emphasis on three technological concepts: process, knowledge, and context (ITEA, 1994). It is a unique study of both content and processes with appropriate hands-on/minds-on activities (McCade & Weymer, 1996). It involves designing, making, developing, producing, using, managing, and assessing technological systems and products. It involves application of mathematical, scientific, societal, and environmental concepts and principles.

Technology education is an organized program of studies taught in schools for the purpose of learning how people alter their environment by making changes in the forms of materials, and the societal problems that result from the human use of technology. It is an element of both a balanced liberal or general education, and a means of integrating the other disciplines through application.

Contemporary Understanding of Technology Education: The British View

In 1986, Britain launched the Technical and Vocational Education Initiative (TVEI). Craft, Design, Technology (CDT); Home Economics; and associated subjects were combined into a new subject area: Technology. Millions of pounds in funding were
poured into developing technology education in the schools. The National Curriculum incorporated Technology as a foundation subject, one that occupies a new and central place in Britain’s school curriculum. It has acquired a higher status, new identity, and a new title, which is Design and Technology Education. The emphasis is on the identification and solution of problems, decision-making through the use of materials, the provision of first-hand experiences, the integration of knowledge, and the organization of work in a community context. It is a compulsory subject from the age of 5 for all children in state schools in England up to 16 years and in Wales up to 14 years.

*Contemporary Understanding of Technology Education: The North American View*

In 1996, the International Technology Education Association reported that technology education was perceived to have a very low status within the United States. It was seen as an avenue for lesser able learners, while the most able children proceeded to higher education to follow professional and managerial courses. These status barriers have impeded the infusion of technology into the school curriculum for all students. Those who make things in our system are controlled by those who do not. The spectacular success of Japanese manufacturing industry where culturally these divisions do not exist, points to justification for the need for change in the United States (ITEA, 1996).

Most people in the U.S. do not comprehend the basic concepts of today’s technological society. Relatively few are able to comprehend the technological issues in the news or perform routine technological activities. We have historically ignored training students to understand or to become capable in technology. Since technological
processes and systems have become so complex, Americans have not been able to simply gain literacy through their daily lives (ITEA, 1996).

Technological literacy is a must for all Americans facing the new millennium. All citizens need assurance that they will receive the foundation they need to increase their levels of technological literacy, so that they can participate in and adapt to our rapidly changing technological world. Technology should be an essential subject for all students so that every American can understand the nature of technology, appropriately use technological devices and processes, and participate in society’s decisions on technological issues. Educational programs should engage the learners in critical thinking; designing; and producing products, systems, and environments to solve the practical problems of our times (ITEA, 1996).

Technological literacy is vital to the prosperity of the individual as well as the community and our nation. It is more than using computers; it is the ability to use, manage, and understand the technology available to us (ITEA, 1996). That is, the technologically literate person is capable of using the key human adaptive systems of the time; they have the ability to manage technology appropriately and with efficiency; and they are able to synthesize information into new insights. ITEA (1996) portrays the characteristics of a technologically-literate person as:

1. a problem-solver with astute insight and consideration for various points of view and contexts, and who understands that the technological issues involved in creating a technology can be quite complex as trade-offs, user groups, and the environment are factored into a solution;
2. a person who is able to understand the interrelationship of the components of a system, and uses his/her knowledge of the concepts within the disciplines of mathematics, science, social studies, and the humanities to seek solutions for a technological problem;

3. a person who is able to identify a problem, formulate alternative solutions, plan and develop a selected solution, and evaluate the solution for a specific technological challenge;

4. a person who understands and can assess the critical technological concepts behind current issues, and can use the technological processes to enhance health, entertainment, and career;

5. a person who can use creative and productive thinking and processes to produce solutions to problems, and can evaluate the impact and consequences of technological systems on various user groups and on the environment;

6. a person who understands the nature of technology and technological developments as the result of human innovation in action, and can make informed technological decisions.

Since technological processes and systems have become so complex, it is imperative that the study of the adaptive system we call technology becomes predominant in the education of every learner (ITEA, 1996).

*A Conceptual Framework for Technology Education*

Twenty-five leaders in technology education developed the document *A Conceptual Framework for Technology Education* (Savage & Sterry, 1990) to address
such issues as theoretical perspective, rationale, content, structure, and technology as a
discipline. They provided the following definition of technology: “Technology is a body
of knowledge and the application of resources to produce outcomes in response to human
needs and wants (p.7). The body of knowledge in technology education is viewed as the
knowledge of practice.

Technology educators organize curriculum so students are involved in the
creation of new knowledge as they are immersed in “doing” technology not just
“knowing” about technology (Todd, 1990). In the conceptual framework document, the
“technological method” is identified as a method of inquiry and is an approach to
problem solving. Todd describes the technological method:

By attending to human needs and wants 1) problems and opportunities 2) can be
addressed by applying resources 3) and technological knowledge 4) through
technological processes 5) the result of this effort can be evaluated 6) to assess the
solutions and impacts 7) resulting from these general technological activities. (p. 3)

Although there is no consensus on a taxonomy of technology, the most widely
accepted North American view of technology education reflects Jackson’s Mill
Curriculum Theory (Erekson, 1992). This theory suggests that programs be centered
around the Human Adaptive Systems Model (manufacturing, communication,
construction, and transportation). It proposes a Universal Systems Model (inputs,
processes, outputs, and feedback) as a lens through which all technological systems can
be understood and evaluated.

Within the context of a Universal Systems Model, the organizing principle for
technology becomes the aspect of “human endeavor.” The “big four” adaptive systems’
categories of communication, construction, manufacturing, and transportation are
recognized as subsystems of human technological/sociological endeavor, technical systems that are basic to every society (ITEA, 1996). However, technological knowledge is not limited to only industrial-related technologies as its only source. Bio-related technologies provide diverse technological areas for inclusion and study. In fact, the conceptual framework document identified four content sources for technology education as communication, transportation, production, and bio-related technology (Savage & Sterry, 1990). Leaders in the field recognize that these technologies are representative ones that could be included in the curriculum since new technologies are rapidly developing that will need to be studied in the future.

The conceptual framework document offers a structure for technology education:

1. Content is organized by communication, transportation, production, and bio-related technologies with emphasis placed on designing, developing, and utilizing technological systems;

2. Responding to human needs and wants provide the substance of open-ended, problem-based design opportunities and inquiry into the social and environmental impacts of technology;

3. The technological method is identified as the method of inquiry and includes cognitive, manipulative, and affective learning strategies (Erekson, 1992; Savage & Sterry, 1990; Todd, 1990).
Content Standards for Students in a Technological World: Technology Across the Curriculum

A new set of standards have been defined for technology education as a field of study and to provide a road map for those who want to go forward but don’t know how. The new standards do more than give a checklist of facts, concepts, and capabilities that students in technology education should master, but also provide an explanation of how and why technology education fits in naturally with the broad mission of the schools.

Layton (1985) says that technology has become the basic capital for society in the 21st century and that students need to be able to orient themselves in the world of technology. According to Novakova (1999), that principle is becoming more and more accepted for the new millennium. Organized by UNESCO in Paris in July 1993, the World Forum has been devoted to Project 2000+ that clearly formulates the tasks for technology education. The view of the World Forum is that technology education has an essential part and a significant role in the general education for all students during the rapid and intensive, scientific technological development of the 21st century.

Novakova (1999) states that technology education is becoming an essential component of general education because it acquaints students with the general concepts of basic production processes, including sophisticated computer technology, the use of computers in every day human activity, and with computer management. “The system of technology education creates within the general education a ‘bridge’ between the school and real life and forms a precondition for the acquisition of technological literacy and for lifelong education” (p. 77). As modern technologies change and contribute to the development of economies, students will need to have the technological knowledge,
skills, and attitudes whereby they can become able and flexible workers of the future.

Technology education can help develop students’ knowledge skills, abilities, and attitudes toward technology that will impact their ability to solve problems, to assess social economic questions correctly, and to develop ecological thinking.

The standards seek to explain why, with all the other competency exams and other pressures, technology education should be an integral part of the curricula in our schools (ITEA, 2000). A listing of the standards for technological literacy is provided on the ITEA website at http://www.iteawww.org/TAA/Listing.htm and can be found in *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000, p. 210).

The Nature of Technology

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

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

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

Technology and Society

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

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

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

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

Design

Standard 8: Students will develop an understanding of the attributes of design.

Standard 9: Students will develop an understanding of engineering design.
Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Abilities of a Technological World
Standard 11: Students will develop abilities to apply the design process.
Standard 12: Students will develop abilities to use and maintain technological products and systems.
Standard 13: Students will develop abilities to assess the impact of products and systems.

The Designed World
Standard 14: Students will develop an understanding of and be able to select and use medical technologies.
Standard 15: Students will develop an understanding of and be able to select and use agricultural and related biotechnologies.
Standard 16: Students will develop an understanding of and be able to select and use energy and power technologies.
Standard 17: Students will develop an understanding of and be able to select and use information and communication technologies.
Standard 18: Students will develop an understanding of and be able to select and use transportation technologies.
Standard 19: Students will develop an understanding of and be able to select and use manufacturing technologies.
Standard 20: Students will develop an understanding of and be able to select and use construction technologies. (p. 210)

Technology education can play an important role in students’ learning in other subjects. It reinforces material learned in other classes (ITEA, 2000). Technology education should be a way to apply and integrate knowledge from many other fields of study – not just mathematics and science and computer classes but also social studies, languages, music, and art. It provides an avenue for students to apply material in a way that captures interests and imagination.

The best way to make sure students retain information is by bringing together lessons from several classes. Then they are much more likely to make the material their own. Integration among subjects is done easiest in elementary school where the same
teacher handles most or all of a student’s classes and does not have to work with several other teachers to coordinate lessons. She can easily implement a lesson about technology by taking a different course with a subject already being taught (ITEA, 1996).

In the middle and high schools, there are more practical difficulties in integrating technology, but the payoffs are proportionally greater. Technology education classes provide a neutral ground for the different subjects to come together, often in the guise of devising a solution to practical problems. Real-world problem solving helps students in other courses by making content meaningful (ITEA, 1996).

A measure of learning something is being able to apply it. This is the rationale for labs in chemistry, word problems in mathematics, and conversational periods in French, but technology education takes this logic one step further. Students are expected to apply and synthesize information from other subjects, as well as from the technology classroom. Thus, they learn to make connections between different fields of knowledge and about how all knowledge is interconnected (ITEA, 1996).

Technology is a wide-ranging pursuit, borrowing from and being influenced by many spheres of human activity, and technology education classes naturally reflect that. Many people, however, think of technology in terms of its artifacts: computers and cars, television and toasters, pesticides, flu shots, solar cells, genetically engineered tomatoes. But to practitioners and to the people who study it, technology is more accurately thought of in terms of the knowledge and process that creates these artifacts, and this process is intimately dependent upon many factors in the outside world (ITEA, 1996).

Technology is the innovation or change of the natural environment in order to satisfy perceived human needs and wants. To determine what those needs and wants are
and to figure out how to satisfy them requires the consideration of several factors simultaneously, such as universal design principles, optimization, and trade-offs. For this reason, technology has been called “the great integrator” (ITEA, 1996, p. 6) and consequently, technology education classes can never be a separate subject, cut off from the rest of the curriculum.

The Technological Process

One of the most important goals of education is to provide students with a set of mental tools they can put to use in their lives. Besides reading, writing, mathematics, and basic details, students need practice in learning how to think, how to face a novel situation or problem, how to question, how to analyze, and how to come up with a reasonable response. Teaching science in schools to students who may never need the bits of biology, chemistry, and physics facts they learn, is valuable none-the-less, since the most useful lesson is seeing how scientists arrive at their answers through inquiry. The scientific method of observation, hypothesis formation, and testing is one of the most powerful tools humanity has created for dealing with the world around us. It provides a mental toolbox to use in understanding and solving daily challenges (ITEA, 1996).

The Design Process

Technology education offers another powerful tool used not for analysis or discovery, but for creation. This technological method is often referred to simply as “the design process” It begins with a clear definition of the problem–there is a need to be met and the designer must understand exactly what it is. Then the designer generates a
number of ideas for a solution. After brainstorming ideas in groups, and taking the
original design criteria into account along with various constraints, one design is chosen
as the most promising. This design is modeled, tested, and reevaluated. If necessary, the
original design is dropped and another is tried. Eventually through a series of alterations,
the inventor zeros in on a final design. The design process can be applied to any sort of
creation, whether it is the construction of models of designs or building working
prototypes (ITEA, 1996).

Hands-on/minds-on learning engages the students more than lectures, problem
solving on paper, or lab exercises that follow a preset series of steps. It encourages active
learning. The technology education labs reward students who come up with innovative
solutions. Technology education teaches an approach to dealing with the world in
different but complementary ways to that offered in other classes, and gives students an
important tool to help them face life’s challenges (ITEA, 2000).

*Technological Literacy*

Because technology is so fluid and changing, technology education classes spend
less time on specific details and more on principles and practices. The goal in technology
education is to produce students with a more abstract understanding of technology and its
place in society, that is, students who can grasp and evaluate new bits of technology that
they might never have seen before. It is to this end that new content standards have been
developed to emphasize comprehension of the basic elements that go into any technology
(ITEA, 2000).
The Technological Method Model

The Technological Method Model offers a universal systems model that suggests a way to sort out all the components of human endeavor and classify them in a meaningful way. The model identifies the process boundaries for technology education that includes the concepts, principles, generalizations, and unifying themes of technology. It represents the dynamic, action-oriented, doing nature of technology as well as the contributions it makes to the body of knowledge about technology. It is a theory and practice model that identifies a way to engage the individual or groups in technological action. The model utilizes the problem-solving method, and technological processes and resources in order to achieve outcomes that are needed or wanted. The outcomes may come with consequences that may be either desirable or undesirable. Therefore, humans need to be able to properly manage and assess technological practice by analyzing the feedback from the consequences of technological developments (ITEA, 1996).

The model provides a framework for teaching technology that immerses learners in actual technological practice. This model, along with its educational counterparts, have students identifying problems or opportunities, utilizing inquiry methods, and selecting the resources they think are appropriate. Students employ technological processes that will produce outcomes and consequences that they will assess. Students are involved in the “doing” of technology.

The model shifts technology education from a manual-based production model to “process education.” It requires students to engage in thinking and acting in a systematic way when they solve problems. It requires teachers to be facilitators of learning instead of subject-centered specialists. It encourages divergent thinking as well as convergent
thinking; a solution based on a methodological process rather than objective view; and a thought-and-action process that reaches to the higher levels of the domains of learning. The elements of the model include: (a) the design process; (b) development and creation of a system by which the design is produced as a finished product; (c) the use and management of the product which could ultimately result in its success or failure; and (d) evaluation of the benefits or harms sometimes hidden in the product (ITEA, 2000).

Each of these steps in the technological process demands a different set of mental tools. One of the basic lessons of technology education is that technology not only solves problems, but also creates new ones. Technology inevitably involves trade-offs between benefits and costs. Intelligent decisions about a technology need to take both into account. In technology education, students should come to see each technology as a tool, neither good nor bad in itself, but one whose cost and benefits should be weighed to decide if it is worth keeping (ITEA, 2000).

The goal of the new content standards is to prepare students to become technologically literate citizens -- citizens who will understand what technology is, how it is created, how it shapes society, and in turn is shaped by society. A technologically literate person will be able to hear a story about technology and evaluate the information in the story intelligently; put that information in context; and form an opinion based on that information; and will be comfortable with and objective about technology, being neither scared of it nor too infatuated with it (ITEA, 2000).

Since technology is advancing so quickly, and knowledge, processes, and systems are becoming obsolete over night, it is important to have a structure for technology education that focuses on the universals of technology that are considered to
be significant and timeless. *The Technology for All Americans Project’s: A Rationale and Structure for the Study of Technology* (ITEA, 1996) lays out the foundation for developing standards for technology education. This structure includes the following three major organizers or Universals:

1. **Knowledge** – includes the nature and evolution of technology; linkages based on impacts, consequences, resources and other fields; and technological concepts and principles;

2. **Processes** – human activities to create, invent, design, transform, produce, control, maintain, and use products of systems; and

3. **Contexts** – involves the many practical reasons why and where technology is developed, applied, and studied which are categorized by physical, chemical and biological, and informational technologies. (p. 16)

As a paradigm for the study of technology the Universals offer a general framework for what each student in grades K-12 should learn in order to become technologically literate. The Universals are divided into two Unifying Concepts and Principles, namely,

1. **Unifying Knowledge and Processes**, and

2. **Unifying Contexts**

Unifying Knowledge and Processes evolved from the integration of the knowledge and process universals and represent the blending of the cognitive, procedural, and tacit knowledge as well as the hands-on or doing process that are central in the study of technology. A second level, called Dimensions, provides another level of the essential elements of the Unifying Knowledge and Processes. All the dimensions must be used
together in developing curriculum and delivering instruction in order to reflect the complete content of technology education. They are:

1. Nature and Evolution of Technology
2. Linkages
3. Technological Concepts and Principles
4. Designing and Developing Technological Systems
5. Determining and Controlling the Behavior of Technological Systems
6. Utilizing Technological Systems

The Unifying Contexts describe the larger domains where technology is studied and provide a structure that encompasses the major technological systems. These contexts have evolved from an interaction with science, engineering, and mathematics. These contexts are categorized into three macro-systems:

1. Physical Technology
2. Chemical and Biological Technology
3. Informational Technology

All three context categories of technology rely on the seven Dimensions. These contexts may not fully represent all present as well as future technological systems, but they do provide a comprehensive organization of the current, major technologies (ITEA, 1996). (See Figure 2.1.)
Figure 2.1: A structure for the study of technology - The universals

Contemporary Understanding of Elementary School Technology Education

Elementary school technology education (ESTE) is an educational program in which children engage in constructional activities designed to help them learn about themselves and the world around them (Kirkwood & Foster, 1997). ESTE reflects a constructivist standpoint grounded in the theories of Ausubel (1968), Dewey (1916a, 1916c), Donaldson, (1978, 1992), Piaget (1964), Siraj-Blatchford (1993), and Vygotsky (1978). Gardner and Hill (1999) define technology education as it relates to the primary education curriculum as:

That part of the curriculum concerned with helping learners to become technologically capable: to identify human needs for which technological solutions are possible, design and make appropriate products (physical products or organizational systems), and to evaluate their quality and their potential societal and environmental effects. (p.104)

Technology education in the elementary school includes a large variety of hands-on/minds-on activities. Technology activities are valuable vehicles driving learning of all types such as mathematical and scientific concepts, problem solving, and collaboration. Stables (1997) says ESTE adds a rich environment, fertile with technological activity that promotes a wide range of learning opportunities which add value to the elementary school curriculum. Zuga (1997) concurs and writes that ESTE appears to be a motivator for teaching other subjects and to increase creativity, self-confidence, and self-expression. According to Kieft (1997), ESTE is expected to play an important part in the elementary school curriculum in the near future, and elementary school teachers will be responsible for its success. Therefore, teachers need to have a clearer understanding about ESTE and how to implement it.

Zuga (1984, 1989) says elementary school technology education needs to have personal relevance for the student. ESTE is not simply providing hands-on/minds-on
activities for students. Rather, it a program that engages students in the development of their curriculum. That is, it begins with where the student is in her/his understanding of a concept. It is a student-centered approach based on fostering a learning environment in which students can question, discover, explore materials, create, and evaluate, and in which the curriculum becomes personally meaningful.

According to Zuga (1984, 1989), an ESTE program has as its core strength, the development of intellectual processes and skills. Students are engaged in higher level thinking skills as they negotiate the curriculum with their teachers and share in reflective interaction and collaboration with their peers. From the outset, students participate in setting goals for their learning based on their past knowledge and experiences. They engage in planning and decision-making as they approach solving problems. They participate in designing, creating, and evaluating their work.

In an ESTE program, students are given the opportunity to explore their environment and learn that they have control of their surroundings. The program fosters student awareness and actively engages them in social relevance and reconstruction. They are given the opportunity to have influence over their own environment and to make the world a better place in which to live (Zuga, 1984, 1989). By identifying real-world problems; planning, designing, and developing solutions to them; and evaluating their implementation, students engage in making improvements for their fellow humans.

In our fast-paced global society, we are experiencing an information and technology explosion. For all the pluses that it affords us, it has robbed students of the chance to interact with materials, create items for necessity, or repair them as needed. Students (as well as most/many adults in our society) are suffering from a lack of
technical literacy. Our past shows us rich examples of craftsmanship as artisans took pride in their designs and creation. Our students need the opportunity to become technically literate citizens. In an ESTE program, these opportunities are imbedded into their daily curriculum to build technical competencies and literacy (Zuga, 1984, 1989).

Zuga (1984, 1989) maintains that an ESTE program not only supports conceptual development in technology, but it is easily integrated with other academic subject matter from other disciplines. It is academically relevant as it propels students to be life-long learners that embrace challenges with curiosity, inquiry, and ingenuity. ESTE programs help students to be confident that their ideas and creations are worthwhile and they are capable of solving their own personal, social, and environmental problems.

Impact of Technology Education on Student Outcomes

As technology education enters into the realm of primary education, many feel that it adds an additional burden to the overcrowding conditions of the existing elementary curriculum (Braukmann, 1993; Knamiller, 1991). The overcrowding conditions in the curriculum force teachers to make subjective judgments about the time given and value placed on any particular subject (Osborne & Simon, 1996). Primary teachers often find it difficult to meet the time demands for all subjects (Harlen, 1999). In order to feel competent and confident to teach technology, teachers need to know how the essential characteristics of the subject can add value to their students' learning (Aubusson & Webb 1992; Harlen, Holroyd & Byrne, 1995).

Thomson (2004) suggests that if it is to be accepted as an important dimension in the education of young children, it is imperative to identify the unique and appropriate
characteristics of technology education and how it adds value to the current primary curriculum. She reviewed the most recent developments in technology education in England and Wales, Scotland, New South Wales, Australia, and the USA. Her review of the literature indicated four major areas of characteristics distinctive to elementary school technology education: “knowledge and understanding, skills, attitudes and values, and methodology” (p. 16). Although Foster’s study (1997b) analyzes technology as content, process, and method, most programs in the primary curriculum include all these areas while placing emphasis on different areas.

In the USA, the ITEA (2000) approaches technology as having “concepts that characterize it and set it apart from other fields of study” (p. 32). The “core concepts” of technology were identified as systems, resources, requirements, optimization and trade-off, processes, and controls. The generally accepted commonalities of conceptualization are the concepts of systems, energy use, conservation, and control (Thomson, 2004).

Although there are many anecdotal beneficial claims being made for positive impact on children’s learning through technology education, Foster (1997a) reports that primary technology education is nearly non-existent in the USA. While a National Curriculum in England and Wales have required primary technology education to be taught since 1990, Davies (1999) reports that “some primary schools are actually teaching less technology than they did before the National Curriculum appeared” (p. 26).

With the limited research base in technology education (Cajas, 2000; Layton, 1993; Zuga, 1995, 1999), it seems the picture looks bleak for including primary technology education in the elementary curriculum. Still, teachers continue to engage children in technological activities, organizations like ITEA continue to deliver standards,
and governments continue to fund changes to enhance children’s technological learning experiences. It appears that there is a strong belief that technology education should be in the curriculum. Consequently, researchers must continue to try to identify the unique characteristics of technology education that are appropriate for elementary school children’s learning (Thomson, 2004).

It was for this purpose, to identify the unique and fundamental characteristics appropriate for an elementary school technology education curriculum in the USA, that Thomson (2004) conducted a modified, rotational Delphi study. The author reports a unique feature of the sample of participants in the study: only 33.3% of the technology education experts were female; while 93.3% of the elementary teachers were female. She noticed an overall trend of a reduction in the number of male experts at lower levels of experience ranging from 5-10 years. The age profile was skewed to upper age categories for both the experts (83% over 40 years-old) and the teachers (73% over 40 years-old.)

Experts in technology education and primary teachers with some experience in technology education comprised two groups who completed three rounds of the Delphi study using an electronic survey on the World Wide Web. The participants in Thomson’s survey were asked to rate 27 characteristics of methodology, 22 characteristics of knowledge and understanding, and 43 skills. “The items were rotated around the two groups to prevent fatigue” (Thomson, 2004, p. 1). The survey results identified seven items of technology methodology characteristics which are unique and appropriate for children’s learning, with all but one considered unique by both the experts and the teachers. It seems both experts and teachers alike are aware of the need to provide appropriate methodology for elementary school students.
Results suggest the most unique characteristics important in primary technology education are those of skills and methodology, followed to a much lesser degree by knowledge and understanding. Thomson’s findings, based on input from these two groups, identify three unique and appropriate characteristics of elementary technology education: (a) intellectual capabilities (knowledge), (b) practical skills, and (c) design and problem solving (methodology). Technological concepts unique to primary technology education were identified as systems, resources, requirements, optimization and trade-offs, processes, and controls. The generally accepted commonalities of conceptualization are the concepts of systems, energy use, conservation, and control.

Since the Standards for Technological Literacy (ITEA, 2000) does not include attitudes and values as a major area of technology education, Thomson (2004) did not include a section in the research instrument. However, she reviewed the literature on children’s attitudes toward technology education because the section on methodology considers some issues concerning children’s learning styles.

The results indicate that primary education teachers expect a technology curriculum that is skill based. However, the experts’ results show consensus for only one item in the skill category, “Technology education should enable children to work as part of a team to design and make a product to solve a problem or need” (p. 21). She suggests that this kind of teamwork provides the scaffolding of ideas that Vygotsky considers as essential for children to learn. Although this finding is compatible with the ITEA (2000) standards for technological literacy, the results are not totally consistent with the same standards as the results suggest an emphasis not on knowledge and understanding, but on skills. According to Thomson (2004), “Teachers who believe in methodology and skills
as most important are going to find it difficult to deliver all the knowledge and understanding stated as necessary in the document” (p. 22).

In summary, Thomson (2004) discusses that while technology education experts and primary teachers in the USA see skills and methodology as more important than knowledge and understanding at the elementary level, the national trends point toward the more academic side of the curriculum. She suggests that to have a successful, sustainable elementary technology education curriculum, a focus on fewer core characteristics may be in order. She suggests the need for further research in other countries to better identify and understand the unique and essential characteristics of ESTE.

Technology Education is gaining world-wide attention and countries are searching for information to establish a framework on which to build their technology education curriculum. In preparation for the scope and sequence for a national curriculum in Finland, Rasinen (2003) studied the curricula of six countries that have developed technology education programs over the past ten years and have provided research, experimental programs, and the development of learning materials, focusing upon Australia, England, The Netherlands, and the United States. His goal was to synthesize the theory and practice, not to compare the programs. Additionally, his goal was to find more detailed and concrete curriculum models for provincial, district, municipal, and school purposes.

Rasinen (2003) used a method called systematic analysis to analyze the technology education curricula of the six countries in more depth. He explains that in this method, the factors connected to a particular theoretical idea or “method family” are
identified and applied. A qualitative analysis is performed on selected parts of the content text. The aim is to bring forward the essential, core ideas and concepts embedded in the thinking and structures of the text, and to clarify the original thought to be able to develop them further if needed.

Rasinen (2003) developed a two dimensional analysis framework to conduct the analysis. One dimension included three influencers of curriculum: the society, the school, and the individual. The second dimension included three internal elements of the curriculum: objectives, methods, and content. The objectives, methods, and content were compared against the perspectives of society, school, and the student.

The findings indicate that technology is seen universally as an important part of human life, and that students need to understand the history and development of technology as it affects all human beings and the environment. It was not perceived with a value judgment of “good” or “bad” but as simply something that is around us regardless whether we want it or not. Therefore, students must be educated to cope and deal with it, to learn to develop it in harmony with the environment, and to approach its study with a realistic, yet critical, manner. All of the curricula included in the study suggested the importance of the study of technology. The countries studied share a common rationale that students need to be prepared to live in a rapidly changing technological world. Additionally, a universal consensus placed emphasis on learning to plan and produce solutions to technological problems, to become discriminating and informed users of technology, and to become innovative thinkers. The six countries in the study also emphasized the importance of understanding underlying social, aesthetic, and
environmental issues. Finally, the importance of learning by doing and problem solving is evident in all the curriculums studied.

Rasinen’s (2003) research indicates several universal trends in technology education that appear among the countries studied:

1. Curriculum objectives include understanding the role of science and technology in society, the balance between technology and the environment, and the development of technological literacy;

2. Development of skills includes planning, making, evaluating, social/moral/ethical thinking, innovativeness, awareness, flexibility, and entrepreneurship;

3. Prominent methods used focus on experiences for students that engage them in planning, analyzing, inventing, innovating, making, and evaluating;

4. Content includes the systems and structures of technology, professions in technology and industry, safety practices, ergonomics, design, construction techniques, assessment practices, the role and history of technological development, problem-solving strategies, and evaluating and valuing the relationship between society and nature;

5. The content included in the curricula of the six countries is extremely broad and extensive and the standards of teaching varies widely from one country to another;

6. Among the countries studied, technology education is developed to the greatest extent at the middle school/junior high levels;
7. Though technology education in the US has existed for a number of years, there are still few programs at the elementary level.

Student Attitudes and Perceptions About Technology

Mottier (1999) introduced the PATT conference to newcomers in technology education as a conference that first focused on research studies related to pupils’ attitudes towards technology, thus the acronym PATT. Originally held in the Netherlands, this international conference expanded its focus to include the whole of technology education and now is considered an international forum for technology education. Research related to student outcomes remains a consistent theme at the PATT conferences.

The PATT conference has been hosted in countries all over the world, including the Netherlands, Poland, Sweden, Kenya, and South Africa, and retains an informal “working” climate with a consistent group of participants. At the request of the International Technology Education Association, the conference was held in the United States in conjunction with the 1992 and 1999 ITEA conferences. Every two years, the conference deals with a specific theme such as “impacts of technology education” and plays a valuable role in creating a network of technology educators worldwide.

The first Pupils’ Attitudes Towards Technology project by Jan Raat and Marc de Vries (1985) in the Netherlands was developed to understand the knowledge and attitudes students have about technology. Initial studies using this instrument made it clear that students’ understanding of the concepts of technology were limited and vague, particularly the relationship of technology to physics. Differences were observed between
boys and girls in their attitudes toward technology as well, with girls being less interested in technology and seeing it as less important.

Bame et al. (1993) suggest that it is necessary to understand the knowledge and attitudes students have about technology to develop effective teaching strategies in technology education. It is important to consider students’ interest, opinions, and needs when developing the technological environment in which to foster student technological literacy (de Klerk Wolters, 1989). Researchers agree it is logical that students will develop positive attitudes about technology, be more interested in technology, have a greater interest in pursuing technological careers, and become more technologically literate if they have a positive experience in a technology education program (Boser et al., 1998). Popham (1994) indicates that research in the affective domain has shown that students with a positive attitude toward a subject are more often engaged in learning both during and after instruction.

In order to assess middle and junior high school student attitudes toward and conceptual understanding of technology, Bame and Dugger, Jr. (1989) revised, tested, and validated the PATT questionnaire to use in the United States (PATT-USA). Bame et al. (1993) administered the PATT-USA to 10,000 thirteen- and fifteen-year-old students enrolled in technology education/industrial arts classes from seven states in the United States. Their hope was that the PATT-USA could measure attitudinal changes in perceptions toward technology which might be linked to enhancing technological literacy.

The PATT-USA instrument consists of four parts: (a) a question asking students to describe their concept of technology; (b) eleven items to gather demographic data and
data about the technological climate of the home; (c) a five-part Likert-type scale with 57 statements assessing students’ attitudes and perceptions related to technology; and (d) a three-part, Likert-type scale of 31 items assessing pupils’ concept of technology. The five subscales measuring attitudes and perceptions include general interest in technology, attitude toward technology, technology as an activity for both boys and girls, consequences of technology, and technology difficulty. The subscale items related to concept of technology evaluate students’ understanding of the impact of technology in shaping the world.

The results of the PATT-USA study indicated age and gender differences in students’ interest in and perceptions of technology. On the Technology as an Activity for Both Boys and Girls subscale, students in the USA thought that technology is for both girls and boys, but girls were more convinced than boys the technology is a field for both genders. On the Interest in Technology subscale, findings indicated that students in the USA are interested in technology, but boys are more interested than girls. Students with technology education had more positive attitudes on all subscales than students who did not experience technology classes.

Results showed students in the USA were strongly aware of the importance of technology. However, they scored lower compared to students from other industrialized countries. Students in the USA had narrow concepts or misconceptions of what comprises technology. Findings indicated there were positive attitudinal influences related to the existence of technical toys in the home and parents’ technology professions.

A standardized attitude measure like the PATT-USA has not been used to assess the changes in students’ attitudes after participating in a technology education program.
However, Boser et al. (1998) conducted a study to determine changes in middle school students' attitudes toward technology after experiencing four teaching approaches typically used in technology education, i.e., an industrial arts approach, an integrated approach, a modular approach, and a problem-solving approach. The sample consisted of 155 seventh graders from four different middle schools where one of the four targeted instructional approaches was used. The authors administered the PATT-USA using a pretest and posttest design. The premise of their study was that demonstration of attitude changes toward technology might be linked to enhanced technological literacy, and the PATT-USA could measure that change.

Using the statistical analysis procedures followed in the Bame and Dugger, Jr. (1989) PATT-USA study, a factor analysis was performed on all attitude items to validate item grouping of subscales. A factor analysis conducted on the pretest data established the validity of the subscale categories and supported the item loadings and the subscale categories used on the PATT-USA questionnaire. A Guttman analysis was used to assess internal reliability of the concept of technology items. A Cronbach’s Alpha internal consistency reliability estimate was computed for the combinations of all attitude and concept items. Attitudinal changes between the pretests and posttests for each subscale were determined with one-sample t-tests. To analyze the differences on the attitude subscales that could be attributed to gender, two-sample t-tests and MANOVA were used.

The findings indicated that statistically significant differences between genders occurred on three of the five attitude subscales: General Interest in Technology, Technology as an Activity for Both Boys and Girls, and Technology is Difficult. From
the analysis, it appeared that female and male students perceived some aspects of technology differently. Consistently, female students perceived technology to be less interesting than did male students. Although different approaches may affect student attitudes in some areas, none of the instructional approaches used significantly affected students’ interest in technology during the 9-week period. The authors indicated that interest in technology may not be as easily affected as the more immediate attitudinal impacts related to studying about the benefits and consequences of technology, or overcoming the difficulty of a technological problem.

Girls, more than boys, perceived technology to be an activity for both boys and girls. Boys held stereotypical views about the roles of girls in technology. The instructional approach used did not cause this bias to improve, with the exception of industrial arts. There was no clear direction of change in attitudes attributed to an instructional approach.

In the modular approach, significant differences occurred on two subscales. Girls scored higher than males on the concept of technology subscale, indicating that girls in this approach had a better understanding of technology than did boys. As they gained experience in technological learning activities, all students perceived technology as less difficult, but females believed technology to be a more difficult subject than did males, particularly using the industrial arts approach. The authors suggested that TE may not be meeting the need of females.

Student attitudes and perceptions were less favorable in two of the four approaches. The Integrated approach showed negative change. Boser et al. (1998) explained that students perhaps had attained a more balanced view of technology.
Students retained more positive outlooks toward technology when they participated in less controversial content. The researchers suggested that perhaps at the beginning of technology activities, students underestimated the complexity of technology and its potential for both positive and negative consequences.

Boser et al. (1998) reported student attitudes toward technology and student conceptual understanding of technology were generally consistent with the PATT and the PATT – USA studies. They indicated that there was no significant change in students’ conceptual understanding of technology that would point to increased levels of technology literacy.

The PATT9 conference addressed the impact of technology education on student outcomes. In his keynote presentation at the PATT9 conference, Custer (1999) reported that although technology education appears to have gathered political support, which may suggest that others consider technology education to be important, empirical evidence of an impact of technology education on students is still absent or extremely scarce. Zuga (1999) reported a similar finding that there is very little research that has been done on the impact of technology education on students. She reports that a mere 8% of all professional research articles in the period from 1987-1998 deals with the effectiveness of technology education on pupil outcomes.

Since many countries have established technology education as an element in the curriculum, de Vries (1999) asks for the empirical evidence that technology education is doing what it has promised to do. He says research is needed to determine whether or not technology education is fulfilling its promise to create technological literacy in students.
Can we really say that Technology Education created technological literacy with our pupils and students? Can we say that we have been able to change their concept of and attitude towards technology, so that they have acquired a balanced perspective on technology and a positive, but not uncritical attitude towards it? Is their (sic) any empirical evidence that Technology Education is really doing the job that it was announced to do? (p. 115)

However, de Vries (1999) raises the hope that perhaps barriers that have impeded the collection of empirical evidence related to the success of technology education in the past can now be addressed. He identifies the following barriers and difficulties as researchers strive to gather evidence of the impact of technology education:

1. Technology education is relatively new and not generally accepted by pupils, teachers, headmasters, local authorities, businesses, and governments as a school subject; the number of various players complicates the situation so that technology education is not successfully introduced or realized; therefore collecting empirical evidence of successes is impaired.

2. Teachers not only need content knowledge and skills of technology education, but also of pedagogy and school issues which adds a burden to teachers.

3. A repertoire of research instruments needs to be developed to provide empirical evidence of the impact of technology education, and methodological problems with the PATT need to be addressed.

4. The economic and political circumstances within a country may cause problems with the implementation of technology education and thus with gathering evidence of the impact.

With the problem of gathering empirical evidence in mind, PATT conference presenters have provided some studies that suggest a real impact of technology education.
Volk (1999) conducted a study that revealed an impact of Design and Technology as a school subject on pupils’ attitudes. He examined the attitudes that Hong Kong students form about technology through a tracked or “banded” learning environment.

In Hong Kong, the band in which a student is placed determines the type of secondary education and school that a student attends, which in turn influences the student’s future employment opportunities. Since the quality of education students receive is influenced by their academic banding, and technology plays an important part in students’ lives, their attitudes toward technology will influence their actions both currently and in the future. According to Volk (1999) attitudes students have about technology can serve to predict or influence their future responses toward technology. Their negative or positive attitudes toward technology can impact their participatory roles in society as adults.

Volk (1999) used the Pupils’ Attitudes Towards Technology – Hong Kong (PATT-HK), an instrument patterned after the Bame et al. (1993) study, to assess students’ attitudes toward technology. Over 3,000 students from the Secondary 3 level (12-15 years old) who were in their final year of free and mandatory education, were surveyed with a five-part Likert scale containing 58 items. Student responses ranging from “strongly agree” to “strongly disagree” were grouped into six attitude categories: (a) interest, (b) role pattern (technology as an activity for both girls and boys), (c) difficulty, (d) consequence, (e) curriculum, and (f) career aspiration.

In the study, data collection resulted in 3,276 usable surveys from 17 schools (7 upper band and 10 lower band) that were analyzed in two specific groups; that is, the upper band schools (Band 1 and 2) and the lower band schools (Band 4 and 5) with Band
3 being omitted given the potential for overlap. A two-way Analysis of Variance (ANOVA) was performed to determine the interaction between high and low academic band characteristics with the six identified attitude categories. Volk (1999) identified an interaction between the independent variable of “banding” and the six dependent attitude categories. The characteristic of having “taken design and technology or other technical subject” was the only variable identified as being related to students’ attitudes. The relationship reported was for the categories of “Interest,” “Curriculum,” and “Career Aspiration.” The author identified significant attitudinal differences for students who were from different bands that had technical classes such as Design & Technology. In other words, the findings showed that taking Design & Technology or other technical studies was significantly related to students’ attitudes toward technology. Other characteristics, such as having a personal computer, were not significantly related to student attitudes when examined for the effect of “Banding.”

Volk (1999) concluded that technology subjects such as Design & Technology have a strong relationship to students’ attitudes toward technology and should be further explored as an area of study for all students. He suggests that quality technology education programs can foster positive student attitudes toward technology which could then impact their future course and career choices.

In a later study, Volk et al. (2003) examined Hong Kong pupils’ attitudes toward technology. Over 2,800 students in 22 secondary schools were subjects of the study that duplicated the first PATT-HK research conducted earlier by Volk and Yip in 1999. Using the PATT-HK, they examined the attitudes of Secondary 3 students (12-15 years old) in Hong Kong toward technology. A list provided by the education department of all
secondary schools that offered the Design & Technology course indicated whether boys and girls were studying the subject for three years or whether girls were just beginning to experience Design & Technology for the first time in Secondary 3. Using proportionate sampling techniques, 14 out of 40 schools having girls just taking Design & Technology for the first time and 8 out of 24 schools that had girls who had experienced Design & Technology for three years participated in the study. Through questionnaires, telephone interviews, and site visits, each school’s Design & Technology program was classified as being traditional (craft based activities, focus on skill development, and follows an old 1983 syllabus) or innovative (problem solving and group activities; new equipment; and new topics such as robotics, electronics, and control technology).

The PATT2-HK (Volk et al., 2003) was the same as the original PATT-HK questionnaire (Volk & Yip, 1999). Students were asked to describe what technology is, provide demographic information, and to respond to 58 Likert-type statements about their attitudes toward technology. Six categories of attitude statements were identified: (a) Interest in technology (Interest), (b) Technology as an activity for both boys and girls (Role Pattern), (c) Perception of the difficulty of technology (Difficulty), (d) Consequences of technology (Consequences), (e) Technology in the school curriculum (Curriculum), (f) Ideas about pursuing a career related to technology (Career Aspiration).

The findings of their study suggest that Design & Technology programs may be starting to have a positive influence on the student attitudes toward technology. The study suggests that innovative programs, after several years of implementation may produce a more powerful learning experience for students when compared to traditional approaches. It also indicates that teaching strategies, learning materials, group activities,
and the comfortable environment in an innovative technology program are related to enabling girls to be more confident and successful in school. From the evidence in their study, the authors state that Design & Technology programs that encourage creativity, problem-solving, and collaborative skills are related to positive student attitudes toward technology. They suggest educators recognize and commit to technology education as desirable for all students in all schools.

Becker and Maunsaiyat (2002) developed and tested the Technology Attitude and Concept Scale for Thailand (TACS-Thai). In their study, they compared differences in students’ attitudes toward technology between Thailand students and those in the United States. The sample used in this study included 616 students enrolled in secondary schools recognized as leaders in providing technology education and technological opportunities for their students. Since seventh, eighth, and ninth grade students were included, a stratified sampling was used. The researcher distributed the instrument to participating teachers with instructions to administer the TACS-Thai to the sample students in random classes. The instrument was administered to 292 boys and 324 girls, ages 11 to 16 years-old. Of the 616 students, 452 (73.4%) had completed a class in technology education.

The instrument that Becker and Maunsaiyat (2002) used, the TACS-Thai, was modeled on a shortened version of the TAS-USA that was developed by Jeffery (1993) to use with middle school students. With an overall alpha coefficient of .81 (Kuder-Richardson 20) on the attitude scale and an overall reliability coefficient of .83 on the concept of technology scale, Jeffery reported the content validity and reliability of the
TAS-USA instrument to be acceptable for measuring pupils’ attitudes and concepts of technology. A panel of experts was used to validate the content of the TAS-USA.

Like the original PATT-USA and the TAS-USA, the TACS-Thai was used as a descriptive instrument to collect data. With 63 items, the instrument measures both attitudes toward technology (26 items) and concepts of technology (28 items). The attitude subscales include interest, role pattern, consequences, difficulty, curriculum, and career. The subscales of the concept scale portion include technology and society, technology and science, technology and skills, and technology and pillars. The overall reliability estimate (Kuder-Richardson) of the six attitude subscales in the pilot study was .74 and the overall reliability estimate (Cronbach’s alpha) of the concept of technology scale was .72. It was concluded that the TACS-Thai instrument could be used to ascertain the attitude toward and concepts of technology of secondary school students (grades 7 – 9) in Thailand.

The researchers collected and examined demographic information about students’ perception of the technical nature of their parents’ jobs, the technological climate in their homes, and gender differences. They selected three attitude subscales to compare to the results of the TAS-USA study. The subscales compared were (a) General interest in technology, (b) Gender difference, and (c) Consequences of technology. Analyses of variance (ANOVAs) were used to determine if the demographic characteristics were related to attitudes toward technology.

The findings of the TACS-Thai study compared with those from the PATT-USA showed that there were some differences in students’ attitudes toward technology between the United States and Thailand students which they attributed to culture and the
educational system. It was noted that the teacher-centered methodology used in the Thai classroom was specifically correlated with these differences. However, the results of the study showed the overall patterns of attitudes and concepts of technology among students in both countries to be similar. More specifically:

1. Students in both the United States and Thailand are interested in technology although Thai students had a higher general, overall interest in technology.

2. In both countries, boys indicated more interest in technology than girls did.

3. US students regarded technology as an activity for both boys and girls, more so than the Thai students. Girls are more convinced of this than boys.

4. US and Thai students had similar opinions on the importance of technology in the world in general.

5. A positive correlation of parental technological profession with student attitude was found in Thailand and in the PATT-USA study.

6. Similar to the PATT-USA study, Thai students' understanding of the concepts of technology increased with age.

7. Gender had a significant correlation with attitude subscales of Interest, Role Pattern, and Difficulty in both the US and Thailand.

8. Thai and US boys score similarly on the concept items, whereas Thai girls had a higher understanding of the concepts of technology than US girls.
Barak and Doppelt (1999) studied the effects of a “rich learning environment” on student attitudes toward studies and school. The Creative Thinking and Technology (CTT) program was developed to use project-based learning to develop creative thinking (Barak & Doppelt, 1998). In the CTT program, students create authentic technological projects integrating creative thinking activities into the technology curriculum, students are encouraged to learn from their mistakes, and student portfolios are used for authentic assessment of the learning process. The LEGO/Logo learning environment was the basis for implementing the CTT program.

The subjects of the Barak and Doppelt (1999) study were 10th grade low-achieving, at-risk pupils in Israel who had chosen the Machine Control Department in which to major. In recent years, high achieving students in Israel have been directed to the Computers and Electronics Department while the low-achieving students have been directed to the Machine Control Department. A total of 56 pupils participated in a 5-year intervention program (9 to 24 students each year). The researchers concentrated on examining the influence of the CTT program on two student groups in the 1994 and 1995 classes.

Data was collected using both qualitative and quantitative tools: observations of class activities, interviews with pupils and parents, and following the pupils’ academic achievements. Based on a content analysis of the interviews, the authors developed a questionnaire to assess pupils’ progress in an open learning environment in terms of input-output relationship from the pupils’ viewpoint. Pupils from both groups filled in the questionnaire. Fifteen inputs of the learning environment included such items as freedom to choose subjects, team projects, individual progress, and construction
activities. Outcomes were items such as personal initiative, self-confidence, interest in technology studies, and curiosity.

An analysis of the findings produced an average score calculated for every cell that represented the relationship of each input with every output. The averages of inputs and the averages of the outputs were ranked and sorted. In both classes, a similar structure in perception was found. From the students’ point of view, as teachers design the learning environment, they should include construction activities, freedom to choose, team projects, programming activities, thinking activities, and independent study. Students considered these inputs to have the most significant influence on developing the learning outcomes of independent work, personal initiative, imagination, challenges, interest in technology studies, and curiosity.

After applying the CTT program over a number of years, Doppelt and Barak (1999) found that the project-based learning approach consistently correlates with students’ ability to create imaginative, authentic projects; create a community of learners (both parents and students) that seek to invent and who are united in achieving collaborative goals; and elicit positive attitudes, which were verbalized in the interviews from both parents and students. Improvements in pupils’ self-esteem, self-confidence, interest, and success in technology subjects were indicated. The authors report that pupils changed their attitudes toward every-day learning and their intentions to pursue future technology-related studies.

Their findings suggest that educators can develop rich and modern technology learning environments to foster improvement in both cognitive and affective domains, and that these learning environments may be especially important for at-risk students.
Their research demonstrates the attractiveness of using LEGO/Logo in technology education to encourage pupils’ authentic projects in learning technology as previous works by Jarvela (1995) and Kromholtz (1998) have suggested. Doppelt and Barak (1999) conclude that students ask for specific outcomes that are often ignored by educational systems that only focus on academic achievements.

Atkinson (1999) examined the relationship between pupil motivation and the internal and external factors of pupil performance in Design and Technology project work, pupil skills associated with Design and Technology project work, pupil personal goal orientation, pupil cognitive style, pupil creativity, teaching strategy, and teacher motivation. The sample of fifty 15- and 16-year-old students were selected from eight schools in the northeast region of England. Data was collected throughout a Design and Technology course work project. The author used a case study approach, based on observation and informal interviews, to monitor students throughout the design and construction of their projects. On completion of the projects, a summative questionnaire, a goal orientation index, and a creativity test were administered to each student.

As each set of data was collected, it was coded and analyzed. The statistical analysis included percentage distribution, rank order, one same chi-square test of variance, unpaired comparison of averages using t-tests, chi-square test for independence, and Fisher’s Exact Test for 2x2 tables. Descriptive analysis provided mean scores and line charts.

The findings indicate a significantly high proportion of the total sample were unmotivated by the project activity in which they were involved. A positive relationship existed between a pupil’s ability to perform and their level of motivation. Factors such as
student ways of thinking and working, personal goal orientation, and skills appropriate to Design and Technology showed a positive relationship with both performance and motivation. While a student’s creativity was found to relate positively to performance, no relationship was found between creativity and motivation. The findings revealed the prescriptive nature of the examination design process models adopted, as well as the effect of Design and Technology assessment criteria upon ways of working, were frustrating for many pupils, especially those who were creative (Atkinson, 1999). Additionally, external factors such as delivery programs and teaching strategies used to meet examination deadlines and requirements, influenced student performance and motivation.

Atkinson (1999) suggests that examination boards develop holistic assessment procedures that would encourage the use of more appropriate, flexible, design process models. She recommended that teachers need to develop strategies in which they guide pupils through the design process so ownership is a joint affair between student and teacher. A sense of ownership can develop a sense of responsibility, pride in work, and the motivation to succeed.

**Student Conceptual Understanding of Technology**

Paydon (2002) conducted a study of a two-year required exploratory program to determine the conceptual understanding and technological literacy of 7th and 8th grade students as measured against the 1998 Wisconsin Model Academic Standards. The student sample from both grades was a randomly selected, cluster grouping according to a computer program used by the school scheduling office.
An 82-question instrument was developed through the Wisconsin Academy of Staff Development Initiative focused upon integrative work in mathematics, science, and technology education aligned with the state’s technological standards. The technological literacy concepts selected (50 items) were related to space, computer literacy, high tech medicine, environmental issues, transportation, energy issues, super weapons and arms control, and biotechnology. The questions are multiple choice questions about the topics ending with a 32-question measurement section in which students were asked to read a metric and English ruler correctly. Paydon (2002) states that one threat to statistical validity of technology literacy is that there are no standard instruments at the state or national level, and each different program determines its own evaluation tool.

Students were evaluated using the paper-and-pencil evaluation tool before and after the technology education class. Through testing and hands on activities, students in both grades demonstrated what they knew about the evaluated topics. Pretest and posttest data were analyzed based on the total group ($n = 68$) number of correct responses out of 82 possible points, as well as gender comparisons.

Paydon (2002) determined that while the level of technology literacy of incoming seventh grade students was low, there were no significant differences between males and females. A t-test using Levene’s test for equality of variances was used to determine significant differences between grades 7 and 8. A one-way analysis of variance using the pretest and posttest between groups and within groups of the seventh and eighth grade was performed. The author examined the means of the seventh grade pretest to posttest differences, the seventh grade posttest to eighth grade pretest differences, the eighth grade pretest to posttest differences, and the seventh grade pretest to eighth grade posttest
differences. The findings did appear to increase in the mean scores between the pretest and posttest for both seventh- and eighth-grade levels, indicating achievement and learning, and the plausibility that literacy was taking place. However, the findings were not significant for the study between or within the groups.

Davis, Ginns, and McRobbie (2002) studied students’ outcomes as they engaged in design and technology activities. They designed their study to identify students’ understandings of selected technology concepts and changes in those understandings. The sample included 92 participants, maintaining gender balance across a range of ages corresponding to elementary school grades 2, 4, and 6. The authors used the interviews-about-instances research method that presents students with artifacts or pictures to explore concepts they associate with a particular label. The investigators report that this methodology has been used to identify students’ understandings of a wide range of science concepts. All students were interviewed individually. Data was collected over a 3-month period.

With transcript analysis, the common elements and understandings evident in students’ ideas and explanations of concepts were identified. Explanations were grouped as naïve (students unable to discriminate between the properties of different materials), artifact related (explanations appear to be dependent on the nature of the material out of which the presented object is constructed), and non-artifact related (explanations were not limited to the artifact but generalizable to other settings). In their findings Davies et al. (2002) suggest that commonalities and variations in students’ explanation of material strength and stability may exist. The authors suggest there is a progression toward more abstract common explanations as students increase in age.
They suggest there is a need to devise probes into students’ understandings of technological concepts that are not tied to particular artifacts or technological process. They also suggest there may be an identifiable progression in the abstractness of the basis of those explanations related to the age of the student. Davis et al. (2002) encourage further research to determine if similar groups of explanations exist for other key technology concepts.

Although Pierre-Henri Senesi (1999) conducted a study that purported to measure attitudes of young children about technological objects, he also identified their understanding of technology. The intent of the study was to find out whether performing real technological action can change the way they perceive some simple objects. Twenty-one pupils from three levels of a French pre-primary school (3- to 6 years-old) who had never been taught any technology were involved. The students were first asked to talk about simple man-made objects. Students were interviewed in sets of two. The questions covered the fields of perceptions about the objects, knowledge about the materials they were made of, and knowledge of the processes used to make them. Secondly, students were monitored during construction activities that followed. The objects made were a spinning top, a fridge magnet, a train wagon, or a cut-out figure. A second interview was conducted in the same way but with different objects from those in the first interview.

The interviews were transcribed. Both interviews were compared using statistical analysis. A significant decrease was found in talking about the function of objects, e.g., scissors cut. Talking about objects being man-made increased significantly, and the number of accurate descriptions of the tooling process increased significantly, e.g.,
shaping and cutting. The findings indicate progress in students’ accurate technical knowledge. They shifted from only perceiving the way they could use an object to perceiving and talking about its other features. By practicing the tooling techniques they learned to use them, students became more able to recognize their effects on existing objects. Senesi (1999) notes that they seemed to have moved from a user’s or consumer’s point of view to a producer’s perspective.

Technology Education and the Educational Needs of Gifted Students

According to the National Science Foundation (1997), by 2010, one-fourth of all new jobs will be information-intensive and involve technology. Our future leaders and citizens will need to develop their skill and confidence in using and manipulating technology and information. As educators seek to provide quality educational programming to address the specialized needs of gifted learners, technology can provide an essential component in building an effective learning environment (Nugeni, 2001).

Maker and Neilson (1982) suggest that effective learning environments for gifted students have specific characteristics that focus on the learner rather than the teacher; promote independence and ownership of learning; promote and encourage new ideas, inventions, innovations, and discoveries; focus on complex ideas and issues; provide flexible groupings; provide flexible structure; encourage freedom of movement; promote differentiated curriculum with opportunity for greater depth and investigation of a variety of topics; and encourage an accelerated pace to advance knowledge as well as mastery. Clark (1997) and Gallagher and Gallagher (1994) state that gifted students are capable of learning more complex material more rapidly than their same-age peers. Providing a
differentiated curriculum with greater depth, a variety of topics, and an accelerated pace could facilitate the learning of these students beyond simply mastery and encourage advancement in knowledge.

Technological integration in the gifted classroom is dependent upon adequate teacher training and the efforts of teachers to implement innovative technology. Teachers of gifted students must actively seek sources of funding and grants to acquire and maintain the needed materials for such innovations (Nugeni, 2001). To plan appropriate educational experiences, teachers of gifted students often must acquire materials beyond what they have available in the regular curricular materials (Lewis, 1998). Teachers can find a wealth of resources for this purpose in technology from local businesses, governmental agencies, and organizations.

When various technologies are incorporated into the learning environment, teachers can readily address the individual needs and learning preferences of the gifted student. Learning experiences can be structured to develop student strengths, provide flexible pacing so they have the opportunity to work at their own speed and ability level, and encourage ownership of their learning as active participants (Jones, 1990).

Technology can empower gifted students to create new, original, and innovative products thereby becoming producers of knowledge, rather than simply consumers of knowledge. It can eliminate the need for repetition of previously mastered knowledge and encourage the opportunity to conduct independent research, explore topics and issues at a greater depth and breadth, think critically while addressing real-world situations, and collaborate with other learners to solve problems (Nugeni, 2001). Other authors in gifted education, such as Jones, Lewis, Morgan, Poftak, Renzulli & Reis, Sais, and Washington,
state that technology can empower students to seek new roles as leaders, take new learning risks, and facilitate the learning of others. It gives them practice in using tools that are applicable to the real world. Moreover, integrating technology builds competencies needed for students to become technologically literate in an information-based world (Nugeni).

However, little empirical research examining the effectiveness of integrating technology into the gifted curriculum has been reported in the journals that focus on the gifted learner (Riley & Brown, 1997). The journals report mostly on “best practices” that point out strategies and programs that have been used with particular populations (Nugeni, 2001; Riley & Brown). These usually include using the Internet, distance learning, and the use of multimedia presentation tools.

Reports on best practices have discussed using the Internet as a research tool which provides the gifted learner an opportunity to delve into any topic as deeply and broadly as desired for any assignment. Meanwhile the student is required to be an informed consumer, discerning the accuracy and plausibility of the information presented (Krupnick, 1997; Lewis, 1998). Lewis reports that using the internet allows students to obtain information and communicate with others freely, thereby overcoming the previous impediments of physical, social, and geographic barriers.

The Internet can provide online mentoring of gifted students through connections with universities or industry (Krupnick, 1997). Students can have virtual contact with researchers in the field to pose questions about actual research instead of just reading about results of an experiment. Electronic mail (e-mail), another web-based tool, can facilitate cooperative learning and interaction on the student-to-student level, student-to-
teacher, or the student-to-expert level (Krupnick; Lewis, 1998; Mann, 1994). Students and teachers can connect instantaneously with people from distant lands (Lewis). E-mail can be a good way to facilitate communication between students and their parents (Lewis). Online discussion groups via electronic mailing lists or listservs are available to students which provide a forum with others interested in a common topic, and can provide a way for them to overcome isolation (Ko & Rossen, 2001). Moreover, gifted students can experience the camaraderie of getting to know other gifted students who experience similar intellectual, social, or emotional needs and challenges (Lewis).

The Internet provides a medium for students to publish their work, whether it is a web page of stories, news, or other creative endeavors. Since web pages can be continually updated, they enable gifted students to take control of learning and product development in a continuous fashion (Strot, 1997).

Distance education provides a form of learning that does not involve the regular classroom setting in which student and instructor are both in the same location at the same time (Ko & Rossen, 2001). Telecommunications can be in the form of audio conferencing using speaker phone, online coursework, electronic blackboards, video conferencing, satellite downlinks, and virtual fieldtrips (Adams & Cross, 2000; Ko & Rossen; Mann, 1994). Distance learning can provide differentiation for students who need to go beyond the general curriculum, or students living in remote locations who may not have access to advanced course content (Lewis, 1998; McBride & Lewis, 1993; Southern & Spicker, 1989). Similarly, students with disabilities, illnesses, or injuries unable to attend a gifted class can benefit from distance learning.
Barak (2000) conducted a study in Israel to examine the image of technology education from the students’ point of view and their considerations as they choose their field of study in high school. An attitude questionnaire was developed and administered to “excellent” ninth-grade students in their last year of junior high school. “Excellent” students as defined in this study are high-achievement students. They are students who will enroll in physics studies and are interested in the most optimal course of study in high school from the very beginning. In order to succeed in the fierce competition that exists in Israel over admission into the most desired university institutions, and since a high score in physics in the matriculation certificate increases their chances of admission into such a university, “excellent” students usually enroll in physics. Although they may be interested in electronics, “excellent” students generally do not choose to study electronics because of the heavy scholastic load.

The students in this study were at the stage of choosing subjects to study according to their preferences as they enter high school. The questionnaire was designed to ask students about the nature of technology studies and about the possibility of their choosing technology as a major subject in their future studies in high school.

The sample included 600 students who represented populations from different kinds of settlements, i.e., a large city, a peripheral town, a rural settlement, and a school in an Arab-speaking settlement. Twelve schools with 24 classes were included in the sample. The researchers examined the attitudes of “excellent” students toward the electronics technology program which emphasized conceptual understanding and the development of intellectual skills, such as creative thinking and problem solving through project-based learning. The authors report that two major factors influenced the
motivation of highly talented students to study technology: (a) the desire to learn interesting subjects and (b) the expectation for long-term benefits for students who study both electronics and physics.

Fritz (1998) conducted a study to identify learning environments, attitudes, and outcomes associated with students who excel in technology. The author collected data from students in the Design and Technology program in secondary school, years 7 and 8 in New South Wales. This program is delivered through project-based learning and organized around ten contexts: agriculture; built environment; clothing and accessories; engineered systems; food, health, and welfare; information and communication; leisure and lifestyle; manufacturing; transport; and distribution. She also collected data from regional winners of The Minister’s Young Designers Awards (MYDA). This program challenges students to submit design projects in any area of the ten contexts and to compete with each other for recognition of excellence. The collected data included information about students’ perception of their learning environments, their personal attitudes to it and to the task, and about their perception of the most valuable learning outcomes of their technology project.

The data collection sample included 1,000 students in 18 schools over a two year period. The instrument was an unusual combination of a Likert-type scale and a semantic differential. The questionnaire contained 15 bipolar choices and four open answer questions. The questionnaires were administered by teachers who had been trained in the process. Questionnaires were sent to the teachers of the regional winners of the MYDA with 60 responses collected from the winners.
The open answers were text coded and the results analyzed using SPSS statistics. A discriminate analysis was used to identify the factors that account for the variations in the data. Three factors significantly defined the learning experience: ease, satisfaction, and independence. There were no significant gender differences and no difference for the three major factors related to whether the students worked individually or in groups.

The results showed the major difference between winners and non-winners was the frequency with which the winners appreciated the generally applicable nature of their learning during the project work. That is, they valued their new planning, management and cooperation skills, and reflected more thoroughly about their own learning as opposed to the non-winners. The research findings suggest that to increase excellence in technology education, teachers may need to place emphasis on critical evaluation by students of their own thinking and learning; provide balance between guidance in planning and management; freedom in project definition, making significant decisions, and taking responsibility for their work; and encourage reflection on the nature of their learning processes so students can recognize, value, and guide their own learning.

**Gifted Female Students**

McLester (1998) noted that although girls and boys begin on an even level with technology and show similar feelings and competence with technological activities during their early elementary school years, when girls reach their upper elementary school years, they lose interest in pursuing technological activities. The gender gap continues to widen as educational levels increase. A lack of advanced technological training may exclude females from careers in science, mathematics, and technology.
McLester encourages teachers of the gifted to work strongly to reverse this trend and give girls many opportunities for open-ended exploration. McLester suggests that as students work in cooperative and coed groups, the teacher should ensure equal opportunities for girls to perform high-status, computer-based tasks such as installing new software, loading printers, or monitoring computer labs. He suggests that as teachers design technology-integrated lessons, they should include activities that meet girls' needs for social interaction. Furthermore, he encourages teachers to challenge girls to think beyond the tradition female domains and involve them early on in the areas of mathematics, science, and technology.

**Gifted At-Risk Students**

Gifted at-risk students (those who are culturally diverse, possess multiple exceptionalities, or underachieve) have difficulty engaging in the activities of the classroom if they are bored or unchallenged. They are often self-conscious about being exceptionally different than their peers (Nugeni, 2001). Being uninterested or under-stimulated, these students fall into a conflict cycle of discipline problems, dropping out of school, or harming themselves or others. However, these at-risk students do respond well to technology and will engage with print media when technology is integrated into their curriculum, helping them to develop confidence in themselves, self-reliance, and social adaptation skills (Lieb, 1997). Programs that involve interactive, real-life simulations that require students to confront the consequences of simulated behaviors often appeal to at-risk gifted students (Lieb). New learning communities facilitated through the Internet
can expand the realm of communication and break down some of the barriers that some at-risk populations encounter (Nugeni).

Summary

The work of Dewey (1915, 1916a, 1916b, 1916c) provides the theoretical framework for this study. Specifically, his theories on children’s natural instincts, simulations of occupations, and learning by doing, are the basis for much of the instruction in technology education. Literature related to the development, validation, and use of the Pupils’ Attitudes Towards Technology survey in various countries served to guide the methodology and analyses of the current study (Bame & Dugger, Jr. 1989; Bame et al., 1993; Becker & Maunsaiyat, 2002; Boser et al., 1998; Raat & de Vries, 1985; Volk et al., 2003; Volk & Yip, 1999).
CHAPTER 3

METHODS

Introduction

Chapter 3 addresses the methodological perspective and the mixed method research methodology that frames this investigation and guides the research procedures. A description of the research methodology and procedures specifically used in this study are presented in this chapter. The subjects; the context of the classroom research site; the procedures and timeline for the classroom technology education activities; and the research design, including data collection and analysis; are discussed.

Subjects of Study

This research study was conducted in a suburban, elementary magnet school in Ohio. Data was collected from 20 fifth-grade students, ages 10 -11 years-old who have been identified as having superior cognitive ability (i.e., gifted and talented) according the State Rule of Ohio, and are learning in a full-time, self-contained elementary school classroom. The curriculum is interdisciplinary and integrated with an emphasis on problem-based learning strategies in mathematics, science, and technology. The 20 identified gifted and talented fifth-grade students participated in technology education activities and experiences. Data also was collected from 19 gifted and talented fifth-grade students who did not participate in the TE activities, 21 fifth-grade students in a
regular classroom who did not participate in the TE activities, 17 gifted and talented fourth-grade students who did not participate in the TE activities, 19 gifted and talented fourth-grade students who did not participate in the TE activities, and 25 fourth-grade students in a regular classroom who did not participate in the TE activities (see Table 3.1).

<table>
<thead>
<tr>
<th>Student Groups</th>
<th>5th Grade, Gifted &amp; Talented, Technology Education Activities</th>
<th>5th Grade, Gifted &amp; Talented</th>
<th>5th Grade, Regular</th>
<th>4th Grade, Gifted &amp; Talented</th>
<th>4th Grade, Regular</th>
</tr>
</thead>
<tbody>
<tr>
<td>Girls</td>
<td>9</td>
<td>9</td>
<td>11</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>Boys</td>
<td>11</td>
<td>10</td>
<td>10</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td>Total</td>
<td>20</td>
<td>19</td>
<td>21</td>
<td>17</td>
<td>19</td>
</tr>
</tbody>
</table>

Table 3.1: Research subjects.

Context of Study

For the last 15 years, the researcher has been teaching in a fifth-grade self-contained elementary classroom for students identified with superior cognitive ability. These gifted and talented students require more in-depth and extended curriculum activities. Serving these students requires that they have opportunity to be immersed daily in learning challenges and groupings with their intellectual peers so they can consider problems and issues in depth.
The curriculum for these students was constructed beginning with an alignment to the district’s course of study, which is aligned to the Ohio Academic Content Standards and the Proficiency Learning Outcomes in English language arts, mathematics, science, and social studies. With these standards as a foundation, course work that was challenging, compacted, differentiated, problem-based, and enriched was designed. In order to give an in-depth picture of student performance and progress towards the academic content standards, assessment consisted of classroom-level portfolio assessments that included open tasks and constructed responses, performance tasks, informal assessments, and self-assessments and reflections. Instructional decisions were developed based on assessment data of what students know and are able to do, and was planned to meet individual student learning needs and enhance student strengths. Students in the classroom experienced performance-based assessment, which was ongoing and part of the instructional process to provide feedback for growth. Assessments provided information from which to develop future learning experiences; students were taught and encouraged to have a role in assessment of their progress and learning. As their mentor, the teacher guided the students to view content from multiple viewpoints and perspectives. Students were also assessed using mandated state and local standardized assessments.

The classroom environment and teaching strategies reflected cognitive constructivist pedagogy. The learners in the classroom were actively engaged in constructing their own knowledge as they tried to make meaning through their experiences, interaction with nature, and interpersonal relationships. Constructivist theory addresses higher-order thinking, problem-based learning, and collaborative work skills,
as well as the mission, curriculum, and pedagogy of technology education. In this environment, the students were given the opportunity to develop the habits of thinking, researching, and problem solving necessary to succeed in the rapidly changing world of the 21st century.

The boundaries of the classroom were extended beyond the four walls of the classroom to include local, state, national, and international communities. To promote student appreciation of other members of the community, students’ parents were actively involved in the classroom as partners in the education of their children. With parent support, it was possible to offer students more challenging, enriching, and exciting programs. Guests were invited to come into the classroom to present their talents, experiences, expertise, hobbies, or other interests that would enhance the education of the students in the classroom.

As technological changes sweep through society, children in the new millennium are being raised in a world of instant access to knowledge, a world where vivid images supply information that once was presented through text alone. Students are used to controlling their environment and their flow and access to information through items such as a video game controller, remote control, mouse, or touch-tone phone. In order to give the students the education they need to succeed in the global, technologically-intense world, the classroom learning environment was designed to consider students’ natural learning abilities, their experiences outside of school, and their existing technological competence.

The classroom was a learning environment rich in elementary school technology education (ESTE) activities and experiences that challenged the students to solve
personally relevant, real-life problems. As they were given the opportunity to wonder, question, investigate, and play with new ideas, students could develop social awareness and concern as well as intellectual skills.

The curriculum was planned to engage students in activities in which intellectual outcomes were integrated and related to students’ everyday lives. Issues were addressed to help students formulate an awareness of how their individual learning could impact society. The curriculum in this ESTE program provided students with the opportunity to explore their environment and learn that they can have influence over their own environment to make the world a better place in which to live. The program was designed to develop student awareness and actively engage them in socially relevant situations. By identifying real-world problems; planning, designing, and developing solutions to them; and evaluating their implementation, students engaged in making improvements for their fellow humans.

The teacher was resolved to provide a curriculum designed to promote student opportunities to be actively engaged in meaningful and collaborative learning journeys; experiences designed to challenge students to address concerns about social problems and issues they may confront as adults. Learning avenues were provided to develop student awareness that their contributions to solving problems can make a difference in the larger community and add value to the world. Opportunities were planned for students to connect with the community and the larger world outside the classroom, to participate in the civic life of their community, and become better equipped to succeed in the adult world. For example, students participated in Partners in Conservation, a project of the local zoo, to assist orphaned children in Rwanda, Africa in a variety of ways. This
approach to developing authentic tasks gave the students opportunities that were challenging and multidisciplinary in nature and the chance to take a stand on the driving issues they investigated, as they will eventually have the opportunity to do as they confront pressing social problems as adults.

Students assumed an active role in the classroom through problem-based learning (PBL) activities that connected to their lives. The process required them to become self-directed learners with the desire to know and learn, find needed information, think through situations, solve problems, and present their findings. PBL readily motivates, builds critical thinking and reasoning skills, furthers creativity and students’ independence, and helps them have a sense of ownership of their work. Students initiated and managed many of their own activities. They were allowed to learn from making their own mistakes. PBL strategies enable students to learn a body of essential knowledge to deal with problems that are as close to real-life situations as possible, developing effective use of their knowledge and understanding using an active student-centered approach.

With standards in the forefront, the students and the teacher negotiated what to investigate, set learning goals, decided on problems to solve, and explored through new learning journeys. Actively engaged in planning and decision-making as they approached solving problems, learning involved the act of discovery. Students examined the problem, researched its background, analyzed possible solutions, developed a proposal, and produced a final result. They participated in designing, creating, and evaluating their work. Students were encouraged to make choices so they could become strategic learners who learn how to learn. Through constructing, applying and transferring knowledge, and
refining strategies to solve problems, they should become less dependent upon instruction and more willing to experiment with new ideas.

To foster engaged learning and take ownership of their learning, the students were required to be responsible for developing their own goals in addressing problems that were meaningful to them, based on standards of excellence. Serving as a facilitator of learning and giving students’ choices in decision-making, planning, implementing, and evaluating investigations, the teacher endeavored to help students see themselves as the responsible person in charge of their learning. Recognizing their own strengths and weaknesses, students developed assessments and standards for the tasks they chose, then evaluated their success in accomplishing their learning goals. Student autonomy, drive, and collaboration were reflected in the language of their conversations.

Students were supported with a generative and collaborative approach to problem-based learning. Grouping was flexible within the classroom and organized around collaborative work according to specific instructional purposes. Groups were configured and reconfigured so that each student could work with different people. This flexibility allowed for both heterogeneous grouping as well as forming groups around common interests or needs. Cooperative learning strategies were used to give students experience in working together on a task of interest to them, demanding practical thinking and placing them in simulated roles that accurately portray a picture of the adult world and human progress. Students were given the opportunity to learn to value diversity and empathize with multiple perspectives. They developed skills in communication to learn how to deal with conflicting views. Planning how and what they would learn together promotes collaborative learning as students build teamwork skills, learn from each other,
and work together to solve the problems. Using a PBL interdisciplinary approach
required the students to read and write, research and analyze, think, and calculate for
purposeful communication.

Classroom Procedures and Timeline for Technology Education Activities

The Standards for Technological Literacy, funded by the National Science
Foundation and the National Aeronautics and Space Administration, were developed by
the International Technology Education Association Technology Content Standards
during the Technology for All Americans Project (ITEA, 2000). They define what
students need to know and be able to do to be technologically literate in the 21st century.
The Standards prescribe the student outcomes of the study of technology in grades K-12.

In an effort to develop student technological literacy through the implementation
of the Technology Content Standards in the classroom, TE instructional activities and
experiences were selected to engage students in a variety of problem-based learning
situations as part of their regular instructional program for approximately a 6-month
period of time. The instructional activities were aligned with the Technology Content
Standards. These standards are listed in Table 3.2. Hands-on/minds-on experiences in
fundamental physical science concepts involving simple machines served as a prequisite
to robotics activities. The various activities required different amounts of time, ranging
from a day to several weeks. Students worked in cooperative learning teams of six or
seven and engaged in several team-building activities.
Table 3.2: Technology content standards related to TE activities and experiences.
Activity #1- LEGO DACTA® sets – Month of September. This activity began to build the robotics technology environment in the fifth-grade classroom of gifted and talented students by first introducing and reviewing with students the basic elements of simple machines, such as gears, pulleys, and levers. Using the LEGO DACTA® Gear Set #9610 (The LEGO Group, 1997a), the LEGO DACTA® Pulley Set #9614 (The LEGO Group, 1997b), and the LEGO DACTA® Lever Set #9612 (The LEGO Group, 1997c), the students explored the concepts of simple machines through hands-on/minds-on building activities, investigated the principles and main ideas behind the concepts, and solved simple extension problems. The students worked with a partner, which fostered and enhanced cooperative learning, which is vital throughout the robotics program. The technology education objectives of these investigations relate to Design: Standards 8, 9, and 10 and The Designed World: Standard 16 (see Table 3.3).
Table 3.3: Instructional objectives and technology content standards for LEGO DACTA® sets: Gears, pulleys, and levers.

Activity #2 – Robots - 2 days. In the next activity, students viewed the video *Robots* (A&E Television Networks, 2001) produced for The History Channel® Where the Past Comes Alive™. They examined and discussed the multiple uses of robots from the past to the present, and envisioned future uses. The Technology Content Standards related to the video and class discussions were: The Nature of Technology (Standards 1, 2, and 3); Technology and Society (Standards 4 and 6); Design (Standards 8, 9, and 10); and Abilities for a Technological World (Standard 13). (See Table 3.4.)
Table 3.4: Instructional objectives and technology content standards for activity #2:
View and discuss the video *Robots*.

<table>
<thead>
<tr>
<th>Instructional Activity</th>
<th>Instructional Objectives</th>
<th>Technology Content Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>View and Discuss the Video, <em>Robots</em></td>
<td>To develop student understanding of the characteristics and scope of technology.</td>
<td>The Nature of Technology: Standards 1, 2, &amp; 3</td>
</tr>
<tr>
<td></td>
<td>To develop student understanding of the relationships among technologies and the connections between technology and the other fields of study.</td>
<td>Technology &amp; Society: Standards 4 &amp; 6</td>
</tr>
<tr>
<td></td>
<td>To develop student understanding of the cultural, social, economic, and political effects of technology.</td>
<td>Design: Standards 8, 9, &amp; 10</td>
</tr>
<tr>
<td></td>
<td>To develop student understanding of the role of society in the development and use of technology.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>To develop student understanding of the historical time line of the development of robots in science fiction, through the early engineering of robotic technology in the 20th and 21st century, and on to the most current state-of-the-art robots.</td>
<td>Abilities for a Technological World: Standard 13</td>
</tr>
<tr>
<td></td>
<td>To develop student understanding of the major concepts, terminology, and uses of robots and robotic engineering.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>To develop student problem finding and problem solving in regard to using robotic technology for solutions to real-life problems.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>To develop student understanding of the attributes of design and an understanding of engineering design.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>To develop student understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving for later use in classroom robotics design activities.</td>
<td></td>
</tr>
</tbody>
</table>

Activity #3 - Robotics in the Classroom: A Collaborative Unit for 5th and 6th Grade Students in Science, Math, and Language Arts (Wright Patterson Air Force Base Educational Outreach Office [WPAFB], 2001) – Month of October. The WPAFB curriculum was used to further introduce the students to the development of robotics and the prevalence of robotic technology in today’s world, targeting Design (Standards 8, 9, and 10) and Abilities for a Designed World (Standards 11, 12, and 13). (See Table 3.5.)
The curriculum includes tasks referred to as Authentic Learning Tasks (ALT) that focus on the history and uses of robots, the components of robots, and the design of robots. The curriculum leads students to a transfer activity (in this case, LEGO® MINDSTORMSTM Robotics Invention System™, 2000) in which students apply what they learned to real-world problems by designing, building, and programming their own robot to accomplish designated tasks. Students have the opportunity to modify their solutions until they are successful.
<table>
<thead>
<tr>
<th>Section 1</th>
<th>Section 2</th>
<th>Section 3</th>
<th>Curriculum Connections</th>
<th>Technology Content Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>History and Uses of Robots</td>
<td>Components of Robots</td>
<td>Design of Robots</td>
<td>Science &amp; Technology &amp; Society: Standards 4 &amp; 6</td>
<td>Design: Standards 8 – 10</td>
</tr>
<tr>
<td>1. Robot Uses – Students will examine, through video and discussion, the multiple uses of robots - past, present, and future.</td>
<td>1. Physics and Robotics – Students will demonstrate an understanding of the relationship among mass, force, work, power, and energy, and how those terms have an impact on the selection of robotic components.</td>
<td>1. Robot Designing Using the Scientific Method – Students will apply knowledge of the process of the scientific method as they design a new type of robot.</td>
<td>Abilities for a Technological World : Standards 11-13</td>
<td></td>
</tr>
<tr>
<td>2. Instruction Sequencing – Using logic and sequence, students will write instructions to complete given tasks.</td>
<td>2. Robot Programming – Students will be introduced to different kinds of robot sensors. Students will use distance formulas and ratios, instead of a sensor, to be able to tell a robot how far to move.</td>
<td>2. Robot Design Sketch – Students will make drawings of their robot using the concepts of proportion and scale.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Examining Robotic History Through Writing – Students will infer the impact robots have made on society through history; and demonstrate their knowledge/opinions through writing.</td>
<td>3. Critical Thinking: What Makes a “Good” Robot? – Students will use prior knowledge of robotic components to write a detailed description of the robot they want to design.</td>
<td>3. Evaluation: Was Your Robot a “Good” Robot? - Students will evaluate, through writing, the design of their robots. They will compare and contrast their design with that of an already existing robot.</td>
<td>Language Arts Technology &amp; Society: Standards 4 &amp; 6</td>
<td></td>
</tr>
</tbody>
</table>

Table 3.5: Instructional objectives and technology content standards for robotics in the classroom.

Activity #4 - Forming engineering teams - 2 days. Students participated in team-building activities. The class discussed the purpose of the FIRST/LEGO League to
celebrate the mind by discovering the fun in science and technology while building self-confidence, knowledge, and essential life skills. Some of the logistics of forming a team were discussed. The teacher’s previous experiences served to guide the team formation and to keep all members on each team engaged. Since an extra Mindstorms™ set was available, three teams were formed (two teams of 7 students and one team of 6 students).

Activity #5 - LEGO® MINDSTORMSTM Robotics Invention System™ - Months of October and November. After the completion of the first three sets of activities, students were ready to apply their knowledge in a transfer activity. The LEGO® MINDSTORMSTM Robotics Invention System™ was selected to align with Abilities in a Technological World: Standards 11, 12, and 13. MINDSTORMSTM provides a simple and intuitive way for students to learn to program yet empowers students with a wide range of possibilities. Using the RCX™ programmable microcomputer Lego brick, students can create, modify, and download computer programs to robots that gather sensory information, can learn from their environment, and prioritize their actions. To expand upon the material previously learned, students were given the chance to build and program their own robots to perform specific tasks.

Activity #6 - FIRST LEGO® League Robotics Challenge: CITY SIGHTS! – Months of November through December. The FIRST LEGO® League (FLL) Robotics Challenge is an educational program sponsored jointly by the organization For Inspiration and Recognition of Science and Technology (FIRST) of Manchester, NH and the LEGO® Company. The program inspires a high level of curiosity; stimulates students’ problem-solving ability; and gives them a chance to better understand how careers in science, technology, and engineering relate to their daily lives. With the FIRST
LEGO® League Robotics Challenge, the students had the opportunity to see how the concepts and ideas they learned connected to real-world problems and solutions (The Nature of Technology: Standards 1, 2, and 3 and Technology and Society: Standards 4 and 6).

The FLL program creates an exceptional learning environment that brings with it the excitement of building a robot that is applicable to real-world situations. Competitions are organized throughout the United States and countries around the world. As students master teamwork dynamics and problem solving, they design, construct, program, and test fully autonomous robots (Design Standards 8, 9, and 10). Students are immersed in an atmosphere in which they can explore their own ways of approaching science, mathematics, and technology in positive and non-threatening ways (The Designed World: Standards 16, 17, and 19).

Each year, teams face a complex scenario that requires them to use robotics design to overcome a series of challenges much like those facing society today. The research for this study was conducted during the 2003 challenge, CITY SIGHTS! For this challenge, students took on the role of urban planners who faced very real problems in providing basic services to the inhabitants of the city, including toxic waste disposal, building and housing construction, and energy and food production. Teams learned how to use robotics technology to explore solutions for different cities (Design: Standards 8, 9, and 10 and Abilities for a Designed World: Standards 11, 12, and 13).

The FLL 2003 Challenge: CITY SIGHTS! has two main parts: (a) the robot performance part in which students design, develop, and program an autonomous robot device that can perform more than one task, solve the missions of the challenge, and is
capable of assisting the city planners and employees and (b) the research assignment in which each team has to give a detailed research presentation to a panel of judges that demonstrates the team’s ability to analyze problems, propose new workable robotic technology solutions to meet the needs of the inhabitants of the city, and create a presentation of their research findings and conclusions. The assignment relates to the Challenge for the year and enhances the overall FLL experience. During this phase, students collectively develop their creativity, enhance their research and collaborative abilities, refine their public speaking skills, and become more comfortable with these talents.

The FIRST LEGO® League Teams learned how to design, build, and program prototype robots that were needed to face challenges, obstacles, and restrictions that the scientists, civil engineers, and urban planners of today face on a daily basis. Students became aware of how these people provide the citizens of a city the basic services such as housing, clean water, a safe environment, educational and medical assistance, sustainable energy, mass transportation, and communication venues. Deploying a robot, in place of humans whenever possible, would minimize the risk that city personnel encounter when trying to implement and maintain the smooth operation of their communities. Students were required to consider the variables and factors such as population, finite land and water resources, and unique geographical situations as they explored solutions to the challenges (Design: Standards 8, 9, and 10 and Abilities for a Designed World: Standards 11, 12, and 13).

Students built and programmed their robots to direct them through the challenge course of CITY SIGHTS! This performance required students to combine elementary
computer programming, mechanical design, strategy, and sportsmanship (Design Standards 8, 9, and 10 and Abilities for a Designed World: Standards 11, 12, and 13).

Students studied and analyzed urban problems and proposed new workable robotic solutions, planned strategies, and developed understanding of the various issues and scientific disciplines involved with them in the challenge. One team designed “frogbots” that would test the water quality of their city to detect possible contaminants that may enter the water supply. The “frogbots” could warn the city of terrorists who might try to sabotage our water supply. Another team designed a robot that could screen travelers and baggage entering the Los Angeles airport or the shipping docks. One team created a robot for the homeless in Paris that could inform them in several languages where food, clothing, shelter, and jobs existed that could assist them.

Activity #7 – Tournaments for the FLL 2003 Challenge: CITY SIGHTS! - December and March. The FIRST LEGO League challenge season culminated as teams came together to celebrate Robot design and performance, teamwork, sportsmanship, and documented research -- the criteria judges used to determine award winners and present trophies that signify team technical and performance excellence. The teams made creative presentations of their research, technical knowledge, and robotic solutions through skits, written plays, formal reports, displays, and power point presentations (The Designed World: Standards 16, 17, and 19).

Activity #8 - Guest Speakers and Engineers – Months of October to December, and the month of March. Visiting scientists, engineers and city managers, and community members provided mentorship and support for the robotics teams as they prepared detailed research presentations about urban problems. Local municipal planners, such as
the City Electric Utility Manager, the City Water Utility Manager, and the City
Community Planner, visited the class and described their jobs, discussed water and
electric conservation, and considered alternative energy sources with the students.
Engineers worked with the students on the engineering design process, the technical
tasks, and programming (Design: Standards 8, 9, and 10 and Abilities for a Designed
World: Standards 11, 12, and 13).

Activity #9 - Children’s Engineering and Design Exhibition: A Showcase and
Celebration of Technological Accomplishments in the FIRST/LEGO® League Robotics
Challenge IV: CITY SIGHTS! – Month of May. Teachers at the school were invited to
bring their students to see an exhibition of CITY SIGHTS! including the robot
performance and the research presentations. Parents, relatives, and community members
were invited to the showcase in the evening. (See Table 3.6 for a timeline for the 9
technology education activities and experiences.)
<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Assessment</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>September: The Challenge is released; Registration – May 1 to September 30</td>
<td>Activity #1 - LEGO DACTA® sets Activity #2 - Robots</td>
<td></td>
<td></td>
</tr>
<tr>
<td>October: Students are introduced to the challenge, begin basic curriculum of science concepts and the design process, and begin basic programming skills Select teams and begin assigning team roles. Begin refinement of concepts such as power, torque, gear ratios, and structural strength of design. Assess individual strengths and team contribution. Begin research of science concepts Students conduct research, build and program their robots and prepare presentations.</td>
<td>Activity #3 - Wright Patterson Air Force Base Educational Outreach Office (WBPAF) - Robotics in the Classroom: A Collaborative Unit for 5th and 6th Grade Students in Science, Math, and Language Arts Activity #4 - Forming Engineering Teams Activity #5 - LEGO® MINDSTORMSTM Robotics Invention System™ Activity #6 - FIRST LEGO® League (FLL) 2003 Robotics Challenge CITY SIGHTS!</td>
<td>Team presentations on concepts and completion of lesson skills according to rubric assessment The research and technical components The robot performance component: planning, building, programming, troubleshooting</td>
<td>Discover how math/science concepts are used to solve real-world problems</td>
</tr>
<tr>
<td>November: Select final team roles. Assign other jobs such as programmer, builder, website creation and maintenance, journalist, press and public relations, historian, etc. Begin local competitions.</td>
<td>Activity #7 - Tournament Component for the FLL 2003 Robotics Challenge: CITY SIGHTS! Local, qualifying Regional and State Tournaments The Research and Technical Components</td>
<td>Observation of team interaction and accomplishment of goals and objectives.</td>
<td>Practical application of team management concept of a total project, and career discovery through support roles.</td>
</tr>
<tr>
<td>December: Refine team practices, and begin presentation by class to the school of the team’s progress. Attend regional and state tournaments.</td>
<td></td>
<td></td>
<td>Team pride in accomplishment.</td>
</tr>
</tbody>
</table>

Table 3.6: Timeline of technology education activities and experiences.
Table 3.6 (continued)

March: Attend more local tournaments. Follow up on real-world concepts by asking students to give a presentation on how these concepts are used in other common-place items besides robots (such as automobiles, phones, lawnmowers, etc). Have students design and build an invention of their choice.

<table>
<thead>
<tr>
<th>May:</th>
<th>Activity #8 - Guest Speakers and Engineers</th>
<th>Rubric assessment based on use of scientific method, design process, and teamwork.</th>
<th>Application of skills learned to new situations.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Activity #9- Children’s Engineering and Design Showcase</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Research Design

Rationale for a Mixed Methodology

This descriptive study employed a mixed methodology, combining paradigms to ensure maximum insight and understanding to characterize student attitudes and outcomes related to a specific classroom and specific teaching education activities and experiences. The research was not forced rigidly into either the quantitative or the qualitative paradigm, but the tools from both were used.

Both quantitative and qualitative approaches were used to triangulate the data. As Wright (1999) indicates, research in technology education should include a mixed methodology of quantitative and qualitative studies. Research is called for that uses both
paradigms to provide useful and valuable findings and implications about how
elementary students can benefit from or are affected by technology education.

After extensive review of the research literature in technology education over the
period of 1987-1993, Zuga (1994) reported that 83% of the studies were quantitative with
65% of these being descriptive. These data are similar to those of Foster (1992) who
found that about 92% of 503 graduate research theses in industrial and technology
education were quantitative, and 54% were of the survey type.

Many researchers in elementary school technology education are recognizing the
benefits of using qualitative approaches for inquiry in the classroom. Both Foster (1992)
and Zuga (1994) suggested that the predominance of quantitative descriptive research
reinforces the marginality of qualitative interpretive studies. This predominance informs
only a limited range of problems within a limited context and depth of understanding. It
appears that leaders in the field share the premise that research should proceed along
several lines encompassing a range of research paradigms (Foster, 1992; Foster &
Wright, 1996; Petrina, 1998; Wicklein et al., 1991; Zuga, 1994).

Petrina (1998) offered researchers in the field of TE a comprehensive research
framework for “cultural framing questions.” These questions seek to find out how we
come to practice and understand technology, the purpose of technology education, the
nature of technological knowledge, how the content of the subject should be organized,
how the subject today is influenced by its history, how technology is practiced across
cultures, and who participates in the subject.

As researchers select areas of inquiry that are compelling and valuable to them,
Lewis (1999) reminds them that TE research studies must: (a) relate fundamentally to the
basic claims of the field; (b) ultimately be about learning and teaching and the primary actors in that enterprise must be brought into sharper focus; and (c) share and conform to conceptual frameworks, such as situated cognition and constructivism, that unite technology education with other school subjects. According to Lewis, it is essential to get primary evidence from first-hand, on-site observations. Researchers in ESTE need to be willing to use phenomenological and critical modes of inquiry. In fact, with the shortage of researchers in technology education, teachers themselves can be a rich source of collaborative researchers to assist the field in furthering studies needed to examine the elements of technological literacy (Hoepfl, 1997; Petrina, 1998; Zuga, 1994).

With the predominant research methods being quantitative approaches, Zuga (1994) suggests that the recent use of qualitative research is successfully identifying new issues with respect to elementary school technology education. The influence of foreign researchers from Canada, Australia, Sweden, and New Zealand are providing fresh insights into ESTE practice using qualitative methods. For example, Rowell (2001) conducted case studies to assess students’ understanding of technological tasks and reported data that showed knowledge gain.

Fasse and Kolodner (2000) suggest that research methods should include clinical interview, discourse analysis, and ethnographies of classrooms. Asking the right research questions and using design experiments can help to better understand students’ learning.

The assumptions of any paradigm of inquiry are based on value choices. The role of logic dictates the statements or actions that stem from those values and assumptions (Swepson, 1995). A paradigm for inquiry can be selected according to its pragmatic fitness to the purpose of the research endeavor. The different choices made logically lead
to different methods. Consequently, a mixed methodology is the appropriate choice for the current study.

The quantitative research methods of the study provided tests of “statistical interaction.” Statistical interaction involves the use of statistical procedures that do not meet representativeness criteria. The inability to obtain samples that are representative of the populations from which they came, especially if studied in various settings and at different times, results in the inability to generalize beyond the persons, time, and setting of the original study. When effects of differing magnitude exist, the researcher must delineate when and where the effect holds and when and where it does not (Cook & Campbell, 1979).

The qualitative methods provided in-depth analysis based on “design experiment” in the classroom (Kolodner, 2001). Assuming that qualitative research has to be conducted in complex settings, particularly in the context of curriculum materials development, Kolodner called for powerful methods to do research not only on learning, but also on teaching. A design experiment bases research in classrooms. Basically, what happens in a design experiment is that qualitative researchers engineer the environment to promote learning, take what is known about learning and about practice, and put these together to figure out what should be happening in the classroom to promote learning. Design experiments allow researchers, focused on student and/or teacher learning, to analyze the learning environment in ways that may lead to useful changes.

Kvale (1995) says the trustworthiness and credibility of a study rests in part on the craftsmanship of research and the quality of the researcher, based on the quality of his or her past research and experience in the area. This section presents a reflection of the
researcher’s teaching practice and previous experiences to establish trustworthiness and credibility for the reader. First, a glimpse of the researcher’s academic and professional background and secondly, a description of various awards bestowed upon the researcher will be presented.

The researcher/teacher graduated magna cum laude with a B.S. degree in education from Auburn University in 1974 and with an M.A. in gifted education from The Ohio State University in 1989. For the past 15 years, the researcher/teacher has been a fifth-grade teacher in a self-contained classroom of gifted and talented students at two suburban magnet schools. Previously, she taught learning disabled students for 3 years and developmentally handicapped students for 4 years.

The researcher/teacher has given numerous presentations for teacher groups and has served in nearly two dozen advisor and mentor roles in her school system during the last decade. She is affiliated with many professional technology education organizations and has a lengthy list of professional achievements, including numerous awards earned by the students in her charge. For the past 9 years, she conducted her own unique program, Students and Scientists: Linking for Learning, bringing university researchers and local engineers to the classroom as role models and mentors.

The researcher/teacher was selected for membership in Phi Kappa Phi National Honor Society and the Kappa Delta Pi Education Honor Society, and was in the University Honors Program during her undergraduate years. She was selected for membership in Epsilon Pi Tau, the International Honorary for Professions in Technology in 2000. In 1997, she was selected as an Ohio SchoolNet Software Evaluation program consultant and is a five-time honoree named in Who’s Who Among America’s Teachers.
She was honored Teacher of the Year in 1997 by the Ohio Association for Gifted Children, and is a four-time recipient of the Golden Apple Achiever Award given nationally by the Ashland Oil Company to outstanding teachers. In 1995, she was honored with the Superintendent’s A+ Teacher Award given by her school district. She is a two-time nominee for the Disney Teacher Awards.

In November, 2002, the researcher/teacher received the FIRST/LEGO League Robotics Challenge Coach’s Award at the Toledo Regional Competition for the outstanding performance of three teams, the 20 members of her class. The teams brought home at least nine separate awards from four competitions across Ohio during November and December.

Most recently, in 2004, the researcher/teacher was selected to be a member of the Ohio Department of Education Technology Model Curriculum Writing Team to develop model lessons for the technology curriculum for Ohio’s K-12 students. She was 1 of 10 teachers selected across the country to be a National Science Foundation Classroom/International Technology Education Association Field Test Teacher for Technology Education Curriculum for the Invention, Innovation, and Inquiry Project. She received National Board Certification from the National Board for Professional Teaching Standards in the Fall, 2002. About that same time, she was selected for the National Teacher Advisory Board for Scholastic, Inc., a publisher for educational books and magazines, and currently remains on the Board. She is 1 of 50 teachers chosen nationally from 3,000 applicants.
Data Collection and Analysis

Quantitative Methodology

Students were asked to respond to a survey to assess attitudes and perceptions related to technology and conceptual understanding of technology. The Likert-type survey, Student Attitudes Toward Technology (SATT), was administered using a pretest and posttest design. The original instrument was comprised of 40 statements with a 5-point Likert-type scale ranging from Strongly Disagree (SD) to Strongly Agree (SA). The possible range of scores is 40 to 200. There are 22 items directed toward attitudes and perceptions related to technology; for example, Technology is as much for girls as it is for boys (item 27) and Technology is very important in life (item 33). Seventeen questions are directed toward conceptual understanding of technology; for example, Technology improves the quality of human life (item 12) and To learn technology, you need to understand mathematics (item 30). The 40 items were randomly ordered using a standard statistical chart of random numbers. Table 3.7 provides the format for some sample items on the SATT.
Table 3.7: Sample items from the instrument Student Attitudes Toward Technology.

The original survey instrument was based on examples of PATT-USA provided by Boser et al. (1998). The five attitude sub-scales on the PATT-USA are (a) General Interest in Technology, (b) Attitude Toward Technology, (c) Technology as an Activity for Boys and Girls, (d) Consequences of Technology, and (e) Technology is Difficult. The Concept of Technology items represent a single subscale. As opposed to attitudes, the concept items attempt to arrive at students’ understanding of the role of technology in shaping the world. Table 3.8 shows the items from these categories in the PATT-USA that were included in developing the SATT instrument used in the current study.
<table>
<thead>
<tr>
<th>Item</th>
<th>Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>General Interest in Technology</strong></td>
</tr>
<tr>
<td>23.</td>
<td>I will probably choose a job in technology.</td>
</tr>
<tr>
<td>32.</td>
<td>At school you hear a lot about technology.</td>
</tr>
<tr>
<td>34.</td>
<td>When something new is discovered I want to know more about it immediately.</td>
</tr>
<tr>
<td>39.</td>
<td>Technology is a subject that should be studied by all students.</td>
</tr>
<tr>
<td></td>
<td><strong>Attitude Toward Technology</strong></td>
</tr>
<tr>
<td>2.</td>
<td>There should be less TV and radio programs about technology.</td>
</tr>
<tr>
<td>4.</td>
<td>Technology caused large unemployment.</td>
</tr>
<tr>
<td>21.</td>
<td>Technology does not need a lot of mathematics.</td>
</tr>
<tr>
<td>35.</td>
<td>Because technology caused pollution, we should use less of it.</td>
</tr>
<tr>
<td></td>
<td><strong>Technology as Activity for Both Boys and Girls</strong></td>
</tr>
<tr>
<td>1.</td>
<td>More girls should work in technology.</td>
</tr>
<tr>
<td>3.</td>
<td>Technology is as difficult for boys as it is for girls.</td>
</tr>
<tr>
<td>13.</td>
<td>Boys know more about technology than girls do.</td>
</tr>
<tr>
<td>37.</td>
<td>Boys are able to do practical things better than girls.</td>
</tr>
<tr>
<td></td>
<td><strong>Consequences of Technology</strong></td>
</tr>
<tr>
<td>6.</td>
<td>Technology is good for the future of our country.</td>
</tr>
<tr>
<td>11.</td>
<td>Technology makes everything work better.</td>
</tr>
<tr>
<td>17.</td>
<td>Technology has brought more good things than bad.</td>
</tr>
<tr>
<td>33.</td>
<td>Technology is very important in life.</td>
</tr>
<tr>
<td></td>
<td><strong>Technology is Difficult</strong></td>
</tr>
<tr>
<td>9.</td>
<td>You can study technology only when you are good at both mathematics and science</td>
</tr>
<tr>
<td>18.</td>
<td>To understand technology you have to take a difficult training course.</td>
</tr>
<tr>
<td>20.</td>
<td>You have to be smart to study technology.</td>
</tr>
<tr>
<td>36.</td>
<td>Technology is only for smart people.</td>
</tr>
<tr>
<td>38.</td>
<td>To study technology you have to be talented.</td>
</tr>
<tr>
<td></td>
<td><strong>Concept of Technology</strong></td>
</tr>
<tr>
<td>70.</td>
<td>When I think of technology I mostly think of computers.</td>
</tr>
<tr>
<td>80.</td>
<td>Elements of science are seldom used in technology.</td>
</tr>
<tr>
<td>97.</td>
<td>Technology has little to do with daily life.</td>
</tr>
</tbody>
</table>

Table 3.8: PATT-USA.
The SATT also includes items from the Attitudes Toward Science survey created by Berlin and White (2000). These items are numbered 10, 14, 15, 16, 19, 22, 24, 25, 26, 28, 29, and 40. The remaining items (5, 7, 8, 12, 27, 30, and 31) were developed specifically for this study. (See Appendix A for the Student Attitudes Toward Technology survey.)

Twenty gifted and talented fifth-grade students who participated in technology education activities and experiences responded to the SATT as a pretest and a posttest survey. The pretest was administered during the beginning of the TE activities and experiences during the month of September and the posttest was administered at the conclusion of the activities in May. Additional students were administered the posttest only in May. These students included 19 gifted and talented fifth-grade students who did not participate in the TE activities, 21 fifth-grade students in a regular classroom students who did not participate in the TE activities, 19 gifted and talented fourth-grade students who did not participate in the TE activities, 17 gifted and talented fourth-grade students who did not participate in the TE activities, and 25 fourth-grade students in a regular classroom who did not participate in the TE activities.

Data from the Likert survey Student Attitudes Toward Technology was collected from students and transferred into SPSS (Statistical Package for the Social Sciences 12.0). Items were recoded by assigning a value of 5 to reflect all valued responses. (See Appendix B for recoding of the Student Attitudes Toward Technology). All information was recorded and reported in such a manner that students could not be identified directly or through identifiers linked to the subjects. To assure the accuracy of data tabulation, responses on 20% of the original instrument were compared to the entered data files to
identify any errors. Similar statistical procedures were used to those in previous studies using the PATT-USA (Bame & Dugger, Jr., 1989; Boser et al., 1998).

The following specific statistical analysis procedures were used for the Student Attitudes Toward Technology instrument: (a) posttest responses were analyzed using a principal component analysis to identify item grouping for subscales; (b) Cronbach’s Alpha internal consistency reliability test was computed for the subscales; (c) multivariate analysis of variance (MANOVA) and univariate analyses of variance (ANOVA) were used to identify attitudinal changes from pretest to posttest by gender on the subscales, combined and individually; and (d) multivariate analysis of variance (MANOVA) and univariate analyses of variance (ANOVA) were used to identify attitudinal differences between classes by gender on the subscales for combined and individual subscales.

Students were asked to respond to a pretest and posttest semantic differential to identify attitudes and perceptions related to “Robotics” (see Appendix C). This instrument was adapted from one created by Berlin and White (2000) and has 12 items. Each pair of words uses 5 points and bi-polar adjectives for students to respond to how they feel about robotics. The possible range of scores is 12 to 60. An example is provided in Table 3.9.
Twenty gifted fifth-grade students who participated in technology education activities and experiences responded to the semantic differential “Robotics” designed to measure attitudes and perceptions related to robotics. The instrument was administered at the beginning of this study in September as a pretest and then again at the end of the TE activities and experiences in May as a posttest. All information was recorded and reported in such a manner that students could not be identified directly or through identifiers linked to the subjects. To assure the accuracy of data tabulation, responses on 20% of the original instrument were compared to the entered data files to identify any errors. Items were recoded by assigning a value of 5 to reflect all valued responses. (See Appendix D for recoding of the semantic different “Robotics”.)

The following specific statistical analysis procedures were used for the semantic differential for “Robotics”: (a) Cronbach’s Alpha internal consistency reliability test was computed for both the pretest and posttest and (b) univariate analysis of variance (ANOVA) was used to identify attitudinal changes from the pretest to the posttest by gender.
Qualitative Methodology

Using qualitative interview methods, students were asked to participate in focus group discussions related to robotics and technology education activities and experiences. To gain further insight and understanding of the attitudes and perceptions related to technology, attitudes and perceptions related to robotics, and technological literacy outcomes, 10 focus group interview questions were designed to produce open-ended discussion and reflections and address the three primary research questions along with potential gender differences (see Table 3.10).

1. What new technology skills do you have now that you have experienced robotics?
2. What aspects of technology are particularly good for girls? Boys?
3. Do you think this is the kind of technology program that should be available for you at your next grade level? If so, why? If not, why not?
4. Imagine that you were the teacher. How would you teach robotics differently?
5. Are there any new areas of science and technology in which you are more interested now that you have experienced robotics?
6. How would you describe a robotics program to students from other classes who don’t know about the program?
7. Why do you think students should learn about robotic technology?
8. What is one important thing you learned from our robotics program that you think all students should learn?
9. What do you wonder about now after experiencing the robotics program?
10. After studying about robotics and society, what issues concern you?

Table 3.10: Focus group interview questions.

The interview data was collected at the end of the year in May, after students had engaged in technology education experiences and activities. The conversations and
dialogue were used to gain a better understanding of students’ attitudes and perceptions related to technology and robotics as well as their conceptual understanding of technology. A naturalistic approach to research emphasizes the constructive nature of the knowledge created through the interaction between the participants in interview conversations.

Students were divided into two groups of 9 girls and 11 boys. Although the 20 students had participated in the technology education (TE) activities in three mixed-gendered teams, it was decided to collect this data using all girl and all boy groups. It was expected that the students would be freer to express their opinions without the social dynamics and influences related to the preteen years. The students at this age and at the school year’s end were beginning to experience a high degree of awareness of and distraction by members of the opposite sex. The purpose of the design of the interviews was to eliminate the possibility of these distractions through the use of single-gender groups for gathering of information.

The focus group discussion was conducted first with the girls because it was convenient to do so, and then with the boys. Each group sat around a table with the researcher and a cassette tape recorder in the middle of the table. The students were informed of the goals to gather more information about their attitudes and perceptions related to the TE experiences and activities. The students were well aware of the research objectives and were eager to help with the research endeavor – and as always to express their opinions. Each focus group discussion took 1 ½ hours and was conducted in the classroom.
Focus group discussions were recorded on audiotapes. After recording the discussion, the tapes were transcribed as closely as possible to the original statements. However, some of the girls were soft-spoken and some words were indiscernible. Even though the gist of their statements could be inferred, the researcher refrained from “filling in the blanks.” The data used were statements that were clearly heard. Pseudonyms were used to record and report data related to student responses.

The transcribed focus group interviews were examined to identify emerging patterns in pupils’ attitudes and perceptions related to TE activities and experiences using systematic coding and categorization through content analysis supported by ethnographic summary (Morgan, 1988). One by one, the responses to each discussion question were examined, first for the girls and then for the boys. A content analysis of the responses revealed specific coding and categories which provided a means of sorting the descriptive data for main ideas and themes. A chart of the general ideas expressed in the responses of each focus group member was developed for each interview question. In that way, initial patterns in student responses could be determined. Analysis of preliminary patterns across all students as well as those specific to girls or boys were identified. This process was repeated a number of times to entertain potential alternative themes and patterns. Through this iterative process, specific themes and patterns were confirmed along with supportive direct quotations.

To identify student literacy outcomes related to the Technology Content Standards and to develop a student profile of technological literacy during these learning situations, an observation chart was designed. Observations of Student Performance Related to Technology Content Standards (see Appendix E). The profile chart lists the
Technology Content Standards associated with each of the technology activities and experiences implemented in the classroom.

Students were observed during the activities to develop a student profile of technological literacy. Notes were made about student performance related to the Technology Content Standards during various activities. At the end of each TE activity, students were rated at a “novice” (N), “apprentice” (A), or a “researcher” (R) level of accomplishment which was interpreted as a beginning level (1 point), a developing level (2 points), and an accomplished level (3 points) relevant to their age range. Table 3.11 shows sample items from the student profile Observations of Student Performance Related to Technology Content Standards.

<table>
<thead>
<tr>
<th>Technology Content Standards</th>
<th>Performance Level</th>
<th>Source of Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Novice</td>
<td>Apprentice</td>
</tr>
<tr>
<td></td>
<td>1 point</td>
<td>2 points</td>
</tr>
</tbody>
</table>

**The Nature of Technology**

1. Students will develop an understanding of the characteristics and scope of technology. Activity #2 – Robots

2. Students will develop an understanding of the core concepts of technology. Activity #6 - FIRST LEGO® League (FLL) 2003 Robotics Challenge CITY SIGHTS!

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

Table 3.11: Sample items from student profile Observations of Student Performance Related to Technology Content Standards.
A summary of the data collection and analysis procedures used in this study is provided in Table 3.12. The table depicts both the quantitative and qualitative methodology. The sample of students who participated in data collection for each methodology is provided. Results of these analyses are presented in Chapter 4.
<table>
<thead>
<tr>
<th>Student Groups</th>
<th>5&lt;sup&gt;th&lt;/sup&gt; Grade, Gifted &amp; Talented, Technology Education Activities</th>
<th>5&lt;sup&gt;th&lt;/sup&gt; Grade, Gifted &amp; Talented</th>
<th>5&lt;sup&gt;th&lt;/sup&gt; Grade, Regular</th>
<th>4&lt;sup&gt;th&lt;/sup&gt; Grade, Gifted &amp; Talented</th>
<th>4&lt;sup&gt;th&lt;/sup&gt; Grade, Gifted &amp; Talented</th>
<th>4&lt;sup&gt;th&lt;/sup&gt; Grade, Regular</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n = 20</td>
<td>n = 19</td>
<td>n = 21</td>
<td>n = 17</td>
<td>n = 19</td>
<td>n = 25</td>
</tr>
<tr>
<td><strong>Quantitative</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student Attitudes Toward Technology (SATT) Likert Survey</td>
<td>Pretest/Posttest</td>
<td>Posttest</td>
<td>Posttest</td>
<td>Posttest</td>
<td>Posttest</td>
<td>Posttest</td>
</tr>
<tr>
<td>Analysis</td>
<td>Principal Component Reliability</td>
<td>Principal Component Reliability</td>
<td>Principal Component Reliability</td>
<td>Principal Component Reliability</td>
<td>Principal Component Reliability</td>
<td>Principal Component Reliability</td>
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<tr>
<td></td>
<td>MANOVA</td>
<td>MANOVA</td>
<td>ANOVA</td>
<td>ANOVA</td>
<td>ANOVA</td>
<td>ANOVA</td>
</tr>
<tr>
<td>Robotics Semantic Differential</td>
<td>Pretest/Posttest</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Analysis</td>
<td>Reliability</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td>ANOVA</td>
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<tr>
<td><strong>Qualitative</strong></td>
<td></td>
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<tr>
<td>Focus Group Interviews</td>
<td></td>
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<tr>
<td>Analysis</td>
<td>Content Analysis</td>
<td></td>
<td></td>
<td>Coding</td>
<td>Categorization</td>
<td>Ethnographic summary</td>
</tr>
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<td></td>
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<td></td>
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<tr>
<td>Student Profile</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Analysis</td>
<td>Content Analysis</td>
<td></td>
<td></td>
<td>Coding</td>
<td>Categorization</td>
<td>Ethnographic summary</td>
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</tbody>
</table>

Table 3.12: Data collection and analysis summary.
CHAPTER 4

RESULTS

The organization of this chapter reflects the mixed methodology. Statistical procedures using the Statistical Program for the Social Sciences (SPSS Version 12.0 for MS Windows) were used to analyze responses to the Student Attitudes Toward Technology (SATT) survey and the semantic differential to measure attitudes and perceptions related to robotics (“Robotics”). For the SATT, the following statistical procedures were computed: (a) principal component analysis, (b) reliabilities, (c) multivariate analysis of variance, and (d) univariate analyses of variance. For the “Robotics” semantic differential the following statistical procedures were computed: (a) reliabilities and (b) univariate analysis of variance. Qualitative procedures, including systematic coding and categorization via content analysis and ethnographic summary were used to analyze student responses to the focus group interview questions. Student profiles based on the Observations of Student Performance Related to Technology Education Standards were recorded and averaged across students and by gender.
Quantitative Results

Student Attitudes Toward Technology (SATT) Survey

Principal component analysis is a statistical procedure that offers a high degree of flexibility. This statistical technique simplifies data through reducing the variables to smaller groupings of components characterized by a common dimension or component underlying the data.

To begin the data analysis for this study, data from the Student Attitudes Toward Technology (SATT) survey were entered into an Excel spreadsheet (Microsoft), transferred to SPSS files, and recoded for statistical analysis. Of the original 20 gifted and talented fifth-grade students who participated in technology education (TE) activities and experiences, the data from one student was deleted based upon a test to identify statistical outliers using the default criteria ($p < .0013$) from the statistical outlier analysis of the multiple linear regression procedure. Consequently, subjects included in the principal component analysis were 19 gifted and talented fifth-grade students who participated in TE activities, 19 gifted and talented fifth-grade students who did not participate in the TE activities, 21 students in a traditional fifth-grade classroom who did not participate in the TE activities, 19 gifted and talented fourth-grade students who did not participate in the TE activities, 17 gifted and talented fourth-grade students who did not participate in the TE activities, and 25 students in a traditional fourth-grade classroom who did not participate in the TE activities.

A principal component analysis was computed on the posttest SATT data for 120 subjects to identify underlying variables, or components, to explain the pattern of correlations among the responses to the survey items. The correlations were examined to
reveal if there was significant overlap of items within a subgroup to provide evidence for construct validity.

Based upon the Eigenvalues and total variance explained, a Scree plot of the Eigenvalue by component number was produced. The Rotation Method was Varimax with Kaiser Normalization. Based upon the Scree plot, extraction by Varimax rotation for 2, 3, 4, and 5 components were selected for consideration.

A simple solution structure, based upon the following criteria was used to determine the best solution: (a) the break in the Scree plot and (b) the solution which gives the least number of items split across more than one component. The Scree plot began leveling after five components (see Figure 4.1 for the SPSS Scree plot).

Figure 4.1: Scree plot for posttest SATT

Base upon the simple structure criteria, the 4-component structure was selected as the best solution for the SATT posttest data. Table 4.1 shows the Eigenvalues, percent of variance, and cumulative percent by component.
<table>
<thead>
<tr>
<th>Component</th>
<th>Eigenvalue</th>
<th>% of Variance</th>
<th>Cumulative % of Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.69</td>
<td>14.22</td>
<td>14.22</td>
</tr>
<tr>
<td>2</td>
<td>4.17</td>
<td>10.41</td>
<td>24.63</td>
</tr>
<tr>
<td>3</td>
<td>3.12</td>
<td>7.79</td>
<td>32.42</td>
</tr>
<tr>
<td>4</td>
<td>2.83</td>
<td>7.08</td>
<td>39.50</td>
</tr>
</tbody>
</table>

Table 4.1: SATT principal components summary.

Items with component loadings of .40 or greater for each component were listed and examined for what the components represented conceptually. For the sample in this study, loadings of .40 or greater reflected significance of \( p < .01 \), indicating a strong likelihood of the relationship of the individual items to the construct represented by the components (Ferguson, 1966). The components identified were: Component 1: Student attitudes and perceptions related to gender and technology (Girls and Technology), Component 2: Student attitudes and perceptions related to interest in technology (Interest in Technology), Component 3: Student attitudes and perceptions related to ability to do technology (Ability to Do Technology), and Component 4: Student attitudes and perceptions related to the value of technology (Value of Technology).

There are 9 items associated with the Girls and Technology subscale. This subscale identifies perceived differences between girls and boys in their knowledge of
and ability to do technology. Table 4.2 shows the item numbers from the original instrument, component loadings, and item statements for this subscale.

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Loading</th>
<th>Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>31.</td>
<td>.83</td>
<td>Technology is for boys not girls.</td>
</tr>
<tr>
<td>37.</td>
<td>.80</td>
<td>Boys are able to do practical things better than girls.</td>
</tr>
<tr>
<td>13.</td>
<td>.78</td>
<td>Boys know more about technology than girls do.</td>
</tr>
<tr>
<td>27.</td>
<td>.74</td>
<td>Technology is as much for girls as it is for boys.</td>
</tr>
<tr>
<td>24.</td>
<td>.62</td>
<td>Girls know little about fixing or working with machines.</td>
</tr>
<tr>
<td>3.</td>
<td>.60</td>
<td>Technology is as difficult for boys as it is for girls.</td>
</tr>
<tr>
<td>40.</td>
<td>.55</td>
<td>Girls are discouraged from trying work that involves technology.</td>
</tr>
<tr>
<td>1.</td>
<td>.48</td>
<td>More girls should work in technology.</td>
</tr>
<tr>
<td>16.</td>
<td>.41</td>
<td>Boys are encouraged more than girls to study technology.</td>
</tr>
</tbody>
</table>

Table 4.2: Items loading on the Girls and Technology subscale.

There are 9 items associated with the Interest in Technology subscale. This subscale identifies perceived interest related to technology. Table 4.3 shows the item
numbers from the original instrument, component loadings, and item statements for this subscale.

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Loading</th>
<th>Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.</td>
<td>.83</td>
<td>I look forward to learning more about technology.</td>
</tr>
<tr>
<td>8.</td>
<td>.81</td>
<td>Learning about technology is interesting.</td>
</tr>
<tr>
<td>15.</td>
<td>.71</td>
<td>Technology work is boring.</td>
</tr>
<tr>
<td>39.</td>
<td>.50</td>
<td>Technology is a subject that should be studied by all students.</td>
</tr>
<tr>
<td>30.</td>
<td>.48</td>
<td>To learn technology, you need to understand mathematics.</td>
</tr>
<tr>
<td>34.</td>
<td>.47</td>
<td>When something new is discovered I want to know more about it immediately.</td>
</tr>
<tr>
<td>23.</td>
<td>.47</td>
<td>I will probably choose a job in technology.</td>
</tr>
<tr>
<td>7.</td>
<td>.46</td>
<td>I want to invent something new.</td>
</tr>
<tr>
<td>32.</td>
<td>.42</td>
<td>At school you hear a lot about technology.</td>
</tr>
</tbody>
</table>

Table 4.3: Items loading on the Interest in Technology subscale.

There are 7 items associated with the Ability to Do Technology subscale. This subscale identifies perceptions related to the need for higher intellect and specific
knowledge (e.g., mathematics and science) to do technology. Table 4.4 shows the item numbers from the original instrument, component loadings, and item statements for this subscale.

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Loading</th>
<th>Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>22.</td>
<td>.70</td>
<td>To work with technology you must be very smart.</td>
</tr>
<tr>
<td>9.</td>
<td>.64</td>
<td>You can study technology only when you are good at both mathematics and science.</td>
</tr>
<tr>
<td>20.</td>
<td>.64</td>
<td>You have to be smart to study technology.</td>
</tr>
<tr>
<td>18.</td>
<td>.60</td>
<td>To understand technology you have to take a difficult training course.</td>
</tr>
<tr>
<td>36.</td>
<td>.57</td>
<td>Technology is only for smart people.</td>
</tr>
<tr>
<td>38.</td>
<td>.44</td>
<td>To study technology you have to be talented.</td>
</tr>
<tr>
<td>26.</td>
<td>.43</td>
<td>I am not smart enough to do a job that uses technology.</td>
</tr>
</tbody>
</table>

Table 4.4: Items loading on the Ability to Do Technology subscale.

There are 9 items associated with the Value of Technology subscale. This subscale identifies the value of technology in terms of potential benefits or consequences.
related to quality of life. Table 4.5 shows the item numbers from the original instrument, component loadings, and item statements for this subscale.
<table>
<thead>
<tr>
<th>Item No.</th>
<th>Loading</th>
<th>Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.</td>
<td>.69</td>
<td>Technology improves the quality of human life.</td>
</tr>
<tr>
<td>33.</td>
<td>.65</td>
<td>Technology is very important in life.</td>
</tr>
<tr>
<td>5.</td>
<td>.60</td>
<td>Technology is not good for the average worker.</td>
</tr>
<tr>
<td>28.</td>
<td>.58</td>
<td>Technology helps us to understand the world in which we live.</td>
</tr>
<tr>
<td>25.</td>
<td>.57</td>
<td>Technology has done very little for the average citizen.</td>
</tr>
<tr>
<td>11.</td>
<td>.56</td>
<td>Technology makes everything work better.</td>
</tr>
<tr>
<td>6.</td>
<td>.55</td>
<td>Technology is good for the future of our country.</td>
</tr>
<tr>
<td>17.</td>
<td>.51</td>
<td>Technology has brought more good things than bad.</td>
</tr>
<tr>
<td>35.</td>
<td>.47</td>
<td>Because technology causes pollution, we should use less of it.</td>
</tr>
</tbody>
</table>

Table 4.5: Items loading on the Value of Technology subscale.

Internal consistency reliability estimates for each of the four subscales resulting from the principal component analysis of the posttest SATT responses were computed. Cronbach’s Alpha was .85 for the Girls and Technology subscale, .74 for the Interest in Technology subscale, .76 for the Ability to Do Technology subscale, and .77 for the Value of Technology subscale (see Table 4.6).
A multivariate analysis of variance (MANOVA) with repeated measures related to the four SATT subscales by gender was computed for the gifted and talented students in the fifth-grade classroom that experienced TE activities. These students were administered the SATT both as a pretest and a posttest to explore potential changes in their attitudes and perceptions related to technology. Follow-up univariate analyses of variance with repeated measures were computed for significant MANOVA results.

The MANOVA results, reported as a Wilks’ Lambda, were significant for the main effect of test time and approaching significance for the test time by gender interaction. The main effect of test time was $F_{(5,12)} = 6.15, p = .005$ and the test time by gender interaction was $F_{(5,12)} = 2.60, p = .082$.

Table 4.7 displays the univariate analysis of variance with repeated measures results for the Value of Technology subscale for the main effect of test time and the
interaction effect of test time by gender. The interaction effect of test time by gender

\(F(1, 16) = 8.86, \ p = .009\) was significant.

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Time</td>
<td>371.65</td>
<td>1</td>
<td>371.65</td>
<td>18.25</td>
<td>.001</td>
</tr>
<tr>
<td>Test Time by Gender</td>
<td>180.32</td>
<td>1</td>
<td>180.32</td>
<td>8.86</td>
<td>.009**</td>
</tr>
<tr>
<td>Error</td>
<td>325.82</td>
<td>16</td>
<td>20.36</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*\(p < .05\). **\(p < .01\). ***\(p < .000\).

Table 4.7: Univariate analysis of variance with repeated measures for Value of Technology subscale by test time by gender.

Table 4.8 provides the means and standard deviations for the gifted and talented students in the fifth-grade classroom that experienced TE activities for the Value of Technology subscale. Inspection of this table reveals that the change in mean scores of the girls from the pretest \((M = 32.29, SD = 4.27)\) to their posttest \((M = 30.29, SD = 2.81)\) was significantly different than the change in the mean scores of the boys from the pretest \((M = 36.55, SD = 5.43)\) to the posttest \((M = 25.36, SD = 4.63)\). Figure 4.2 graphically represents this interaction effect of test time by gender.
<table>
<thead>
<tr>
<th>Source</th>
<th>$n$</th>
<th>$M$</th>
<th>$SD$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td>7</td>
<td>32.29</td>
<td>4.27</td>
</tr>
<tr>
<td>Boys</td>
<td>11</td>
<td>36.55</td>
<td>5.43</td>
</tr>
<tr>
<td>Total</td>
<td>18</td>
<td>34.89</td>
<td>5.32</td>
</tr>
<tr>
<td>Posttest</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td>7</td>
<td>30.29</td>
<td>2.81</td>
</tr>
<tr>
<td>Boys</td>
<td>11</td>
<td>25.36</td>
<td>4.63</td>
</tr>
<tr>
<td>Total</td>
<td>18</td>
<td>27.28</td>
<td>4.64</td>
</tr>
</tbody>
</table>

Table 4.8: Means and standard deviations for the Value of Technology subscale by test time by gender.

Figure 4.2: Test time by gender interaction for the Value of Technology subscale
Table 4.9 displays the univariate analysis of variance with repeated measures results for the Girls and Technology subscale for the main effect of test time and the interaction effect of test time by gender. The interaction effect of test time by gender ($F_{(1, 16)} = 3.27, \ p = .089$) is approaching significance.

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Time</td>
<td>31.18</td>
<td>1</td>
<td>31.18</td>
<td>2.73</td>
<td>.118</td>
</tr>
<tr>
<td>Test Time by Gender</td>
<td>37.40</td>
<td>1</td>
<td>37.40</td>
<td>3.27</td>
<td>.089</td>
</tr>
<tr>
<td>Error</td>
<td>182.82</td>
<td>16</td>
<td>11.43</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < .05. **p < .01. ***p < .000.

Table 4.9: Univariate analysis of variance with repeated measures for the Girls and Technology subscale by test time by gender.

Table 4.10 provides the means and standard deviations for the gifted and talented students for the Girls and Technology subscale. Inspection of this table reveals that the changes in mean scores of the girls from the pretest ($M = 37.00, SD = 4.62$) to their posttest ($M = 41.00, SD = 1.00$) appears to be different than the change in mean scores of the boys from the pretest ($M = 28.82, SD = 7.48$) to the posttest ($M = 28.64, SD = 8.09$). Figure 4.3 graphically represents this interaction effect of test time by gender.
Table 4.10: Means and standard deviations for the Girls and Technology subscale by test time by gender.

<table>
<thead>
<tr>
<th>Source</th>
<th>$n$</th>
<th>$M$</th>
<th>$SD$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td>7</td>
<td>37.00</td>
<td>4.62</td>
</tr>
<tr>
<td>Boys</td>
<td>11</td>
<td>28.82</td>
<td>7.48</td>
</tr>
<tr>
<td>Total</td>
<td>18</td>
<td>32.00</td>
<td>7.57</td>
</tr>
<tr>
<td>Posttest</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td>7</td>
<td>41.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Boys</td>
<td>11</td>
<td>28.64</td>
<td>8.09</td>
</tr>
<tr>
<td>Total</td>
<td>18</td>
<td>33.44</td>
<td>8.79</td>
</tr>
</tbody>
</table>

Figure 4.3: Test time by gender interaction for the Girls and Technology subscale
Table 4.11 displays the univariate analysis of variance with repeated measures results for the Ability to Do Technology subscale for the main effect of test time and the interaction effect of test time by gender. The interaction effect of test time by gender \((F_{(1, 16)} = 4.29, \ p = .055)\) is nearly significant.

![Table 4.11: Univariate analysis of variance with repeated measures for the Ability to Do Technology subscale by test time by gender.](image)

Table 4.12 provides the means and standard deviations for the gifted and talented students for the Ability to Do Technology subscale. Inspection of this table reveals the change in the mean scores of the girls from the pretest \((M = 28.57, SD = 3.46)\) to their posttest \((M = 31.57, SD = 3.95)\) appears to be different than the change in the mean scores of the boys from the pretest \((M = 27.82, SD = 4.64)\) to the posttest \((M = 34.91, SD = 4.28)\). Figure 4.4 graphically represents this interaction effect of test time by gender.
<table>
<thead>
<tr>
<th>Source</th>
<th>n</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td>7</td>
<td>28.57</td>
<td>3.46</td>
</tr>
<tr>
<td>Boys</td>
<td>11</td>
<td>27.82</td>
<td>4.64</td>
</tr>
<tr>
<td>Total</td>
<td>18</td>
<td>28.11</td>
<td>4.13</td>
</tr>
<tr>
<td>Posttest</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td>7</td>
<td>31.57</td>
<td>3.95</td>
</tr>
<tr>
<td>Boys</td>
<td>11</td>
<td>34.91</td>
<td>4.28</td>
</tr>
<tr>
<td>Total</td>
<td>18</td>
<td>33.61</td>
<td>4.37</td>
</tr>
</tbody>
</table>

Table 4.12: Means and standard deviations for the Ability to Do Technology subscale for test time by gender.

Figure 4.4: Test time by gender interaction for the Ability to Do Technology subscale
There were no significant main effects of test time and gender for the Interest in Technology subscale. There was no significant interaction effect of test time by gender for the Interest in Technology subscale.

An additional MANOVA was used to compare the posttest responses across the four subscales for the students in the two classrooms of gifted and talented fifth-grade students. Follow up univariate analyses of variance were computed for significant MANOVA results.

The MANOVA results, reported as a Wilks’ Lambda, were significant for the main effects of class and gender and approaching significance for the class by gender interaction. The main effect of gender was $F_{(4, 30)} = 5.04, p = .003$; and the main effect of class was $F_{(4, 30)} = 4.55, p = .005$; and the class by gender interaction was $F_{(4, 30)} = 2.31, p = .081$.

Table 4.13 displays the univariate analysis of variance results for the Girls and Technology subscale for the main effects of class and gender and the interaction effect of class by gender. There is a significant interaction effect of class by gender ($F_{(1, 33)} = 8.83, p = .005$).
Table 4.13: Univariate analysis of variance for Girls and Technology subscale by class by gender.

Table 4.14 provides the means and standard deviations for the gifted and talented girls and the boys in the two fifth-grade classrooms for the Girls and Technology subscale. In the fifth-grade classroom that experienced technology education activities, this table reveals that the mean score of the girls ($M = 41.50, SD = 1.69$) was considerably higher than the mean score of the boys ($M = 28.60, SD = 8.53$). In contrast, in the fifth-grade classroom that did not experience technology education activities, the mean score of the girls ($M = 34.10, SD = 4.79$) was more similar to the mean score of the boys ($M = 32.78, SD = 5.78$). Figure 4.5 provides a graphic representation of this significant interaction for the Girls and Technology subscale.
Table 4.14: Means and standard deviations for the Girls and Technology subscale by class by gender.

<table>
<thead>
<tr>
<th>Source</th>
<th>$n$</th>
<th>$M$</th>
<th>$SD$</th>
</tr>
</thead>
<tbody>
<tr>
<td>With Technology Education</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td>8</td>
<td>41.50</td>
<td>1.69</td>
</tr>
<tr>
<td>Boys</td>
<td>10</td>
<td>28.60</td>
<td>8.53</td>
</tr>
<tr>
<td>Total</td>
<td>18</td>
<td>34.33</td>
<td>9.12</td>
</tr>
<tr>
<td>Without Technology Education</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td>10</td>
<td>34.10</td>
<td>4.79</td>
</tr>
<tr>
<td>Boys</td>
<td>9</td>
<td>32.78</td>
<td>5.78</td>
</tr>
<tr>
<td>Total</td>
<td>19</td>
<td>33.47</td>
<td>5.18</td>
</tr>
</tbody>
</table>

Figure 4.5: Class by gender interaction for the Girls and Technology subscale
Table 4.15 displays the univariate analysis of variance results for the Interest in Technology subscale for the main effects of class and gender and the interaction effect of class by gender. There is a significant main effect of class ($F_{(1,33)} = 8.11, \ p = .008$).

<table>
<thead>
<tr>
<th>Source</th>
<th>$SS$</th>
<th>$df$</th>
<th>$MS$</th>
<th>$F$</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class</td>
<td>164.80</td>
<td>1</td>
<td>164.80</td>
<td>8.11</td>
<td>.008**</td>
</tr>
<tr>
<td>Gender</td>
<td>55.56</td>
<td>1</td>
<td>55.56</td>
<td>2.73</td>
<td>.108</td>
</tr>
<tr>
<td>Class by Gender</td>
<td>6.80</td>
<td>1</td>
<td>6.80</td>
<td>.34</td>
<td>.567</td>
</tr>
<tr>
<td>Error</td>
<td>670.86</td>
<td>33</td>
<td>20.33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>45265.00</td>
<td>37</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < .05. **p < .01. ***p < .000.

Table 4.15: Univariate analysis of variance for Interest in Technology subscale by class by gender.

Table 4.16 provides the means and standard deviations for the gifted and talented students in the two fifth-grade classrooms for the Interest in Technology subscale. Inspection of this table reveals that the mean score of the students in the fifth-grade classroom that experienced technology education activities ($M = 36.89, SD = 4.42$) was significantly higher than the mean score of the students in the fifth-grade classroom that did not experience technology education activities ($M = 32.47, SD = 4.73$).
Table 4.16: Means and standard deviations for the Interest in Technology subscale by class by gender.

Table 4.17 displays the univariate analysis of variance results for the Value of Technology subscale for the main effects of class and gender and the interaction effect of class by gender. There is a significant main effect of class ($F_{1,33} = 7.96, p = .008$).

Table 4.17: Univariate analysis of variance for Value of Technology subscale by class by gender.

* $p < .05$. ** $p < .01$. *** $p < .000$. 

---

<table>
<thead>
<tr>
<th>Source</th>
<th>$n$</th>
<th>$M$</th>
<th>$SD$</th>
</tr>
</thead>
<tbody>
<tr>
<td>With Technology Education</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls</td>
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* $p < .05$. ** $p < .01$. *** $p < .000$. 

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Table 4.17: Univariate analysis of variance for Value of Technology subscale by class by gender.
Table 4.18 provides the means and standard deviations for the gifted and talented students in the two fifth-grade classrooms for the Value of Technology subscale.

Inspection of this table reveals that the mean score of the students in the fifth-grade classroom that experienced technology education activities \((M = 33.61, SD = 4.37)\) was significantly higher than the mean score of the students in the fifth-grade classroom that did not experience technology education activities \((M = 28.11, SD = 6.73)\).

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Table 4.18: Means and standard deviations for Value of Technology subscale by class by gender.

There were no significant main effects of class and gender for the Ability to Do Technology subscale. Also, there was no significant interaction effect of class by gender for the Ability to Do Technology subscale.
"Robotics” Semantic Differential

Gifted and talented students in the fifth grade classroom that participated in technology activities and experiences were administered a pretest and posttest semantic differential to measure attitudes and perceptions related to robotics. Inspection of Table 4.19 indicates that both the pretest and posttest were reliable. For the semantic differential measuring attitudes and perceptions related to robotics, Cronbach’s alpha for the pretest was .89 and Cronbach’s alpha for the posttest was .70.

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<td>18</td>
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Table 4.19: Internal consistency reliability (Cronbach’s Alpha) for the pretest and posttest semantic differential to measure attitudes and perceptions related to robotics.

A univariate analysis of variance with repeated measures was used to compare the scores for the pretest and the posttest semantic differential to measure attitudes and perceptions related to robotics by gender. Table 4.20 indicates that there was a significant trial by gender interaction for attitudes and perceptions related to robotics ($F_{(1, 16)} = 5.31, \ p = .035$).
Table 4.20: Univariate analysis of variance with repeated measures for attitudes and perceptions related to robotics by test time by gender.

Table 4.21 presents the means and standard deviations for both the pretest and posttest for attitudes and perceptions related to robotics by gender. Inspection of the means indicates that attitudes and perceptions related to robotics of the girls ($M = 46.43, SD = 6.43$) were less positive on the pretest than that of the boys ($M = 50.54, SD = 5.22$). However, the attitudes and perceptions related to robotics of the girls ($M = 50.29, SD = 3.25$) were more positive on the posttest than that of the boys ($M = 45.55, SD = 8.72$). This interaction effect can be clearly seen in Figure 4.6.
<table>
<thead>
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Table 4.21: Means and standard deviations for attitudes and perceptions related to robotics by test time by gender.

Figure 4.6: Test time by gender interaction for attitudes and perceptions related to robotics
Qualitative Results

Focus Group Interviews

Student responses in the focus group interviews were subjected to content analysis, systematic coding, and categorization. Using an iterative process, three main themes emerged related to technology education: (a) gender roles, (b) gender and work habits, and (c) student literacy outcomes. Each of these themes are discussed and supported by direct quotes from students (ethnographic summary.) Patterns in the focus group discussions reflect the nature of focus group interview methods. That is, students picked up on one another’s comments, sometimes echoing their responses, extending them, or building upon remarks.

Technology Education: Gender Roles

The girls indicated that they wanted to have new chances and opportunities related to technology education. Many of the girls, including Samantha, Erin, Reagan, Amy, and Alyssa saw themselves as capable of and interested in learning technology. They did not express a stereotypical view about girls and their inability to do technology. For example, Amy said,

Well, I learned how to program and stuff. And then I learned how to build and how to analyze what robots were the best and how to build them.

Reagan echoed this perception at various times during the focus group interview. “I learned how to program more this year.” “And I think I learned a lot more just about how the gearing and just how things work.” “I think I like programming.” Erin talked
about her ability to program and build even though that was not her preferred activity as part of the team.

I’m not a programmer but I learned how to program the robot. . . . And I learned how many times one thing in the program has to be adjusted for the robot. . . . I learned how to program the robot.

Alyssa referred to her learning how to work with various types of sensors and adjust computer programming blocks that controlled timing.

I learned how to use smaller blocks of time because last year when we did robotics we used large blocks. I learned to use smaller blocks of time and work with [rotation] sensors.

Jessica mentioned that some girls were reluctant and less confident in their own abilities regarding technology. “. . . it’s just that the girls didn’t think they could do it and they didn’t believe that they could so they didn’t try. . . .” According to Jessica, the girls often shut down and backed down when boys became assertive.

In contrast, typical gender stereotypes and roles related to technology were noted in the conversations of the boys. They agreed that boys have more opportunities at an earlier age to build and construct and use technology in their home environment. Their toys include building blocks, construction toys, video games, and computer games. For example, Michael and Sam articulated this perception.

I think the reason the girls might not like technology so much is because you always see boys playing with video games all the time and computer games. And we usually, we want to know about the games and stuff. And we think computers are cool, but girls they usually think, “Oh that’s too boyish,” or something.

. . . like you don’t see many girls getting a Lego – a 10,000 piece Lego thing for their birthday, but you see tons of boys asking, “Oh, I want this Lego thing,” because they have the patience and time to take days or weeks to build something. And girls don’t have, I think, the patience to do something like that.
Conversations with the boys revealed that many thought girls were not suited for technology education activities, except for the research part. They expressed that girls were too concerned about how they would appear. Sam noted,

I think boys do want to do the technology more than girls. They kind of back off and do like the research. Yeah, the research, and because they think like the boys are like supposed to do [building and handling the robots]. And they’re afraid ‘cuz like they’re girls and they don’t do that kind of stuff.

Frank remarked,

Maybe it’s just that the girls are afraid to try something because it might not work and they might think it would make them look bad because it didn’t work. . . . They want to build something that works -- yeah -- the first time.

Boys also perceived that girls are afraid to make mistakes. They thought girls had difficulty taking risks for fear of failure and were concerned how they would appear to others if they failed.

Boys thought girls don't want to understand how things work, but that girls should be provided with technology opportunities. They thought that girls really aren't interested and don't want to learn technology. Sam observed that girls “are more compassionate than more aggressive. So they don’t want to try anything.” Sam also felt that girls “just don’t have any interest in it. . . . If they wanted to try it, they’d probably do a lot better.”

Stephen added,

It’s not an insult or anything, but sometimes the little tiny mistakes can sometimes get the girls really upset. And you somewhat have to like show that it’s not that horrible if it [robot] doesn’t complete a task first thing.

The consensus was that maybe there is hope for the girls, if they are immersed in
technology; then, they would get interested in it. Sam commented,

Maybe they’re just not experienced in it and that’s why they don’t like it. It may be that they’d want it if they got experienced in a lot of technology. They’d start getting interested in it and then maybe they’d start excelling and have patience.

Technology Education: Gender and Work Habits

Work habits such as patience, perseverance, and teamwork surfaced often during the discussions with both girls and boys. However, their perceptions were completely contradictory. Each gender attributed positive attributes to their own gender and negative attributes to the other gender.

Many of the girls brought up the work habit issue of perseverance when working on technology education activities. Reagan clearly expressed this need.

One thing – well I also learned never give up and you really have to have perseverance. But one thing I learned was that even if something goes wrong -- something could always happen and you can always fix it, and it’s not about everything being perfect. And it’s not about winning, but it’s about doing the best you can do.

The girls perceived boys as being less persevering and patient, especially when changing individual variables and taking incremental steps. They said boys keep starting over from scratch instead of changing and improving one thing at a time. Girls saw themselves as better able to troubleshoot and fix problems, and as having more common sense and patience than boys. They said girls get less frustrated. Alyssa said,

Well, I think girls are better at programming because usually they don’t get as frustrated after a lot of tries. When things don’t go exactly right, they keep on trying.
I think one of the things you learn in robotics is perseverance, like to try again. And if it doesn’t work you accept it and try some more.

Samantha responded,
Well girls really, well I think Alyssa was kind of right. I mean we have more like patience like to do the stuff. So like if we tried something and if didn’t work, we’d change just a little thing and then we’d try it again, and so on. The boys would just try and if it didn’t work, they’d just change it totally and then go back. And if it didn’t work again, they maybe would change a little bit sometimes, but then they’d change it all.

Sara summed up the girls perceptions in this regard saying,

Well, I agree with Alyssa that you should never give up . . . and that you should keep trying and not just start over from scratch. If you have an idea, just try and make it work.

I think the girls have more common sense and try something simpler before they get so advanced and they just have more patience.

Jessica and Alyssa offered explanations for this perceived difference in work habits.

Jessica expressed,

I think it’s because the boys - they’d think, “it would be really cool if we could do this,” so they’d try to get it to work and if it didn’t work, then everything got messed up. But the girls always just do simple stuff and see if they can get it to work before they get more advanced.

Alyssa gave a different explanation, “I think that boys are really less organized than girls.”

Contrary to what the girls perceived, the boys said that they have many more ideas than girls did, more perseverance and patience to stick to something, and that girls have no patience. For instance, Stephen thought boys have more perseverance and tolerance for not doing something right the first time. Like Michael worked on his program for six months I think until he figured it out right. He worked on it from November to the end of May until it finally worked, yet he like never got totally – I mean trust me – I mean he was frustrated that he couldn’t test it out on our robot all the time, but he kept with his program. And he wasn’t frustrated that it didn’t work the first, second, and thirtieth times.

. . . sometimes boys have a little bit more patience.
Boys perceived themselves as having more perseverance than the girls. Frank stated, “The boys are ready to just jump in and try something, and then try again.” The boys expressed that they often had to redo the girls’ work since girls don’t try to fix their work. The boys felt that they had the drive to implement their ideas whereas girls did not. Sam indicated this perception three different times during the focus group interview.

Boys have more interest in making things work because usually the girls just try to make it and if it doesn’t work, “Oh, well!” . . . not fix it up.

They don’t have the patience to correct it.

They will build like a mechanism, ok? Sorta’ like the crane thing, ok? If it doesn’t work - “Oh, well.” They just won’t try to fix it at all. . . .

Boys complained that girls won’t listen to boys, “who know how,” but boys will listen to girls. Stephen expressed his opinion:

. . . when they build something and it doesn’t work, sometimes they don’t throw it away, but yet they don’t really try to fix it. They just keep trying to do it over and over and over again until they think – until it works. And then sometimes when a boy . . . tries to tell them – show them help – ‘cause they know how they can fix it, they won’t take it because it’s a boy that’s giving them the advice.

Or when a girl gives them advice, they’ll listen to it fully. Where when a boy gives it to them, they won’t even – it’ll just go in one ear and out the other . . . at the speed of light!

The issue of teamwork was mentioned many times by the girls and infrequently by the boys. Girls thought they were more inclined to work well in cooperative groups than boys. The girls wanted to work toward developing better teamwork skills, such as how to come to a consensus of opinion and how to develop their own ideas, while still working cooperatively in a team. For example, Amy reflected, “What I learned is when you have an idea you have to learn how to cope with it and develop it to make it work
while working in a team.” With confirmation from each other, several girls captured this
general perception. Erin stated,

I think the most important aspect of robotics is learning how to cope with your
team and working together.

Girls believed boys would rather work on their own, preferred to do things their
own way, would not ask for help, and have an “all or none” attitude. Their perception
was that girls were open to boys' ideas, but not vice versa. Amy said,

I think boys, they like to build things on their own. And in our group they
wouldn’t let the girls help build anything. And they’d like get something started
and the girls would want to do stuff, but they won’t let you help because they are
too occupied – because it’s their idea.

Alyssa expressed,

The important thing is that we were able to not get mad at them [boys] too easily
and were able to just kind of deal with it – with different ideas. And Erin and I
kind of did our own thing for awhile, but then we started getting into the robotics
more, and the boys started doing a little bit of the research and stuff like that, so I
think we learned how to deal with people!

A few boys expressed a similar viewpoint. For example, Frank remarked that
working in teams required tolerance of others. “You learn to work together with people
that you might not be so fond of.”

Technology Education: Student Literacy Outcomes

Several indicators of student literacy outcomes associated with technology
education were noted consistently throughout the dialogue of both the girls and the boys.
Many students elaborated on problem solving, research, connections to mathematics and
science, and teamwork.
The dialogue seemed to naturally group around specific technology literacy outcomes as expressed in the Technology Content Standards. This could have been due to the type of questions asked in the focus group interviews or the nature of the instruction in the classroom. Consequently, the findings are presented as they relate to the Technology Content Standards. However, the Standards at times, overlap and are not easily separated. In particular, student comments often merged in relation to The Nature of Technology (Standards 1, 2, & 3), Technology and Society (Standards 4 & 6), and Abilities for a Technological World (Standards 11, 12, & 13). Words and phrases from the standards were used to guide the analysis of student responses generated in the focus group interviews. These are included to assist the reader in understanding the relationship of student comments to technological literacy outcomes.

Key ideas used to guide the analysis related to The Nature of Technology (Standards 1, 2, & 3) include: (a) characteristics and scope of technology, (b) core concepts of technology, and (c) connections to other subjects. Students expressed that they valued technology education activities and experiences because they extended their knowledge and understanding about the nature of technology and transferred to personally relevant real-life situations. For example, Alyssa stated,

I think you should do robotics because today . . . in our world a lot of things are surrounded by technology and all the greatest discoveries are mostly in technology. And when we grow up it’s probably going to be most of what the world is. It’s mostly going to be technology ‘cause now the older ways of doing things like writing letters and sending them in the mail is really fading out and instead we use computers to send emails.
Both girls and boys were curious and wanted to continue to learn more about “how things work,” such as how infra red signals work, how motors work, how a computer works, and how programming controls a robot’s actions. Janine shared,

I was wondering how the infrared thing – how the RCX can understand it . . . . How flashes [of light] . . . how can it change that into commands . . . . Like how can the RCX make it into a command? All it is - is a light.

Donald also wondered about the RCX,

I still wonder how when you download the infra red light beam . . . [how it goes] into the RCX and how the RCX contains information off the computer.

Michael shared with the group,

I wonder what actually makes the motor turn – besides the electricity that turns the motor . . . the gear train . . . so what really makes motors tick?

Jessica also wanted to understand more about the operation of motors.

I don’t know how the motors – how they actually – why they work. I mean ‘cause you have to spin them when they’re not powered up to the RCX. You have to spin them on their own, but what causes them to turn?

Samantha added,

. . . I think that’s something that’s just really interesting. Because when you have a motor and then you spin it, it moves, but then when you power it up to the RCX, I mean how does it work? I know it has a wire that goes to it, but what’s inside it to make it work?

The Nature of Technology Standards includes an awareness of technology careers. Students expressed an eagerness to keep learning and some had planned to attend summer technology camps to learn more about computer language and programming. For example, Mason said,

I’ve learned a lot from robotics and personally I want to go on to harder technologies like computer languages now that we’ve done robotics . . . . I was interested in computers a little bit before and this helped me . . . . I’m much more interested in programming and computer language.
Several students shared that they were thinking about their future careers. For example, Frank indicated,

Since I’ve started robotics, I’ve been much more interested in all areas of science. Personally, I actually plan to pursue a career in robotics technology.

Sara shared her thinking about her future career saying,

Now that I have experienced robotics and learned more about technology, I kind of wonder what job I’m going to do -- if it’s going to be about technology or if it’s going to be about something else.

Boys expressed a growing interest in various career fields related to technology such as architecture, building and construction, and neurology. Sam shared his interests “in building robotics and programming things.” Allan noted, “...because I’ve done robotics, I want to do building more...construction.” After working with the LEGO MINDSTORMS® RCX programmable brick, the “brain” of the robot, Nicholas was interested in a career in the neurosciences. Specifically, he said he was interested in “neurology.” Several students indicated confidence in their abilities to pursue difficult careers and attend high ranking universities. For example, Jared discussed his current hope to attend a particular university, “Stanford.”

Many of the students made connections between technology, science, and mathematics bringing coherency and relevancy to the curriculum. Several students expressed the relationship between the technology activities and experiences in the classroom and future career opportunities. For instance, Amy offered,

I think you should teach robotics because it does teach them science and math and science and math will help you when you go to find a job. And if you’re not introduced to robotics, they might be good at it, and they don’t know it and then if they do know they’re good at it, they might want a job in it.

Frank elaborated on the connections between technology and other subject areas.
Well I think personally that robotics technology education should be available from fourth grade, which is when I started, throughout one’s education. I think it really helped with problem solving and getting ideas down and it really helps in other areas too – not just technology. Like for instance, other science classes, math, and any class that would involve computers because you learn a lot about problem solving.

Key ideas used to guide the analysis related to Technology and Society (Standards 4 & 6) include: (a) understanding of the cultural, social, economic, and political effects of technology and (b) understanding of the role of society in the development and use of technology. Involvement in TE activities increased student awareness of the impact of technology on society. They indicated an awareness of history, innovation, and invention and demonstrated a growing awareness of societal needs. Erin indicated her interest in the larger, global community after conducting research for the FLL Challenge CITY SIGHTS! saying,

I liked researching about Paris and learning how many homeless people there are and how much – how little space they have. And so it felt good to know about all the stuff that happens over in a foreign country, other than in the United States.

Students expressed concern for the impact of technology on people in society. Jessica reflected an awareness and concern for the safety of people in communities when she said,

I’d like to learn – I didn’t know there were so many problems that . . . weren’t being seen to. They were just left there. Like when we did our research, our research was on the water treatment plant and they didn’t test for as many other things. There could be some other kind of germ, but they just test it for a few things. But I didn’t know that ‘cause there could be some possibility that’s its in the water. So I didn’t know that any of these problems . . . actually existed.
Amy added,

I’m not really so concerned about robots in the future, like making our beds or anything. But I’m kind of concerned about like what robots can do to . . . to help us people . . . that could affect people and their health.

Reagan contributed that she thought,

. . . robotics can help people but I personally don’t think society is ready for it. You know, they’re so used to humans being on top and nothing comparing to humans and everything. And you know, if you suddenly have this technological thing that’s up there right along with you, you know, I don’t think we’re prepared for that – emotionally . . . . I’m not so concerned about how smart they’re going to get. I don’t think they are going to take over the world or anything, but I guess I’m worried about how society feels.

How society will deal with robots of the future seemed to big a concern to all students. Noting the efforts to create robots with human characteristics and expressions of feelings, Amy went on to say,

I’m . . . more interested in humanoid robots because I was watching [Robosapiens] . . . because there’s all these things they can do . . . for us . . . but they’ve still got a long, long way to go on it. They are seeing like if they [robots] can learn stuff like a baby growing up.

Alyssa added her thoughts about human-like robots focusing on possible ethical questions that might be involved with robotic technology.

Whenever you watch like old movies . . . the robot [is doing something wrong] . . . [you can] get up and . . . switch off his off button or something like that.

On the movie we watched last night, Robosapiens, they had this little robot. Well they had a couple of them. One’s called Kismet, who they’re trying to give a personality to, and they said like “Where’s Kismet?” And they’re trying to get the emotions into the robot, you know . . . . So it’s like there’s a lot of issues we have to think about . . . but one thing they showed was this little bitty robot . . . He was cute . . . and the lady said “Come on now it’s time to go to bed . . . and he said “I don’t want to go to bed!” And she picked him up and turned him off, put him in a sleeping bag, and zipped the bag, and said, “That’s one thing you can’t do with a human child!” I guess the idea is that eventually . . . if the robot’s small, I mean what are you going to do? Turn it off? . . . but if you turn it off . . . it’s like a little
human . . . . If you make a bunch of robots that think for themselves . . . you know it’s like mass production of humans.

Jessica remarked about the consequences of turning off a human-like robot saying, “then they’re going to remember what happens right when it comes back on . . . .” Alyssa, too, was curious about the future regarding the use of robotic technology.

I wonder when they figure out how to make robots that can think on their own. I wonder what will happen when that happens. Will the robots go against us because people who develop them, will they worry about how the robots feel?

Well I’m concerned . . . . I wonder if they do get so smart that the robots have their own brain, because in the future that’s what they’re kind of aiming for. They’re kind of aiming for a robot that can think for itself almost – and if they do that – like people go against other people. So robots could go against themselves or us. There could be a genocide almost because the robots would be different, and they might go against us humans.

Ethical issues continued to surface as Alyssa remarked,

When I think of robots like thinking for themselves, I think of a human. I mean I’m thinking they’ll have all these different . . . human characteristics . . . but what’s it going to be . . . . It won’t be a robot ‘cause it’ll be a mechanic human.

Boys indicated similar concerns about the future of robotic technology, as Nicholas expressed,

I wonder how robotics will turn out in the future and how it will succeed . . . and how robots will take over the world.

Alyssa noted the impact robotics technology has on our world,

I think I discovered how far the robots have come since they have been first invented. When you first read us that novel – how people thought that robots would become smart and take over the entire world - well when we watched the robot video [Robots] to figure out more things - like what had happened in between [then and now] . . . . we found out more about how much farther the world has come through robotics – like the Honda robot.
Student conversations revealed a developing ability to access the impact of products and systems. Frank mentioned,

I’m still concerned with the whole, like I’ve heard of multiple times, where the scientists know – like think an idea and they build it. But people think it might be unethical or it is politically incorrect to do something like that. Then a good idea like that would just go to waste because people don’t think it’s politically correct.

Stephen expressed a similar concern regarding the use of novel ideas, such as the one his FLL team had designed – an underwater frog-type robot that would monitor a city’s water supply for contaminants. He said,

I think we had good ideas like the “Amphibobot” sitting there, but they [scientists, politicians] don’t use them. I mean they think of the idea, but they don’t use them. . . . Like it’s done – it’s over with!

Students expressed a growing awareness that they could make an impact on society with their own learning. Frank said,

I think students should learn that they have a part in the development of robots and it’s not just the scientists and they have to just sit back and wait for things to come out. They should have some part in the development of things too.

Alyssa advised others saying,

If you’re just thinking to yourselves, “Oh, I can’t do anything like help the world with robotics . . . but somebody has to . . .” you should learn about robotics and technology even if you’re not getting the connection right away ‘cause then over the years, I think you’ll get better and I think you should really consider it.

Students indicated a desire to learn more about robot technology in order to correct problems in society. Sara shared,

I didn’t really realize that there were so many things that robots can do for us – and help our world – and like fix a lot of our problems.

I like learning about Los Angeles because it’s really, really crowded there and we learned about the airports and how crowded they can be ‘cause Los Angeles is a really busy place and lots of people go there. And we learned about how many
problems could be there, like pollution and just like fogs and those kind of things. It was fun to learn about some other things besides like Ohio where we live.

Amy and Alyssa, respectively, reflected their interest in addressing larger societal concerns,

I didn’t know there was so much robots can do and I . . . want to learn more about how they can help our world.

I think that when you would get your robot all ready and you would download a program and it would work, it would feel really good if it worked. And it’s just kind of a good feeling. And I would like to learn how to . . . make an actual robot move and . . . help it help with the world [problems]. Like with oil spills, you could design some kind of robot that could go out and like be magnetic to oil or something like that. And it would be like a task on our robot table.

Sara shared her concerns,

I’m concerned that if people don’t believe there’s a difference with robots that they won’t try it. And they should believe ‘cause they could really make a difference.

Several boys also expressed their concern for society. For example, Nicholas said he was concerned about the environment, specifically,

. . . the exhaust gas of cars and trucks because it pollutes the air and that polluted air is not good for us to breathe . . . . We could build something to clean the air.

Allan reminded everyone about another environmental concern,

Global warming! I learned that from last year’s . . . program . . . I still remember.

Key ideas used to guide the analysis related to Design (Standards 8, 9, & 10) include: (a) understanding of the attributes of design; (b) understanding of engineering design; (c) understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving; and (d) higher level thinking, problem solving, intellectual processes, and troubleshooting abilities.
Students reported that they developed abilities to apply the design process and to use, maintain, and access products and systems. They indicated an understanding of design processes and concepts, mentioning the importance of accuracy and precise attention to details, and documenting and recording processes so they could be repeated.

For example, Stephen said,

I learned that you have to take – yeah, it’s the little things sometimes that count. You have to like make sure – it’s not all about just the building and the testing. It’s about – you have to pay attention to exactly what’s going on - maybe not just on the top and the looks, but on the bottom and the structure.

Michael agreed saying,

I just wanted to second what Stephen said about the little things – paying attention to what’s under the bottom because if there’s a big machine and then you think there’s some big thing that’s wrong – it might just be that there’s a little thing.

Glen discussed the responsibility involved in building structurally-sound safe objects for users of technology.

... when we build ... [we have to] weigh it ... [we are] responsible for lives ... one loose screw ... [can cause problems] ... like on the Columbia.

Students, like Nicholas, expressed having better problem-solving strategies after experiencing technology activities and experiences enabling him to use his ideas to create solutions to problems. Nicholas discussed the use of science and mathematics to build, calculate, program, and solve problems required in using rotation sensors on the robots.

I learned more about the gears, pulleys, and levers and how to use ideas to create a solution ... I liked (figuring out) the robot’s circumference a lot.

Michael said, “I think I learned a lot about the building skills like bracing . . . .”

Girls and boys both indicated that they better understood technology concepts or “how things work,” and were able to identify and solve problems using mathematics and
science knowledge. Both Sam and Frank talked about connections they were making saying, respectively,

It [technology activities and experiences] kind of taught me . . . . You can see stuff on machines and you can kind of understand how they work . . . . After you’ve done robotics . . . ‘cause you can see all the gears and levers and bracing on cars and trucks.

Yeah. You can see. If you look under the car, you can see there are things sticking out and there’s the big chain on the bottom that pulls the thing up the hill and afterwards you just let it go . . . and in a simple course . . . you can just tell how things work.

Their responses indicated an understanding of aspects of the design process; the role of problem finding, research, planning, invention, and innovation; building and programming; testing and evaluating solutions; and presenting working solutions. With better “how to” skills, they learned to troubleshoot problems as they occurred. Student responses reflected a sense of confidence in their ability to understand and use technology. Reagan said,

I learned how to program this year . . . I think I learned a lot more just about how the gearing and just how things work.

Frank elaborated on his experiences with technology saying,

Well I remember, two years ago I didn’t know anything about robotics, well . . . . but I think it’s really taught me a lot about the way different things work and the way they use other machines to make a big machine . . . to make it do what it needs to do.

Jessica mentioned her learning about programming and reflected higher level thought processes, saying,

I learned how to program and how to analyze and test the robots and programs and adjust the programming . . . I knew after I figured out what was wrong with one thing I didn’t have to write another whole program. I learned not to do that.

Christopher talked about his learning as well.
one thing I learned . . . was kind of how to figure out more, like when to use sensors. Like it might be a lot easier to use touch sensors . . . when to use the touch sensor.

Key ideas used to guide the analysis related to Abilities for a Technological World (Standards 11, 12, & 13) include: (a) understanding the attributes of design; (b) ability to apply the engineering design process and procedures; (c) ability to research and develop projects and systems; (d) ability to develop, use, and maintain technological products and systems; (e) attitudes, motivation, and personal interest in learning; (f) ability to reconstruct or adapt to society; (g) teaming ability; (h) success work behaviors; (i) skills and interaction with peers; and (j) abilities such as programming and construction.

Students discussed the abilities they have and will need in the technological world of the 21st century and the relevance of technology to individuals in society. They believed technology to be both personally and academically relevant to their own lives. Jessica thought about careers.

Because when you’re an adult you have you get to choose the jobs you work in. And if you like and if you’re interested in robotics and you like technology, then you might want to go into a technology career later on in life.

Students talked positively about their technical abilities such as programming and construction abilities. They said, as students, they need the challenge technology presents and recommended that it should be taught in their subsequent school years. Many students expressed that they wanted to continue doing robotics the following year. Alyssa hoped she could continue in robotics the following year.

I think there should be . . . robotics next year because it’s a lot of work. And after you’ve been doing it for a long time, and then they change it [the FLL robotics
challenge] then you can still profit from it even more . . . . You also learn other things like science and math because like you use math to figure out how the robot moves.

Samantha discussed the benefits of technology education.

I think we would benefit if we could have robotics next year because we know a lot about robotics so we would benefit. We would learn more because we don’t know everything about robotics yet. So like if we have robotics next year, we’ll learn even more about robotics. We’ll have the knowledge that we have now, but then we’ll learn more.

Similarly, Frank said,

Well I think personally that robotics, technology education, should be available from fourth grade, which is when I started, throughout one’s education. I think it really helped with problem solving and getting ideas down and it really helps in other areas too, not just technology. Like for instance, other science classes, math classes, and classes that would involve computers because you learn a lot about problem solving because your robot won’t always just work.

Students believed it is necessary to know about technology and have the skills to use technology to prepare for adulthood. Sara expressed her ideas.

I think they we should learn about it because it will help us in our future when we try to find a job and in deciding on what they want to do. Just like Jessica said, if you like it, you can keep going with it, and just like do the best you can with technology.

They mentioned that technology is important in that it uses other skills such as mathematics and fosters necessary social skills like teamwork. As students discussed what they learned from TE robotics activities and experiences, they recommended the program for other students as well. Alyssa reflected that

. . . well you learn lots of things about science and technology, but you learn about working together. You learn about working as a team. You learn about accepting different ideas besides your own. So I think you learn about a lot of different things, not just about robotics. Everybody needs to learn stuff like that. . . . I learned about how to research better and about how the homeless live.

Sara also mentioned learning how to work in a team as an important skill to have.
I think we learned a real lot from robotics, like how we learned to work with our team and work things out.

Jessica talked about teamwork and perseverance.

You have to learn how to cope with people and to accept other people’s ideas and accept failure. And I think the robotics program is basically, a lot of it is, you have to work in a group. You have to program it and there’s a lot of failure with that.

Samantha offered her reflection on the benefits of cooperative teamwork. She discussed her teams’ solutions to accommodate ideas of all the team members by dividing the RCX programming ports.

I think everyone should [have TE activities] . . . because when we, the Circuit Breakers really had a lot of ideas. Like we really did try our hardest to work as a team. And for the exhibition, we got a slot [on the RCX] so we all had a part of the robot and learned how to work as a team! Yeah, you have to be able to agree with other people.

Janine agreed,

I have to agree with Samantha and Alyssa. There are certain important things we can learn in robotics so it can work and how to accept other people’s ideas.

Several students, like Michael, expressed the value of technology education activities and experiences in relation to learning other subjects such as mathematics and science.

. . . it [math and science] won’t be that hard if you do robotics because the gears and rotation sensors, you have to do all the math of all the gears you have attached to your motor and stuff.

Nicholas reflected on the value of technology education activities as well.

I think it’s good because you learn more and you get more advanced in it. And it offers goals and opportunities and if something goes wrong you can come up with something, like invent something on the spot, or like make something like a pulley or something. You get more knowledge and skills and concepts.
Jessica considered the value of technology in education to reduce fear and apprehension of the unknown. She said,

I think it [technology education activities and experiences] should be offered because it really is a great thing because people are still scared of robots. They’re so afraid that the robots will take over. Now that we know we have control over them, we have less fear and it’s really for the good of everyone.

Donald said it was valuable to learn technology early so that people in society will have a better understanding of technology as adults.

I think it should also be in middle school because it should be a challenge for people and to learn more so they have the opportunity for when they grow up to be able to do that stuff, and not be like, “Uh, I don’t know!” . . . I mean robotics is fun, so they’ll be able to do some fun things, with a challenge, and learn more advanced stuff.

Key ideas used to guide the analysis related to The Designed World (Standards 16, 17, & 19) include: (a) develop understanding and ability to select and use energy and power technologies, (b) develop understanding and ability to select and use information and communication technologies, and (c) develop understanding and ability to select and use manufacturing technologies. Students indicated a better understanding of and ability to use information and communication technologies after having experienced TE activities. Students explained their understanding of technology in terms of their experiences. Stephen explained,

I’m a lot better at working with computers. I used to be one of those kids that looked at the keyboard and I didn’t know anything about computers and I always thought that the job I wanted, I never wanted to see a computer ever . . . . And now actually, I’ve decided that I, umm, don’t write reports anymore, I sorta had rough drafts . . . . [ I would] write a rough draft and then do it on the computer, where I couldn’t write my rough draft on the computer. Now I can just sit down and type . . . . I think I’ve learned a lot about like how to troubleshoot things like when the computer freezes up.
Students discussed how they would explain the TE activities in our classroom to other students. They indicated their understanding of technology and society and ability to do technology as they offered their explanations. Jessica explained,

It’s a program where you build a robot and program it to achieve certain tasks on a table. And you have to help. It’s like helping the world and you also have to do to research a problem that takes place in your hometown or some other choices. And you have to research and make a presentation to present to the research judges at the competition.

Sara explained about programming a computer.

A program is -- you get on the computer. And there’s this Lego Mindstorms. And you actually kind of, write the program which is kind of telling the robot exactly what to do when it’s on the table and kind of – it’s sort of a kind of like a command center – so it’s a thing that you write.

Frank explained his understanding of TE and his ability to do technology.

Well the robotics program, I’d say is mostly figuring out what tasks – what challenges you want to complete – and then figuring out how to achieve those goals using, in this instance, Legos and the parts you’ve been provided. Yeah, with Legos using the robotics set and ideas using robotics technology. And programming. And the robot has to be completely autonomous. I mean you don’t bring in a remote control and control your robot. You have to program it.

Alyssa shared her understanding of TE robotics activities.

I think I would explain it like – you build a robot and there’s a table where you pick a task and you’ll go to the computer and program and like, you design a program and you’ll download it to your robot. Then you’ll put it on the table and test it. And you’ll be going to lots of competitions and you do the same thing there, but you get points for the tasks that you achieve and you have - what is it – two and one-half minutes to do as many of the tasks as you can. And there’s five slots on your robot so there’s enough room to do lots of tasks.

Reagan talked about presenting designs and programming solutions.

. . . you get into teams and you develop a robot out of Legos and you have to make programs for this robot to do certain tasks that are on the table. And you also have to make a technical presentation about what your robot can do and how your robot is built and everything, and a research presentation. And each year,
it’s kinda’ something different, but you have to do some research that’s related to the theme of the robotics site you’re in and make a presentation for that.

Students often expressed their concern that society needs to better understand technology. For example, Janine said,

I was so scared of robots taking over the world ‘cause you know robots can be pretty smart when they start learning stuff ‘cause I mean, there’s all these people that they can learn stuff from. They can learn like everything – and like they could start taking over and making us their maids . . . instead of them working for us. Like what if we worked for them and then they started a genocide?

Samantha explained her thinking.

I don’t think like we’re ready for -- I mean robots can help us a lot, but I don’t think we’re ready to use major robotics – like robots washing the dishes or doing housework for us. I mean the vacuum is sorta’ that, but it’s just that I don’t think we are ready for it yet. Like if people who work with robotics would slowly bring robotics into society they might be ready for robotics.

Frank talked about the value of technology education and the need for students to learn technology. He said,

Well I think in this ever-changing world, we’re using robotics technology more and more so if the students keep coming out of their education without knowing anything about robotics technology, they would not know as much about the world because we’re using the robotics technology more and more.

Michael saw the need for technology education as well.

I think we should learn about robotics technology because if we don’t, like in the year 2020 or so, we won’t be able to tell why our hovercraft broke down. Because we won’t know how to fix it if we don’t learn about technology. I mean technology is moving off.

Nicholas saw technology as improving the human condition. He said,

So we can be more advanced and make life easier like with more inventions . . . . Or we can have a better more stable world.
Observations of Student Performance Related to Technology Content Standards

Students were observed during all technology education activities and experiences during a period of six months. The profile of each student was recorded on the Observations of Student Performance Related to Technology Education Standards, a profile developed by the researcher. Each activity and experience was coded to the Technology Content Standards and students were rated novice, apprentice, or researcher. The scores for each standard were averaged for all students and by gender.

Figure 4.7 shows the results for each Technology Content Standard for all students.

Figure 4.7: Student performance profiles related to the technology content standards following technology education activities
Figure 4.8 indicates that most students were excelling in performance related to Technology Content Standards 1 through 4, 6, 10, 13, and 17. Standards 1 to 3 deal with The Nature of Technology and states:

Standard 1: Students will develop an understanding of the characteristics and scope of technology.
Standard 2: Students will develop an understanding of the core concepts of technology.
Standard 3: Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Standards 4 and 6 deal with Technology and Society and states:

Standard 4: Students will develop an understanding of the cultural, social, economic, and political effects of technology.
Standard 6: Students will develop an understanding of the role of society in the development and use of technology.

Standard 10 deals with Design and states:

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

Standard 13 deals with the Abilities of a Technological World and states:

Standard 13: Students will develop abilities to assess the impact of products and systems.

Standard 17 deals with The Designed World and states:

Standard 17: Students will develop an understanding of and be able to select and use information and communication technologies.

A similar pattern with regard to the Technology Content Standards was observed for girls, but not the boys (see Figure 4.10).
Summary of Results from the Quantitative and Qualitative Data Analysis

Quantitative Results: Attitudes and Perceptions Related to Technology

The analysis of the quantitative data identified four subscales from the original SATT that are descriptive of student attitudes and perceptions related to technology. The four subscales are: (a) Girls and Technology, (b) Interest in Technology, (c) Ability to Do Technology, and (d) Value of Technology. All of the subscales have 9 items except for the Ability to Do subscale which contains 7 items. Reliabilities on the subscales range from .74 to .85.
Results of the analysis of the four subscales administered as a pretest and a posttest to the gifted and talented students in the fifth grade classroom that engaged in technology education activities and experiences were as follows:

1. For the Value of Technology subscale, there was a significant interaction effect for test time by gender. Although mean scores of both girls and boys decreased from pretest to posttest, this change was significantly less for the girls compared to the boys.

2. For the Girls and Technology subscale, there was an interaction effect for test time by gender that was nearly significant. The change in mean scores of the girls from pretest to posttest appears to increase while there is little change in that of the boys.

3. For the Ability to Do Technology subscale, there was a significant test time effect and an interaction effect of test time by gender that is nearly significant. Although the mean scores of both the girls and the boys significantly increased from the pretest to the posttest, this change was more for the boys than that of the girls.

Results of the analysis of the four subscales administered as a posttest to the gifted and talented students in the fifth grade classroom that engaged in technology education activities and experiences and the gifted and talented students in the fifth grade classroom that did not engage in technology education activities and experiences were as follows:

1. For the Girls and Technology subscale, there was a significant interaction effect of class by gender. In the fifth grade classroom that experienced
technology education activities the mean score of the girls was considerably higher than that of the boys. In the fifth grade classroom that did not experience technology education activities, the mean scores of the girls and the boys were nearly similar.

2. For the Interest in Technology subscale, there was a significant class effect. The mean score for all students in the fifth grade classroom that experienced technology education activities was significantly higher than the mean score of the students in the fifth grade classroom that did not experience technology education activities.

3. For the Value of Technology subscale, there was significant class effect. The mean score for all students in the fifth grade classroom that experienced technology education activities was significantly higher than the mean score of the students in the fifth grade classroom that did not experience technology education activities.

Quantitative Results: Attitudes and Perceptions Related to Robotics

The pretest and posttest semantic differential to measure attitudes and perceptions related to robotics was administered to the gifted and talented students in the fifth grade classroom that engaged in technology education activities and experiences. The result of the analysis of the pretest and posttest was:

1. There was a significant test time by gender interaction effect. On the pretest, the attitudes and perceptions related to robotics of the girls were less positive compared to the attitudes and perceptions of the boys.
However, on the posttest, the attitudes and perceptions related to robotics of the girls were more positive compared to the attitudes and perceptions of the boys.

Qualitative Results: Attitudes and Perceptions Related to Technology and Robotics

Gifted and talented students in the fifth grade classroom that engaged in technology education activities and experiences participated in focus group interviews. Results of the analysis of student responses were divided into three themes: (a) gender roles, (b) gender and work habits, and (c) technology literacy outcomes.

Gender Roles

1. Girls perceived that the technology education activities and experiences program gave them a chance to advance and take risks.

2. Girls withdrew when boys became assertive.

3. Girls felt capable and interested in doing technology.

4. Girls expressed they were interested in research.

5. Both girls and boys thought that boys had more technology-related experiences growing up than girls.

6. Boys thought that girls were not suited for technological activities, except for the research.

7. Boys thought that if girls were immersed in technology, then they would get more interested in technology.
Gender and Work Habits

1. Girls perceived boys to be less persevering and patient than girls.
2. Boys perceived themselves as having more perseverance than girls.
3. Girls perceived that they were better able to work in teams than boys.

Technology Literacy Outcomes

Throughout the focus group interviews, students identified key features related to technology literacy outcomes. These included: (a) problem solving, (b) programming, (c) connections to mathematics and science, and (d) teamwork.

The following results were related to problem solving:

1. Students shared ideas regarding the use of science and mathematics to build, calculate, program, and solve problems.
2. Students indicated that they better understood technology concepts or “how things work,” and were able to identify and solve problems using their prior mathematics and science knowledge.

The following results were related to programming:

1. Students expressed interest in learning how to program.
2. Students recognized the value of learning how to program.
3. Students felt capable and confident in their abilities to program.

The following results were related to connections to mathematics and science:

1. Students made connections between technology, science, and mathematics.
2. Students expressed the value of technology education activities and experiences to learn other subjects such as mathematics and science.
The following results were related to teamwork:

1. Students recognized the importance of interpersonal skills and teamwork to successfully engage in technology activities.
2. Students thought teamwork required tolerance of others and acceptance of their ideas.

For student technology literacy outcomes related to the Technology Content Standards, the following results were generated from the focus group interviews:

1. Students expressed that they valued technology education activities and experiences because they extended their knowledge and understanding about the nature of technology.
2. Students expressed that they valued technology education activities and experiences because they transferred to academic and personally relevant real-life situations.
3. Students indicated a positive attitude toward expanding their learning beyond their own personal situation and community.
4. Students expressed the relationship between the technology activities and experiences in the classroom and future career opportunities, and believed it was necessary to know about technology and have the skills to use technology to prepare for adulthood.
5. Students expressed concern for the impact of technology on society.
6. Students expressed concern for the impact of robotics technology on society.
7. Students indicated a positive attitude toward learning about technology
because they thought they could make a positive impact on society.

8. Students expressed a desire to learn more about how things work and particularly about robotics technology in order to solve societal problems.

9. Students expressed having better problem-solving strategies and the desire to learn more so they could use their ideas to create solutions to societal problems.

10. Students expressed having better programming, computer, design, and construction skills.

11. Students considered it valuable to learn technology early so that people will have a better understanding of technology as adults.

12. Students saw the value of technology education to reduce fear and apprehension of the unknown.

13. Students perceived the need to have technological abilities to deal with the technological world of the 21st century.

The following results were obtained from the student profiles recorded on the Observations of Student Performance Related to Technology Education Standards form:

1. Students seemed to be proficient on the Technology Content Standards.

2. Students were closer to the level of “researcher” for Standard 1: Students will develop an understanding of the characteristics and scope of technology.

3. Students were closer to the level of “researcher” for Standard 2: Students will develop an understanding of the core concepts of technology.

4. Students were closer to the level of “researcher” for Standard 3: Students
will develop an understanding of the relationships among technologies and
the connections between technology and other fields of study.

5. Students were closer to the level of “researcher” for Standard 4: Students
will develop an understanding of the cultural, social, economic, and
political effects of technology.

6. Students were closer to the level of “researcher” for Standard 6: Students
will develop an understanding of the role of society in the development
and use of technology.

7. Students were closer to the level of “researcher” for Standard 10: Students
will develop an understanding of the role of troubleshooting, research and
development, invention and innovation, and experimentation in problem
solving.

8. Students were closer to the level of “researcher” for Standard 13: Students
will develop abilities to assess the impact of products and systems.

9. Students were closer to the level of “researcher” for Standard 17: Students
will develop an understanding of and be able to select and use information
and communication technologies.

10. Although the achievement patterns related to the Technology Content
    Standards for the boys were similar to that of the girls, the girls were more
    proficient than boys.

Table 4.22 provides a summary of the results of the data analyses. Both
quantitative and qualitative results are included.
Table 4.22: Summary of results.

Chapter 5 presents the conclusions generated from both the quantitative and qualitative data analyses and results. Reflecting the mixed methodology, results from all analyses will be drawn together to address the three research questions.
CHAPTER 5

CONCLUSIONS AND DISCUSSION

This chapter is organized around each of the primary research questions to provide a framework for discussion. Conclusions generated from the quantitative analyses of the SATT subscales and the semantic differential for “Robotics” along with the results of the qualitative analyses of the focus group interviews and student technology literacy profiles are presented. The findings from the mixed methodology and insights drawn from the literature and the classroom context converge in the conclusions and discussion. Finally, implications for classroom practice and future research are discussed.

Research Question 1: Attitudes and Perceptions Related to Technology
What are the attitudes and perceptions related to technology of gifted and talented fifth-grade students in an elementary school classroom? Are there gender differences in attitudes and perceptions related to technology?

The principle component analysis of student responses to the original SATT instrument identified four components. These components were identified as the following subscales: (a) Girls and Technology, (b) Interest in Technology, (c) Ability to Do Technology, and (d) Value of Technology.
Previous studies that used the PATT (Raat & de Vries, 1985) and the PATT-USA (Bame & Dugger, Jr., 1989; Bame et al., 1993; Boser et al., 1998) serve as a basis for discussion of the findings related to each of the subscales in the current study. Many of the items in the SATT subscales were items from the PATT-USA instrument. Consequently, each SATT subscale is discussed in relationship to the findings from previous studies using the PATT-USA.

Raat and de Vries (1985) developed the PATT to study student attitudes toward technology in the Netherlands. Bame and Dugger, Jr. (1989) and Bame et al. (1993) validated and used the PATT-USA to study student attitudes towards technology in the USA. Boser et al. (1998) used the PATT-USA to examine attitudes and perceptions of seventh graders regarding four different instructional strategies. Specifically, those strategies were (a) industrial arts approach, (b) integrated approach, (c) modular approach, and (d) problem solving approach.

The four instructional approaches used by Boser et al. (1998) are representative of typical instructional strategies associated with technology education. The primary focus of the current study was to explore attitudes and perceptions of gifted and talented fifth-grade students who engaged in specific ESTE activities and experiences. Elements from all the instructional strategies that Boser et al. included in their study were used as part of the ESTE activities and experiences in the current study.

The two primary instructional approaches used in the classroom in the current study included problem solving and integration. The problem-solving strategies emphasized critical thinking and the use of the problem-solving process to develop creative ideas and solutions. The activities in the FLL Challenge: CITY SIGHTS!
incorporate the problem-solving approach. The integrated approach incorporates other disciplines, such as mathematics and science, in the application of knowledge to solve problems. The Wright Patterson AFB curriculum integrates mathematics, science, and language arts. Elements of the industrial arts approach were represented in the classroom through the use of instructional strategies that included experimenting, designing, constructing, and evaluating as well as using tools, machines, materials, and processes to develop understanding about aspects of industry and technology. Similarly, elements of the modular approach were incorporated in the classroom through the use of instructional strategies that use individualized, self-paced, action-oriented units of instruction, such as the LEGO DACTA® sets Gears, Levers, and Pulleys. Although this study has a different focus than Boser et al. (1998) and the grade levels are different, the similarities between the two studies are very striking.

Unique to this study is the use of a mixed methodology providing multiple data sources and triangulation to document and confirm interpretations of the data. Studies using the PATT-USA were primarily quantitative. While the SATT is an instrument very similar to the PATT-USA, the quantitative data is followed up with qualitative focus group interview data to gain greater insight and understanding of student attitudes and perceptions related to technology education as well as student conceptual understanding of the essential components and features of technology. Also, this study uses another quantitative instrument, the semantic differential focusing on attitudes and perceptions related to “robotics.” The term “robotics” was easily used in the classroom to represent what occurred in terms of technology education. In fact, the word “robotics” became synonymous with the word “technology” in the classroom.
**Girls and Technology Subscale**

The Girls and Technology subscale identifies perceptions related to the knowledge of and ability to do technology by girls and boys. Four of the 9 items that appear in the Girls and Technology subscale of the current study come from the PATT-USA subscale entitled Technology as an Activity for Both Boys and Girls. These four items are consistent across the subscales of both instruments and provide evidence of content/concurrent validity. Table 5.1 illustrates the items on the SATT Girls and Technology subscale that appear on the PATT-USA Technology as an Activity for Both Boys and Girls subscale.

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Statements on the SATT Girls and Technology Subscale</th>
<th>Statements on the SATT Matched to PATT-USA Technology as Activity for Both Boys and Girls Subscale</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>More girls should work in technology.</td>
<td>1. More girls should work in technology.</td>
</tr>
<tr>
<td>3.</td>
<td>Technology is as difficult for boys as it is for girls.</td>
<td>3. Technology is as difficult for boys as it is for girls.</td>
</tr>
<tr>
<td>13.</td>
<td>Boys know more about technology than girls do.</td>
<td>13. Boys know more about technology than girls do.</td>
</tr>
<tr>
<td>37.</td>
<td>Boys are able to do practical things better than girls.</td>
<td>37. Boys are able to do practical things better than girls.</td>
</tr>
</tbody>
</table>

Additional Statements on the SATT Girls and Technology Subscale

16. Boys are encouraged more than girls to study technology.
24. Girls know little about fixing or working with machines.
27. Boys are able to do practical things better than girls.
31. More girls should work in technology.
40. Girls are discouraged from trying work that involves technology.

Table 5.1: SATT Girls and Technology subscale compared to PATT-USA.
Analysis of the Girls and Technology subscale revealed that the girls’ attitudes and perceptions related to girls’ knowledge of and ability to do technology increased considerably after engaging in ESTE activities and experiences. The boys’ attitudes and perceptions related to girls’ knowledge of and ability to do technology remained at a constant level, very slightly above neutral. In the class without ESTE activities and experiences, the girls’ and boys’ attitudes and perceptions related to girls’ knowledge of and ability to do technology were positive with little difference between their perceptions.

In the class of gifted and talented fifth-grade students who engaged in ESTE activities and experiences, the attitudes and perceptions of the girls related to girls and their knowledge of and ability to do technology were more positive compared to the attitudes and perceptions of the gifted and talented boys. When comparing the attitudes and perceptions of the gifted and talented girls and boys in the fifth-grade class without ESTE activities and experiences related to the Girls and Technology subscale, the attitudes and perceptions were nearly the same. It appears that more changes occurred for the girls than for the boys for those students engaged in ESTE activities and experiences.

It appears that only the girls who engaged in ESTE activities and experiences perceived to a greater degree that girls were equally capable of participating in technology as boys. These girls expressed knowledge of technology along with a willingness and capability to participate in technology. They felt that ESTE provided an opportunity for them to advance and take risks. In contrast, boys who engaged in ESTE activities and experiences were reluctant to recognize the equal role of girls in
technology. They perceived in the girls, a lack of experience and suitability for technological activities, other than to do research.

Other gender issues surfaced related to the ability to do technology. For example, girls perceived that they were better able to work in teams to do technology than boys. Interestingly, girls perceived girls to be more perseverant during technology activities while boys perceived boys to be more perseverant. Clearly, the girls and boys have a different perspective on the role of girls to do technology.

Bame et al. (1993) reported that in the USA, both girls and boys were convinced that technology is a field for both genders. However, girls were more convinced than boys that technology is for both girls and boys. Boser et al. (1998) used the PATT-USA to explore four technology education approaches to determine the attitude changes toward technology that might be linked to enhancing technological literacy. Findings on the Technology as an Activity for Both Boys and Girls subscale indicated that girls, more than boys, perceived technology to be an activity for both girls and boys. Boys held stereotypical views about roles of girls in technology. Similar to the results of both Bame et al. (1993) and Boser et al. (1998), the current study found girls to have more positive attitudes and perceptions related to girls’ knowledge of and ability to do technology. However, the boys in the current study seemed to maintain a more stereotypical view of the role of girls in technology.

Interest in Technology Subscale

Four of the 9 items in the SATT Interest in Technology subscale are items found in the PATT-USA General Interest in Technology subscale. This subscale identifies
perceived interest related to technology. Again, consistency across the component analyses of both instruments is shown providing evidence of content/concurrent validity.

Table 5.2 illustrates the items on the SATT Interest in Technology subscale that appear in the PATT-USA General Interest in Technology subscale.

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Statements on the SATT Interest in Technology Subscale</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Statements on the SATT Matched to PATT-USA General Interest in Technology Subscale</td>
</tr>
<tr>
<td>23.</td>
<td>I will probably choose a job in technology.</td>
</tr>
<tr>
<td>32.</td>
<td>At school you hear a lot about technology.</td>
</tr>
<tr>
<td>34.</td>
<td>When something new is discovered I want to know more about it immediately.</td>
</tr>
<tr>
<td>39.</td>
<td>Technology is a subject that should be studied by all students.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Additional Statements on the SATT Interest in Technology Subscale</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. I want to invent something new.</td>
</tr>
<tr>
<td>8. Learning about technology is interesting.</td>
</tr>
<tr>
<td>14. I look forward to learning more about technology.</td>
</tr>
<tr>
<td>15. Technology work is boring.</td>
</tr>
<tr>
<td>30. To learn technology, you need to understand mathematics.</td>
</tr>
</tbody>
</table>

Table 5.2: SATT Interest in Technology subscale compared to PATT-USA.

In the class of gifted and talented fifth-grade students who engaged in ESTE activities and experiences, both girls and boys had positive perceptions related to interest in technology. No changes occurred from the pretest to the posttest for either girls or boys in the Interest in Technology subscale. This is not surprising because both girls and boys
started out with high interest in technology and maintained that high interest. This interest in technology was clearly evident in the focus group interviews.

There were differences between the two classes of gifted and talented fifth-grade students regarding the Interest in Technology subscale. The class that had ESTE activities and experiences was more positive with regard to Interest in Technology than the class that did not have ESTE activities and experiences. There were no gender differences obtained for the Interest in Technology subscale.

Findings reported by Raat and de Vries (1985) indicated that girls are less interested in technology than boys in the Netherlands. Similarly, Bame et al. (1993) and Boser et al. (1998) found that although USA students were interested in technology, boys were more interested in technology than girls. Girls consistently perceived technology as less interesting than boys. In the current study, no gender differences related to Interest in Technology were found. Both girls and boys in the class who had ESTE activities and experiences displayed and maintained a positive interest in technology that was more positive than that of the students who did not engage in ESTE activities and experiences.

Value of Technology Subscale

The Value of Technology subscale identifies the value of technology in terms of potential benefits or detriments. Five of the 9 items in the SATT Value of Technology subscale are from the PATT-USA. Four items came from the PATT-USA Consequences of Technology subscale and one item from the Attitudes Toward Technology subscale. Consistency is demonstrated again between the items that were selected from the PATT-USA and their appearance in the SATT subscales, providing further evidence of
content/concurrent validity. Table 5.3 illustrates the items on the SATT Value of Technology subscale that appear on the PATT-USA Consequences of Technology subscale and the PATT-USA Attitude Toward Technology subscale.

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Statements on the SATT Value of Technology Subscale</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Statements on the SATT Matched to PATT-USA Consequences of Technology Subscale</td>
</tr>
<tr>
<td>6.</td>
<td>Technology is good for the future of our country.</td>
</tr>
<tr>
<td>11.</td>
<td>Technology makes everything work better.</td>
</tr>
<tr>
<td>17.</td>
<td>Technology has brought more good things than bad.</td>
</tr>
<tr>
<td>33.</td>
<td>Technology is very important in life.</td>
</tr>
<tr>
<td></td>
<td>Statement on the SATT Matched to PATT-USA Attitude Toward Technology Subscale</td>
</tr>
<tr>
<td>35.</td>
<td>Because technology caused pollution, we should use less of it.</td>
</tr>
<tr>
<td></td>
<td>Additional Statements on the SATT Value of Technology Subscale</td>
</tr>
<tr>
<td>5.</td>
<td>Technology is not good for the average worker.</td>
</tr>
<tr>
<td>12.</td>
<td>Technology improves the quality of human life.</td>
</tr>
<tr>
<td>25.</td>
<td>Technology has done very little for the average citizen.</td>
</tr>
<tr>
<td>28.</td>
<td>Technology helps us to understand the world in which we live.</td>
</tr>
</tbody>
</table>

Table 5.3: SATT Value of Technology subscale compared to PATT-USA.

In the class with ESTE activities and experiences, there was a decrease in the perceptions of the value of technology, which was less for the girls than for the boys. Both the girls and boys started out with positive attitudes and perceptions toward the value of technology and both decreased after engaging in ESTE activities and
experiences. However, the girls’ attitudes and perceptions were positive in regard to the value of technology and remained nearly the same at the end of their experiences. In contrast, the boys’ perception of the value of technology decreased to a slightly negative level.

It was evident in the focus group discussions that all students valued the ESTE activities and experiences that they felt extended their understanding of technology and were academically and personally relevant. They also valued ESTE activities because they enabled them to move beyond their own situation and community. Moreover, they recognized the benefits of ESTE activities and experiences in terms of future careers. They particularly valued their ability to make a positive impact on society and societal problems as a result of their knowledge and skills gained from their ESTE activities and experiences. However, they expressed concern about the impact of technology on society and recognized that the impact could be negative as well as positive. Perhaps, this critical eye influenced the lessening of their value of technology.

Class differences were noticed in the Value of Technology subscale. Both girls and boys in the class with ESTE activities and experiences had more positive perceptions of the value of technology than the students in the class without ESTE activities and experiences.

When Raat and de Vries (1985) developed the PATT, they investigated students’ attitudes toward and conceptual understanding of technology. Their results suggested that girls see technology as less important than boys. Boser et al. (1998) indicated that after using the integrated approach, there was a negative change in attitudes toward technology. The authors explained that perhaps students had achieved a more balanced
view of technology. Students retained a more positive outlook toward technology when they participated in less controversial content. The results from their study suggest that perhaps at the beginning of the integrated approach, students underestimated the complexity of technology with its potential for both positive and negative consequences. In the current study, similar results are suggested. Perhaps the gifted and talented fifth-grade students who engaged in ESTE activities and experiences, particularly boys, began to see technology with a more critical eye, as they learned to assess the impact of technology on society and the environment in terms of both benefits and detriments. However, these same students expressed more positive attitudes and perceptions related to the value of technology compared to students without ESTE activities and experiences.

*Ability to Do Technology Subscale*

The Ability to Do Technology subscale identifies perceptions related to the need for higher intellect to do technology. Again, consistency is noticed between the items on the SATT Ability to Do Technology subscale and the PATT-USA Technology is Difficult subscale providing evidence of content/concurrent validity. Five of the 7 items in the SATT Ability to Do Technology subscale come from the PATT-USA Technology is Difficult subscale. Table 5.4 illustrates the items on the SATT Ability to Do Technology subscale that appear on the PATT-USA Technology is Difficult subscale.
<table>
<thead>
<tr>
<th>Item No.</th>
<th>Statements on the SATT Ability to Do Technology Subscale</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Statements on the SATT Matched to PATT-USA Technology is Difficult Subscale</td>
</tr>
<tr>
<td>9.</td>
<td>You can study technology only when you are good at both mathematics and science</td>
</tr>
<tr>
<td>18.</td>
<td>To understand technology you have to take a difficult training course.</td>
</tr>
<tr>
<td>20.</td>
<td>You have to be smart to study technology.</td>
</tr>
<tr>
<td>36.</td>
<td>Technology is only for smart people</td>
</tr>
<tr>
<td>38.</td>
<td>To study technology you have to be talented.</td>
</tr>
</tbody>
</table>

Additional Statements on the SATT Ability to Do Technology Subscale

| 22. | To work with technology you must be very smart. |
| 26. | I am not smart enough to do a job that uses technology. |

Table 5.4: SATT Ability to Do Technology subscale compared to PATT-USA.

At the onset, all the gifted and talented fifth-grade students who engaged in ESTE activities and experiences were somewhat neutral in their attitudes and perceptions related to the ability to do technology. At the end of the study, both girls and boys recognized that it took more ability to do technology. However, the change in this perception was greater for the boys than the girls.

Both the girls and the boys who engaged in ESTE activities and experiences recognized the intellect and knowledge necessary to do technology. They identified knowledge and skills related to problem solving, mathematics and science, and interpersonal and teamwork skills as integral to the ability to do technology. Both the girls and the boys thought the boys had more technology-related experiences, such as
building blocks and video games, in their home environment. Perhaps the boys associated the ability to do technology with technology-related toys and therefore exhibited a greater change in their perception of what it takes to do technology.

There were no differences between the attitudes and perceptions related to the Ability to Do Technology of gifted and talented fifth-grade students with ESTE activities and experiences compared to the students without ESTE activities and experiences. This is not surprising since both classes were identified as gifted and talented students.

Boser et al. (1998) found that although both girls and boys perceived technology as less difficult after experiencing technology activities and experiences, girls thought technology to be a more difficult subject than did the boys. Particularly, girls thought technology was more difficult to use and understand than did boys when the industrial arts approach was used. In the current study, the gifted talented fifth-grade students who completed ESTE activities and experiences, particularly the boys, perceived technology as requiring more ability to do or as being more difficult.

Research Question 2: Attitudes and Perceptions Related to Robotics

What are the attitudes and perceptions related to robotics of gifted and talented fifth-grade students in an elementary school classroom? Are there gender differences in attitudes and perceptions related to robotics?

“Robotics” activities were implemented in one classroom of gifted and talented students, the focus of this study. The term “robotics” a term familiar to students, was used interchangeably and almost synonymously with the term technology during technology activities and experiences. Scores on the semantic differential were all above
neutral on the pretest and the posttest indicating positive attitudes and perceptions toward robotics for all students.

Prior to the beginning of the ESTE activities and experiences, the attitudes and perceptions related to robotics of the girls were lower than for the boys. However, at the completion of the ESTE activities and experiences, the attitudes and perceptions related to robotics of the girls was considerably higher than for the boys. In addition, the variability of the girls’ scores on the posttest were noticeably less than on the pretest indicating that the girls converged in their attitudes and perceptions by the end of their experiences.

Research Question 3: Technological Literacy Outcomes

What technological literacy outcomes of gifted and talented fifth-grade students in an elementary school classroom are related to the use of technology education activities and experiences? Are there gender differences in student technological literacy outcomes?

In the current study, student profiles were examined in regard to technological literacy outcomes as defined by the Technology Content Standards developed by ITEA. All students, particularly girls, demonstrated proficiency in the targeted Technology Content Standards for The Nature of Technology, Technology and Society, Design, Abilities for a Technological World, and The Designed World.

Students demonstrated understanding of the nature of technology as they identified key features of technology, including problem solving, programming, connections to mathematics and science, and teamwork. Throughout their conversations,
students recognized the role of society in the development and use of technology. In particular, students expressed concern for the impact of technology on society. Students developed an understanding of the design process as they learned what a designer or engineer must consider as s/he develops and evaluates the usefulness of a new product or system. Students applied the design process to design innovations and solutions that met the criteria of the robotics challenge. Lastly, throughout the design process, students used information and communication technologies effectively.

Implications for Classroom Practice

The results of the current study have several implications for the curriculum and instructional strategies for ESTE. Additional technology education activities and experiences need to be developed or selected that would increase student proficiency in specific Technology Content Standards, for example, the design process. Different grouping strategies based upon same gender and/or mixed gender need to be utilized. Additional equipment is preferable so that more students can spend time designing, investigating, and evaluating their own ideas and innovations to share with their team. It would be beneficial to spend additional time and use more activities to develop teamwork, interpersonal skills, group skills, and work ethic. More connections can be made to specific academic content standards in mathematics and science. Additionally, it would be beneficial to explore ways to tie language arts and social studies content standards to technology education activities and experiences. Strategies to incorporate technology education as connected to the academic content standards, rather than as an add-on to the regular curriculum, particularly for the self contained, elementary
classroom, would be beneficial. This study provides suggestions for ESTE praxis for both gifted and talented students and students in the regular elementary classrooms. It clearly has served to enlighten the researcher/teacher about her own teaching practice.

Implications for Future Research

For future research, it may be fruitful to tailor the SATT subscales to elicit personal attitudes and perceptions related to technology as different from general population attitudes and perceptions related to technology. Items that begin with the word “technology” could be added to measure general population attitudes and perceptions, while items that begin with the word “I” could be added to measure individual attitudes and perceptions. Additionally, the subscales may be made more robust by adding additional items. For example, items related to the PATT-USA Conceptual Understanding of Technology could be added. It would be valuable to use the instrument with a larger sample of students, students with different abilities as well as special needs, and students in different grade levels. Additional measures focused on “robotics” may help to differentiate between students’ attitudes and perceptions related to technology and robotics.

The implications for classroom practice derived from this study generated additional research questions related to the implementation of ESTE activities and experiences for the general elementary school population.

1. Is there a difference in attitudes and perceptions related to technology for students with different ability levels?
2. Is there a difference in attitudes and perceptions related to technology for students in different grade levels?

3. Is there a difference in attitudes and perceptions related to robotics for students with different ability levels?

4. Is there a difference in attitudes and perceptions related to robotics for students in different grade levels?

5. Is there a difference in student attitudes and perceptions related to technology compared to student attitudes and perceptions related to robotics?

6. Is there a difference in student attitudes and perceptions related to technology for students in same-gender groups compared to mixed-gender groups for technology education activities? Are there gender differences in student attitudes and perceptions related to technology based upon gender groupings?

7. Is there a difference in student attitudes and perceptions related to robotics for students in same-gender groups compared to mixed-gender groups for technology education activities? Are there gender differences in student attitudes and perceptions related to robotics based upon gender groupings?

Summary

This research study provides information regarding the attitudes and perceptions of gifted and talented fifth-grade students related to technology and how technology education activities and experiences may promote positive attitudinal changes and
facilitate the development of technological literacy. This study may assist teachers and curriculum developers in the design, selection, and implementation of technology-based instructional activities to promote technological literacy in all students.

The demonstration of attitudinal changes toward technology might be linked to enhanced technological literacy. Potentially, this study may provide clues to enhance understanding of technology education for gifted and talented students, specific to (a) their attitudes and perceptions related technology, (b) gender differences related to attitudes and perceptions, (c) the effect of technology education activities and experiences on attitudes and perceptions related to technology, (d) technology literacy outcomes, (e) gender differences related to technology literacy outcomes, (f) the effect of technology activities and experiences on technological literacy outcomes, and (g) gender differences related to the effect of technology activities and experiences on technological literacy outcomes. The findings of this study may contribute to the field of technology education.

Technology education may impact the learning of gifted and talented students. It is a cultural match for students incorporating use of high tech, engaging, and stimulating methods based on the curiosity of students. Students may learn to value their own learning when they see that their learning can have a real impact on society.
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230


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239


APPENDIX A

STUDENT ATTITUDES TOWARD TECHNOLOGY SURVEY
Student Number ___________________________ Date ____________________
School ___________________________ Grade Level _______________

STUDENT ATTITUDES TOWARD TECHNOLOGY

Directions: Each of the statements expresses a feeling about technology. Please indicate whether you disagree or agree with the statement by circling one of the following for each statement:

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>U</th>
<th>D</th>
<th>SA</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>More girls should work in technology.</td>
<td>SD</td>
<td>D</td>
<td>U</td>
<td>A</td>
</tr>
<tr>
<td>2.</td>
<td>There should be less TV and radio programs about technology.</td>
<td>SD</td>
<td>D</td>
<td>U</td>
<td>A</td>
</tr>
<tr>
<td>3.</td>
<td>Technology is as difficult for boys as it is for girls.</td>
<td>SD</td>
<td>D</td>
<td>U</td>
<td>A</td>
</tr>
<tr>
<td>4.</td>
<td>Technology causes large unemployment.</td>
<td>SD</td>
<td>D</td>
<td>U</td>
<td>A</td>
</tr>
<tr>
<td>5.</td>
<td>Technology is not good for the average worker.</td>
<td>SD</td>
<td>D</td>
<td>U</td>
<td>A</td>
</tr>
<tr>
<td>6.</td>
<td>Technology is good for the future of our country.</td>
<td>SD</td>
<td>D</td>
<td>U</td>
<td>A</td>
</tr>
<tr>
<td>7.</td>
<td>I want to invent something new.</td>
<td>SD</td>
<td>D</td>
<td>U</td>
<td>A</td>
</tr>
<tr>
<td>8.</td>
<td>Learning about technology is interesting.</td>
<td>SD</td>
<td>D</td>
<td>U</td>
<td>A</td>
</tr>
<tr>
<td>9.</td>
<td>You can study technology only when you are good at both mathematics and science.</td>
<td>SD</td>
<td>D</td>
<td>U</td>
<td>A</td>
</tr>
<tr>
<td>10.</td>
<td>Most people do not understand enough technology.</td>
<td>SD</td>
<td>D</td>
<td>U</td>
<td>A</td>
</tr>
<tr>
<td>11.</td>
<td>Technology makes everything work better.</td>
<td>SD</td>
<td>D</td>
<td>U</td>
<td>A</td>
</tr>
<tr>
<td>12.</td>
<td>Technology improves the quality of human life.</td>
<td>SD</td>
<td>D</td>
<td>U</td>
<td>A</td>
</tr>
<tr>
<td>13.</td>
<td>Boys know more about technology than girls do.</td>
<td>SD</td>
<td>D</td>
<td>U</td>
<td>A</td>
</tr>
<tr>
<td>14.</td>
<td>I look forward to learning more about technology.</td>
<td>SD</td>
<td>D</td>
<td>U</td>
<td>A</td>
</tr>
<tr>
<td>15.</td>
<td>Technology work is boring.</td>
<td>SD</td>
<td>D</td>
<td>U</td>
<td>A</td>
</tr>
<tr>
<td>16.</td>
<td>Boys are encouraged more than girls to study technology.</td>
<td>SD</td>
<td>D</td>
<td>U</td>
<td>A</td>
</tr>
<tr>
<td>17.</td>
<td>Technology has brought more good things than bad.</td>
<td>SD</td>
<td>D</td>
<td>U</td>
<td>A</td>
</tr>
<tr>
<td>18.</td>
<td>To understand technology you have to take a difficult training course.</td>
<td>SD</td>
<td>D</td>
<td>U</td>
<td>A</td>
</tr>
<tr>
<td>19.</td>
<td>Technology is too hard for the average citizen to understand.</td>
<td>SD</td>
<td>D</td>
<td>U</td>
<td>A</td>
</tr>
<tr>
<td>20.</td>
<td>You have to be smart to study technology.</td>
<td>SD</td>
<td>D</td>
<td>U</td>
<td>A</td>
</tr>
</tbody>
</table>
STUDENT ATTITUDES TOWARD TECHNOLOGY

Directions: Each of the statements expresses a feeling about technology. Please indicate whether you disagree or agree with the statement by circling one of the following for each statement:

<table>
<thead>
<tr>
<th></th>
<th>Agree (A)</th>
<th>Undecided (U)</th>
<th>Strongly Agree (SA)</th>
<th>Disagree (D)</th>
<th>Strongly Disagree (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>21. Technology does not need a lot of mathematics.</td>
<td>SD</td>
<td>D</td>
<td>U</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>22. To work with technology you must be very smart.</td>
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</tbody>
</table>
APPENDIX B

RECODED STUDENT ATTITUDES TOWARD TECHNOLOGY SURVEY
# STUDENT ATTITUDES TOWARD TECHNOLOGY

Directions: Each of the statements expresses a feeling about technology. Please indicate whether you disagree or agree with the statement by circling one of the following for each statement:

- **A**: Agree  
- **U**: Undecided  
- **D**: Disagree  
- **SA**: Strongly Agree  
- **SD**: Strongly Disagree

<p>| | | | | | | | | | | | |</p>
<table>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>More girls should work in technology.</td>
<td>SD</td>
<td>D</td>
<td>U</td>
<td>A</td>
<td>SA</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>2.</td>
<td>There should be less TV and radio programs about technology.</td>
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<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td></td>
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</tr>
<tr>
<td>3.</td>
<td>Technology is as difficult for boys as it is for girls.</td>
<td>SD</td>
<td>D</td>
<td>U</td>
<td>A</td>
<td>SA</td>
<td></td>
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</tr>
<tr>
<td>4.</td>
<td>Technology causes large unemployment.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td></td>
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<tr>
<td>5.</td>
<td>Technology is not good for the average worker.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
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<tr>
<td>6.</td>
<td>Technology is good for the future of our country.</td>
<td>SD</td>
<td>D</td>
<td>U</td>
<td>A</td>
<td>SA</td>
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</tr>
<tr>
<td>7.</td>
<td>I want to invent something new.</td>
<td>SD</td>
<td>D</td>
<td>U</td>
<td>A</td>
<td>SA</td>
<td></td>
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</tr>
<tr>
<td>8.</td>
<td>Learning about technology is interesting.</td>
<td>SD</td>
<td>D</td>
<td>U</td>
<td>A</td>
<td>SA</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>9.</td>
<td>You can study technology only when you are good at both mathematics and science.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td></td>
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</tr>
<tr>
<td>10.</td>
<td>Most people do not understand enough technology.</td>
<td>SD</td>
<td>D</td>
<td>U</td>
<td>A</td>
<td>SA</td>
<td></td>
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<tr>
<td>11.</td>
<td>Technology makes everything work better.</td>
<td>SD</td>
<td>D</td>
<td>U</td>
<td>A</td>
<td>SA</td>
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<td>12.</td>
<td>Technology improves the quality of human life.</td>
<td>SD</td>
<td>D</td>
<td>U</td>
<td>A</td>
<td>SA</td>
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<tr>
<td>13.</td>
<td>Boys know more about technology than girls do.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
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<tr>
<td>14.</td>
<td>I look forward to learning more about technology.</td>
<td>SD</td>
<td>D</td>
<td>U</td>
<td>A</td>
<td>SA</td>
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<tr>
<td>15.</td>
<td>Technology work is boring.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td></td>
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<tr>
<td>16.</td>
<td>Boys are encouraged more than girls to study technology.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
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<tr>
<td>17.</td>
<td>Technology has brought more good things than bad.</td>
<td>SD</td>
<td>D</td>
<td>U</td>
<td>A</td>
<td>SA</td>
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<tr>
<td>18.</td>
<td>To understand technology you have to take a difficult training course.</td>
<td>5</td>
<td>4</td>
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<td>19.</td>
<td>Technology is too hard for the average citizen to understand.</td>
<td>5</td>
<td>4</td>
<td>3</td>
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<td>20.</td>
<td>You have to be smart to study technology.</td>
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<td>21.</td>
<td>Technology does not need a lot of mathematics.</td>
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</table>
APPENDIX C

ATTITUDES AND PERCEPTIONS RELATED TO ROBOTICS SEMANTIC DIFFERENTIAL
Example: For each pair of words below place an X on the blank that best tells how you feel about —

**SNOW**

<table>
<thead>
<tr>
<th>like</th>
<th>_____</th>
<th>_____</th>
<th>_____</th>
<th>______</th>
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<tbody>
<tr>
<td>_____</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
<td>______</td>
</tr>
</tbody>
</table>

| cold | _____ | _____ | _____ | ______ |
|_____ | _____ | _____ | _____ | ______ |

| work | _____ | _____ | _____ | ______ |
|_____ | _____ | _____ | _____ | ______ |

These responses would indicate that the person likes snow but is not crazy about it. The person thinks snow is very cold and that snow means some work and some play.

**Directions:** For each pair of words below place an X on the blank that tells how you feel about —

**ROBOTICS**

<table>
<thead>
<tr>
<th>beneficial</th>
<th>_____</th>
<th>_____</th>
<th>_____</th>
<th>______</th>
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<tbody>
<tr>
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</table>

<table>
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<th>understandable</th>
<th>_____</th>
<th>_____</th>
<th>_____</th>
<th>______</th>
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</thead>
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<tr>
<td>_____</td>
<td>_____</td>
<td>_____</td>
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<td>______</td>
</tr>
</tbody>
</table>

| bad | _____ | _____ | _____ | ______ |
|_____ | _____ | _____ | _____ | ______ |

| tool | _____ | _____ | _____ | ______ |
|_____ | _____ | _____ | _____ | ______ |

| strange | _____ | _____ | _____ | ______ |
|_____ | _____ | _____ | _____ | ______ |

| weak | _____ | _____ | _____ | ______ |
|_____ | _____ | _____ | _____ | ______ |

| sad | _____ | _____ | _____ | ______ |
|_____ | _____ | _____ | _____ | ______ |

| brave | _____ | _____ | _____ | ______ |
|_____ | _____ | _____ | _____ | ______ |

| slow | _____ | _____ | _____ | ______ |
|_____ | _____ | _____ | _____ | ______ |

| boring | _____ | _____ | _____ | ______ |
|_____ | _____ | _____ | _____ | ______ |

| jump in | _____ | _____ | _____ | ______ |
|_____ | _____ | _____ | _____ | ______ |

| hard | _____ | _____ | _____ | ______ |
|_____ | _____ | _____ | _____ | ______ |

252
APPENDIX D

RECODED ATTITUDES AND PERCEPTIONS RELATED TO ROBOTICS SEMANTIC DIFFERENTIAL
Example: For each pair of words below place an X on the blank that best tells how you feel about —

SNOW

like _____ : _X__ : ______ : ______ : ______ : ______ hate

cold ___X___ : ______ : ______ : ______ : ______ hot

work ______ : ______ : ___X___ : ______ : ______ play

These responses would indicate that the person likes snow but is not crazy about it. The person thins snow is very cold and that snow means some work and some play.

Directions: For each pair of words below place an X on the blank that tells how you feel about —

ROBOTICS

beneficial ___5___ : __4__ : __3__ : __2__ : __2__ harmful

understandable ___5___ : __4__ : __3__ : __2__ : __2__ mystery

bad ______ : ______ : ______ : ______ : ______ good

tool ___5___ : __4__ : __3__ : __2__ : __2__ toy

strange ______ : ______ : ______ : ______ : ______ familiar

weak ______ : ______ : ______ : ______ : ______ strong

sad ______ : ______ : ______ : ______ : ______ happy

brave ___5___ : __4__ : __3__ : __2__ : __2__ scared

slow ______ : ______ : ______ : ______ : ______ fast

boring ______ : ______ : ______ : ______ : ______ exciting

jump in ___5___ : __4__ : __3__ : __2__ : __2__ hold back

hard ______ : ______ : ______ : ______ : ______ easy
APPENDIX E

OBSERVATIONS OF STUDENT PERFORMANCE RELATED TO TECHNOLOGY CONTENT STANDARDS
**Observations of Student Performance Related to Technology Content Standards**

<table>
<thead>
<tr>
<th>Technology Standards</th>
<th>Performance Level</th>
<th>Source of Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Novice</td>
<td>Apprentice</td>
</tr>
<tr>
<td></td>
<td>1 point</td>
<td>2 points</td>
</tr>
</tbody>
</table>

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

**Design**

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

11. Students will develop the abilities to apply the design process.
12. Students will develop the abilities to use and maintain technological products and systems.
13. Students will develop the abilities to assess the impact of products and systems.

**The Designed World**

16. Students will develop an understanding of and be able to select and use energy and power technologies.
17. Students will develop an understanding of and be able to select and use information and communication technologies.
19. Students will develop an understanding of and be able to select and use manufacturing technologies.