ABSTRACT

BURT, KATRINA GABOUR. Analysis of the Factors Involved in Technological Problem Solving in a College Technology Education Classroom. (Under the direction of Dr. Richard E. Peterson.)

The purpose of the study was to contribute to the goal of technological literacy by advancing the knowledge base of technological problem solving.

The objective of the study was to examine the relationships between the following factors: technological problem solving potential, problem solving confidence, knowledge of a Myers-Briggs Type Indicator (MBTI) problem solving process, psychological type, problem solving approach, Grade Point Average (GPA), problem-specific interest, problem-specific motivation, desire to solve problems, and desire to learn about problem solving.

The study utilized the pre-experimental design method of one group pretest-posttest design and was conducted at North Carolina State University (NCSU) with sixteen students over a three-day, three-hour-per-day, workshop. Data collection instruments included Myers-Briggs Type Indicator, Problem Solving Inventory (PSI), and other researcher-prepared forms. Pretest and posttest real world problems were given along with a problem solving process intervention. JMP statistical analysis software (SAS Institute) was used to calculate Pearson product-moment correlations, Spearman rank correlations, t-tests, Fisher’s exact test, Signed rank test, and Least Squares Fit with alpha set to 0.05.

Pretest to posttest findings suggest a decrease in mean confidence, an increase in mean potential scores, a negative linear relationship for process scores, an association for desire to learn about problem solving (decrease), and no difference in mean problem
solving approach scores. Pretest findings suggest a reverse linear relationship between confidence and potential scores, a reverse linear relationship between confidence and GPA, a positive linear relationship between process scores and potential scores, a positive correlation between potential scores and problem-specific interest, a positive correlation between process scores and problem-specific interest, a difference in mean potential scores for liking to solve problems (reverse relationship), and a difference in mean confidence scores for liking to solve problems. Posttest findings suggest a difference in mean potential scores for MBTI preferences of [J and P], a difference in mean confidence scores for MBTI preferences of [E and I], and a positive linear relationship between process scores and potential scores.
ANALYSIS OF THE FACTORS INVOLVED
IN TECHNOLOGICAL PROBLEM SOLVING
IN A COLLEGE TECHNOLOGY EDUCATION CLASSROOM

by

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North Carolina State University
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Doctor of Education

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Chair of Advisory Committee
DEDICATION

This dissertation is dedicated to my children

who have been my inspiration.

May they learn to solve complex technological problems

for the betterment of society.
Katrina Gabour Burt graduated as valedictorian from Pelham High School, Pelham, New Hampshire and was listed in Who’s Who Among American High School Students. She attended Worcester Polytechnic Institute (WPI) and was a member and past president of the Alpha Phi Omega National Service Fraternity. While at WPI, she was inducted into the Tau Beta Pi Engineering Honor Society. She worked at Data General Corporation as part of her Co-Op work experience while attending WPI. She graduated from WPI (High Distinction) with a Bachelor of Science degree in Computer Science, specializing in Scientific Computing, and received the Honeywell Outstanding Achievement in Computer Science Award. After graduation, she worked for International Business Machines (IBM) in the Midrange Division’s Strategy and Planning Competitive Evaluation Department and in the Computer Integrated Manufacturing Division’s CATIA Product Management Department. While at IBM she earned her Master of Science in Advanced Technology, specializing in Systems Science, while studying at the Thomas J. Watson School of Engineering and Applied Science at the State University of New York at Binghamton. Her thesis was titled *Components of Scientific Discovery* and was completed under the direction of Professor Donald C. Gause. In 2001, she enrolled at North Carolina State University (NCSU) to work on her doctorate in Technology Education. While at NCSU, she was inducted into both the Epsilon Pi Tau International Honor Society (serving as vice president) and the Phi Kappa Phi National Honor Society. She worked for a year on the TECHknow Project and is currently working under the direction of Dr. Richard E. Peterson.
ACKNOWLEDGEMENTS

I would like to thank Dr. Richard E. Peterson for all of his support and wisdom over the past years. I will be forever thankful to him for sharing the McCaulley article with me, which is the foundation of this research. I would also like to thank my committee members, Dr. V. William DeLuca, Dr. John M. Pettitt, and Dr. Robert E. Wenig for their assistance and support over the past years. In addition, I would like to thank Dr. Ellen S. Vasu for her assistance with statistical questions.

I also would like to thank both Dr. Brian Matthews and Jeremy Ernst who allowed me access to their classrooms for research purposes.

This study would not have been possible without the students. I would like to thank the pilot study students and the final research students who provided the necessary data for this study.

This research would not be possible without the encouragement from my family who supported me throughout my dissertation journey.
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CHAPTER 1: INTRODUCTION

Reich (1992), in his book *The Work of Nations*, portrays the future for citizens of the United States. He explains that “a nation’s real technological assets are the capabilities of its citizens to solve complex problems of the future – which depend, in turn, on their experience in solving today’s and yesterday’s [problems]” (1992, p. 163).

Reich describes three job types of the future and the kinds of education that will be necessary to obtain the skills to perform these jobs. These three jobs are production services, in-person services, and symbolic-analytic services. There are also two other categories of jobs: extractors of natural resources (like farmers) and government employees. Of these categories, the symbolic-analyst is the one that will have the most potential for a promising future. He states, “In the emerging global economy, even the most impressive of positions in the most prestigious of organizations is vulnerable to worldwide competition if it entails easily replicated routines. The only true competitive advantage lies in skill in solving, identifying, and brokering new problems” (Reich, p. 184). Reich argues that Americans must educate future generations to be symbolic analysts and that this will be “gradual, complex, and dependent on many public and private interactions” (1992, p. 239). He proposes that they would learn through puzzles, experiments, games, planning, problem identification, and problem brokering.

Accordingly, many of our current professional and governmental agencies have issued statements that support the need for problem solving education. Foshay
(2003) points out that “the need for learners to become successful problem solvers has become a dominant theme in many national standards” (p. 1).

Agencies such as the National Research Council whose members are comprised of members from the National Academy of Sciences, the National Academy of Engineering and the Institute of Medicine, have financial support from the National Science Foundation, the U.S. Department of Education, the National Aeronautics and Space Administration, The National Institute of Health, and the National Academy of Sciences. The National Research Council created the National Science Education Standards that state “More and more jobs demand advanced skills, requiring that people be able to learn, reason, think creatively, make decisions, and solve problems…other countries are investing heavily to create scientifically and technically literate work forces. To keep pace in the global markets, the United States needs to have an equally capable citizenry” (National Research Council, 1996, p.1).

The National Science Education Standards (1996) cover a wide range of topics, one of which is the Science and Technology Content Standard E that has the following components: identifying a problem or designing an opportunity, proposing designs and choosing between alternative solutions, implementing a proposed solution, evaluating the solution and its consequences, and communicating the problem, process, and solution (p. 192). In addition, Content Standard E also defines that students should understand the following concepts: science advances when new technologies are introduced, new scientific knowledge is realized as a result of solving technological problems, the desire to understand the natural world is the reason for scientific inquiry, the desire to meet human needs and solve human problems is the
reason for technological design, technology has a more direct effect on society compared to science because technology’s purpose is to solve human problems, and new problems are possible from technological solutions (National Research Council, 1996).

Science education is largely dependent upon technological understanding with a heavy focus on technology as an end as well as a process to solving human problems. Other agencies such as the National Academy of Engineering have recognized the need for technological literacy and have issued several recommendations to achieve this goal. Recommendation 6 states that both the National Science Foundation and the Department of Education should fund research on how people learn about technology, specifically the nature and process of technological problem solving, as well as the knowledge of cognitive science applied to technological learning.

In addition, the National Academy of Engineering issued Recommendation 5 that states researches should consider the challenges with assessing technological understanding specifically the “real, sometimes confusing connections between science and technology” (National Academy of Engineering, 2000).

Math education also recognizes the necessity of technology. The National Council of Teachers of Mathematics has issued Principles and Standards for School Mathematics. The sixth Principle is the Technology Principle, which states “technology is essential in teaching and learning mathematics” (The National Council of Teachers of Mathematics, 2000). The sixth Standard is Problem Solving. In this standard, teachers are encouraged to “create an environment that encourages students
to explore, take risks, share failures and successes, and question one another. In such supportive environments, students develop the confidence they need to explore problems and the ability to make adjustments in their problem solving strategies” (The National Council of Teachers of Mathematics, 2000).

In the field of technology education, the Standards for Technological Literacy have a heavy emphasis on problem solving. Technological literacy is defined as “the ability to use, manage, understand, and assess technology” (ITEA, 2000, p. 242). The standards state that “problem solving is basic to technology” (p. 90). There are standards for the design process, as well as for the invention, experimentation, engineering, troubleshooting, and research and development processes. Regardless of the process, all involve critical and creative thinking, as well as decision making and reasoning.

Rationale

There are many agencies focused on the need for students to learn about problem solving, specifically for all of our citizens to be technologically literate. Huitt (1992) states, “Improving individuals’ and groups’ abilities to solve problems and make decisions is recognized as an important issue in education, industry, and government” (para. 1). Many agencies from many disciplines have recognized the need for technological problem solving skills. Since many disciplines have identified this requirement, and since this requirement is related to technology specifically, then it is important for technology education to research technological problem solving and impact analysis. It is highly desirable for a generic problem solving framework to be identified that would be extendable to a variety of different types of technological
problem solving activities. If such as framework was found to be of value, then it is hypothesized that it would be flexible and extendable to other types of problem solving activities such as design, research and development, and invention, to name a few.

Technological literacy is necessary at both the individual and societal levels (ITEA, 2000, p.10). One area of need is in problem solving at the societal governmental level (for example legislators and court systems), whereby the problems are typically broad, complex, and involve many aspects, impacts, agencies, and citizens. To prepare citizens at both the individual and societal levels to perform technological problem solving, it is essential to begin with identifying the factors that experts believe contribute to problem solving abilities. Huitt’s (1992) article claims “Separate research on personality and cognitive styles has identified important individual differences in how people approach and solve problems and make decisions” (section. abstract). There has been research on the relationship between problem solving and personality. However, most of this research is outside the field of technology education, with a few exceptions, such as Custer, Valesey, and Burke (2001). Huit (1992) states the “need to develop and use a problem-solving/decision-making process that is both scientific and considerate of individual differences and viewpoints” (section. summary). Huit (1992, section. benefits) describes the following benefits of using such a process:

(1) “while it may be impossible to have a single process that is applicable to all problems or decisions by all individuals, it is important to have a generalizable, though flexible, process that individuals believe fits with their
unique styles and that can be used to capitalize on strengths and support weaknesses” (section. benefits)

(2) the problem solving process is balanced, in that both creative and critical thinking is involved

(3) the process provides a person with increased confidence that a correct decision is being made

(4) the person using the process is better able to sell the chosen option/solution to his/her superiors because it contains all aspects that may be appealing to his/her management based on their personality type

(5) the process provides for an analysis of consequences for each option

(6) the process forces team members to consider all aspects before selecting an option

(7) the process is comprehensive, in that it insures that many aspects be considered and stated formally so that important issues will not be forgotten or hidden in assumptions

(8) use of a consistent problem solving process within an organization allows all people to easily view the information generated, making a consensus easier to obtain

(9) since the process is based on personality type and since people know their type, then they also know where their strengths and weaknesses lie in the problem solving process. This allows them to consider issues that they would have otherwise omitted or only briefly mentioned.
(10) people can value other’s viewpoints easier since they realize that another’s differing view may be because they have a different emphasis in a specific personality type.

Problem Statement

Given our global technological society and the complexity of current and future societal problems in this society, it is critical that the citizens, especially those involved in decision making at any level, be able to perform technological problem solving. Technological problem solving involves critically and creatively identifying, examining, evaluating, justifying, and recommending solutions to the world’s global problems. This study will examine some of the factors (confidence, knowledge of an Myers-Briggs Type Indicator (MBTI) problem solving process, psychological type, problem-specific motivation, problem-specific interest, desire to solve problems, and desire to learn about problem solving) involved in technological problem solving in order to understand their inter-relationships. A framework for a problem solving process (that may be applicable to technology education in the same manner as the scientific method is applicable to the sciences) will also be introduced. A problem solving process framework may provide a foundation upon which a variety of technological problem solving processes can all be based. The results of the research may help technology educators adjust their instruction to meet the requirements of technological literacy in problem solving.
Purpose of the Study

The purpose of the study was to advance the knowledge base in technological problem solving so that the goal of technological literacy can be achieved by determining the relationships between factors that possibly influence problem solving abilities and by offering a framework for technological problem solving. Specifically, this study will only address the cognitive and affective aspects of technological problem solving and not the psychomotor aspects. This means that the implementation and/or testing phases of the problem solution selected will not be addressed in this study. Since problem solving accounts for a significant amount of time spent when “doing” technology tasks, either in the classroom, workplace, or home, it is desirable for technologically literate citizens to be able to “do” problem solving effectively and efficiently. Before problem solving can be taught effectively and efficiently, a deeper understanding of the factors that contribute to problem solving needs to be understood.

One such factor that influences problem solving is a person’s psychological type. McCaulley (1987), Myers (1995), and others have written about the relationship between psychological type and problem solving abilities. In fact, McCaulley has taken one step further and proposed an MBTI-type problem solving process based on the Myers-Briggs psychological type theory. This leads to a second related factor, which is the knowledge of and ability to use an MBTI-type problem solving process. McCaulley’s MBTI-type problem solving process consists of (1-S) looking at the situation, collecting the facts and defining the problem, (2-N) generating possible solutions, (3-T) assessing the possible solutions, (4-F) assessing the human impacts, (5-E) consulting with the external world, (6-I) thinking alone about the problem, (7-J)
organizing, planning, and gaining awareness of schedules, and (8-P) looking for more information and at all aspects. This process could be developed into a framework for technological problem solving. In addition, another such factor that may influence problem solving may be a person’s technological problem solving confidence level. Heppner (1997) has created a Problem Solving Inventory (PSI) that measures a person’s problem solving confidence level. There are also other factors that seem to influence problem solving abilities. It is the intent of this research to study these factors to determine their inter-relationships and to examine the use of an MBTI-type problem solving process as a framework for technological problem solving. By understanding these factors and their inter-relationships, it is believed that education can be adjusted to meet the requirement of technological literacy in problem solving.

It is hypothesized that problem solving skills are influenced by several factors identified from the literature. These factors are listed in Table 1.
Table 1. List of Factors from Literature Influencing Problem Solving

<table>
<thead>
<tr>
<th>Factors Influencing Problem Solving</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. ability to correctly identify/define a problem or be aware that a problem exists  (ITEA, 2000 &amp; Stice, 1999)</td>
</tr>
<tr>
<td>2. ability to obtain new knowledge (Stice, 1999, DeLuca, 1991)</td>
</tr>
<tr>
<td>3. ability to generate all potential options – creative thinking (Stice, 1999)</td>
</tr>
<tr>
<td>4. ability to analyze and evaluate all potential options – critical thinking (Hirsh, Kummerow, 1990 &amp; Isaksen and Treffinger, 1985)</td>
</tr>
<tr>
<td>5. ability to seek expert knowledge as needed (Stice, 1999)</td>
</tr>
<tr>
<td>6. ability to apply a problem solving process to specific problem (Stice, 1999)</td>
</tr>
<tr>
<td>7. ability to justify the proposed solution (Braukmann &amp; Pedras, 1990)</td>
</tr>
<tr>
<td>8. ability to professionally communicate the solution (Braukmann &amp; Pedras, 1990, Stice, 1999)</td>
</tr>
<tr>
<td>10. motivation (Foshay, 2003, Stice, 1999)</td>
</tr>
<tr>
<td>11. problem acceptance and concern (Koberg &amp; Bagnall, 1981)</td>
</tr>
<tr>
<td>12. confidence (Foshay, 2003, MacPherson, 1998)</td>
</tr>
<tr>
<td>13. knowledge of a problem solving process (Stice, 1999)</td>
</tr>
<tr>
<td>14. intellectual abilities and potentials (Newell &amp; Simon 1972, Morgan, 1974)</td>
</tr>
<tr>
<td>15. knowledge of and ability to apply heuristics (Stice, 1999)</td>
</tr>
<tr>
<td>16. psychological type (McCaulley, 1987)</td>
</tr>
</tbody>
</table>

These factors can be divided into (1) factors that can be examined in a problem’s solution (2) factors that cannot be examined in a problem’s solution (3) factors that can be examined both in a problem’s solution and external to a problem’s solution and (4) factors that are beyond the scope of this study due to complexity. Table 2 contains factors that can be examined in a problem’s solution.
### Table 2. Factors Able to be Examined in a Solution – Internal Factors

<table>
<thead>
<tr>
<th>Factors Comprising Technological Problem Solving Potential</th>
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<tbody>
<tr>
<td>1. ability to obtain new knowledge</td>
</tr>
<tr>
<td>2. ability to seek expert knowledge as needed</td>
</tr>
<tr>
<td>3. ability to apply problem solving process to specific problem</td>
</tr>
<tr>
<td>4. ability to correctly identify/define problem - awareness of problem</td>
</tr>
<tr>
<td>5. ability to generate potential options</td>
</tr>
<tr>
<td>6. ability to analyze and evaluate potential options</td>
</tr>
<tr>
<td>7. ability to justify proposed solution</td>
</tr>
<tr>
<td>8. ability to professionally communicate solution</td>
</tr>
<tr>
<td>9. technical knowledge</td>
</tr>
</tbody>
</table>

Factors one through nine in Table 2 can be consolidated and will be referred to as a student’s *technological problem solving potential*.

The factors listed in Table 3 cannot be examined in a problem’s solution. Instead they are external to the solution and will be examined and measured individually.

### Table 3. Factors Not Able to be Examined in a Solution – External Factors

<table>
<thead>
<tr>
<th>External Factors</th>
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</thead>
<tbody>
<tr>
<td>motivation</td>
</tr>
<tr>
<td>problem acceptance and concern</td>
</tr>
<tr>
<td>confidence</td>
</tr>
<tr>
<td>knowledge of a problem solving process</td>
</tr>
<tr>
<td>intellectual abilities and potentials</td>
</tr>
</tbody>
</table>
The factor of *psychological type* (McCaulley, 1987) can be examined in both a problem’s solution as well as examined and measured individually. The factor of *knowledge of and ability to apply heuristics* (Stice, 1999) was not measured in this study due to its complexity.

This study researched the relationships between the factors of technological problem solving potential (consolidated factors one through nine from Table 1), motivation (Foshay, 2003 & Stice, 1999 & Morgan, 1974), problem acceptance and concern (Koberg, Bagnall, 1981), confidence (Foshay, 2003 & MacPherson, 1998), knowledge of a problem solving process (Stice, 1999), intellectual abilities and potentials (Newell, Simon, 1972 & Morgan, 1974), and psychological type (McCaulley, 1987).

Each of the External and Internal factors was measured according to the information in Tables 4 and 5.
Table 4. Internal Factors and How They Were Measured

<table>
<thead>
<tr>
<th>Internal Factors – Measurable in a Problem Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Factor from Literature</strong></td>
</tr>
<tr>
<td>1. ability to obtain new knowledge</td>
</tr>
<tr>
<td>2. ability to seek expert knowledge as needed</td>
</tr>
<tr>
<td>3. ability to apply problem solving process to specific problem</td>
</tr>
<tr>
<td>4. ability to correctly identify/define problem - awareness of problem</td>
</tr>
<tr>
<td>5. ability to generate potential options</td>
</tr>
<tr>
<td>6. ability to analyze and evaluate potential options</td>
</tr>
<tr>
<td>7. ability to justify proposed solution</td>
</tr>
<tr>
<td>8. ability to professionally communicate solution</td>
</tr>
<tr>
<td>9. technical knowledge</td>
</tr>
<tr>
<td>10. psychological type</td>
</tr>
</tbody>
</table>
### Table 5. External Factors and How They Were Measured

<table>
<thead>
<tr>
<th>External Factors – Not Measurable in a Problem Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Factor from literature</strong></td>
</tr>
</tbody>
</table>
| 1. motivation | • Motivated to solve problem. Likert 1-5  
• Interested in learning about problem solving – Y/N  
• Likes to solve problems – Y/N |
| 2. problem acceptance and concern | • Interested to solve problem. Likert 1-5 |
| 3. confidence | • Problem Solving Inventory (PSI) |
| 4. knowledge of a problem solving process | • Did you use a process?  
  a. List process used  
• What process would you teach? |
| 5. intellectual abilities and potentials | • GPA |
| 6. psychological type | • MBTI |

As a result of determining how each factor could be measured, the problem statement was simplified. The objective of the study was to examine the relationships between the factors of technological problem solving potential, problem solving confidence, psychological type, knowledge of a problem solving process, GPA, problem-specific interest, problem-specific motivation, desire to solve problems, and desire to learn about problem solving.
Research Questions

The following were the research questions guiding the study. Please note for readability, the words potential, confidence, and process have been simplified but all should be preceded by the words technological problem solving. Appendix J contains diagrams depicting the following levels of research questions.

1. What relationship does potential have with confidence, process knowledge, and psychological type?
2. What are the relationships between psychological type, confidence, and process knowledge?
3. Do confidence, process knowledge, potential, problem solving approach and desire to learn about problem solving change as a result of instruction?
4. What is the relationship between psychological type and problem solving approach?
5. What relationship does GPA have with confidence, process knowledge, and potential?
6. What relationship does problem-specific motivation, problem-specific interest, the desire to learn about problem solving, and the desire to solve problems have with confidence, process knowledge, and potential; and what relationship does desire to learn about problem solving and desire to solve problems have with psychological type?
7. What relationship does using a process, and using the same process as a person would teach have with confidence, process knowledge, potential, and psychological type?
Hypotheses

The objective of the study was to examine the relationships between the factors of technological problem solving potential (consolidated factors one through nine above), motivation (Foshay, 2003 & Stice, 1999 & Morgan, 1974), problem acceptance and concern (Koberg, Bagnall, 1981), confidence (Foshay, 2003 & MacPherson, 1998), knowledge of a problem solving process (Stice, 1999), intellectual abilities and potentials (Newell, Simon, 1972 & Morgan, 1974), and psychological type (McCaulley, 1987). After simplification, the objective of the study was to examine the relationships between the factors of technological problem solving potential, problem solving confidence, psychological type, knowledge of a problem solving process, GPA, problem interest, motivation, desire to solve problems, and desire to learn about problem solving.

The hypotheses were grouped into different levels depending upon the research questions, namely Level 1 to Level 7. A graphic for each level showing the hypotheses is included in Appendix J – Levels of Possible Relationships. This study will explore the following null hypotheses:

Level 1: Relationships - potential with confidence, process, and psychological type

1. There is no relationship between problem solving confidence and technological problem solving potential.

2. There is no relationship between knowing an MBTI-type problem solving process and technological problem solving potential.

3. There is no relationship between psychological type and technological problem solving potential.
Level 2: Relationships between confidence, process, and psychological type

4. There is no relationship between problem solving confidence and knowing an MBTI problem solving process.

5. There is no relationship between psychological type and problem solving confidence.

6. There is no relationship between psychological type and knowledge of an MBTI-type problem solving process.

Level 3: Changes in confidence, process knowledge, potential, problem solving approach, and desire to learn about problem solving as a result of the intervention

7. There is no relationship between pre-test problem solving process scores and post-test problem solving process scores.

8. There is no relationship between pre-test problem solving confidence scores and post-test problem solving confidence scores.

9. There is no relationship between pre-test problem solving potential scores and post-test problem solving potential scores.

10. There is no relationship between a researcher’s calculated MBTI type student’s problem solving approach prior to the intervention as compared to a researcher’s calculated MBTI type student’s problem solving approach after the intervention.

11. There is no relationship between a student’s desire to learn about problem solving prior to the intervention as compared to a student’s desire to learn about problem solving after the intervention.
Level 4: Relationship between psychological type and problem solving approach

12. There is no relationship between psychological type and technological problem solving approach.

Level 5: Relationships involving GPA

13. There is no relationship between problem solving potential and GPA.
14. There is no relationship between problem solving confidence and GPA.
15. There is no relationship between process knowledge and GPA.

Level 6: Relationships involving motivation, interest, desire to learn about problem solving, and desire to solve problems

16. There is no relationship between problem solving potential and motivation to solve the specific problem.
17. There is no relationship between problem solving confidence and motivation to solve the specific problem.
18. There is no relationship between process knowledge and motivation to solve the specific problem.
19. There is no relationship between problem solving potential and interest to solve the specific problem.
20. There is no relationship between problem solving confidence and interest to solve the specific problem.
21. There is no relationship between process knowledge and interest to solve the specific problem.
22. There is no relationship between problem solving potential and desire to learn about problem solving.
23. There is no relationship between problem solving confidence and desire to learn about problem solving.

24. There is no relationship between process knowledge and desire to learn about problem solving.

25. There is no relationship between psychological type and desire to learn about problem solving.

26. There is no relationship between problem solving potential and liking to solve problems.

27. There is no relationship between problem solving confidence and liking to solve problems.

28. There is no relationship between process knowledge and liking to solve problems.

29. There is no relationship between psychological type and liking to solve problems.

**Level 7: Relationships involving “using a process” and “using the same process as would teach”**

30. There is no relationship between problem solving potential and using a process.

31. There is no relationship between problem solving confidence and using a process.

32. There is no relationship between process knowledge and using a process.

33. There is no relationship between psychological type and using a process.
34. There is no relationship between problem solving potential and “using the same process as a person would teach.”

35. There is no relationship between problem solving confidence and “using the same process as a person would teach.”

36. There is no relationship between process knowledge and “using the same process as a person would teach.”

37. There is no relationship between psychological type and “using the same process as a person would teach.”

Significance of the Study

Since problem solving involves many factors that theoretically influence the solving of complex technological problems in our global society, it is essential to understand if and how these factors are related. By understanding the inter-relationships of these factors and which factors can be manipulated, technology educators can modify their classroom instruction to insure that all students are able to achieve this essential skill called technological problem solving. It is believed that in order to study problem solving, it is essential to study as many factors as possible that contribute to problem solving simultaneously so that a complete representation of the “problem solving system” in its entirety can be examined. Understanding complex systems such as problem solving requires an understanding of the relationships between the subsystems that comprise the system. This is the intent of this research – to understand the inter-relationships between the sub-systems (or factors) comprising problem solving.
Definitions of Terms

The following definitions are provided to help with the understanding of the study. Unless otherwise noted, these definitions are researcher-developed.

**Confidence** – a measure of how much certainty a person feels towards problem solving.

**Complex problems** – those technological problems whose problem state, goal state, and/or process state have not been clearly defined.

**Complex technological problem solving** – the solving of complex problems in which there is at least one element of technology in the problem state, the goal state, or the process used to get from the problem state to the goal state.

**Design** – a specific type of problem solving process in which a solution is created from a specific set of customer requirements with given constraints.

**Desire to learn about problem solving** – a measure of whether or not a student is interested in learning about problem solving.

**Desire to solve problems** – a measure of whether or not a student likes to solve problems.

**Factor** – an aspect that influences the success of problem solving.

**Goal state** – the goal of solving the problem.

**Interest** – a measure of whether or not a student is interested in solving the specific problem.

**Heuristics** – a set of methods that can be employed to overcome an obstacle during the solving of a problem. These methods are not guaranteed to work for every problem.
**Myers-Briggs Type Indicator (MBTI)** – a forced-choice, self-report inventory that is administered and interpreted by a professional. It classifies people into one of sixteen psychological types. It is based on Jung’s theory of personality type.

**MBTI-type problem solving process** – this is the problem solving process proposed by McCaulley (1987) that is based on the Myers-Briggs Type Indicator. It consists of (1-S) looking at the situation, collecting the facts and defining the problem, (2-N) generating possible solutions, (3-T) assessing the possible solutions, (4-F) assessing the human impacts, (5-E) consulting with the external world, (6-I) thinking alone about the problem, (7-J) organizing, planning, and being aware of schedules, and (8-P) looking for more information and at all aspects.

**Motivation** – a measure of whether or not a student is motivated to solve the specific problem.

**Potential** – a student’s possible problem solving capability. This includes the following: ability to obtain new knowledge, ability to seek expert knowledge as needed, ability to apply a problem solving process to a specific problem, ability to correctly identify/define a problem and an awareness of the problem, ability to generate potential options, ability to analyze and evaluate potential options, ability to justify the proposed solution, ability to professionally communicate the solution, and technical knowledge.

**Problem** – a problem arises when the current state does not match the goal state and there is no known method to the individual on how to move from the current state to the goal state.
**Problem solving** – a system that involves moving from the current state to the goal state, using a process or a set of processes.

**Problem solving approach** – the way a student approaches the written solution to a problem.

**Problem solving abilities** – those skills that are required to “do” problem solving, such as creative and critical thinking skills.

**Problem solving confidence** – a measure of how much certainty a person feels towards problem solving.

**Problem Solving Inventory (PSI)** – The Problem Solving Inventory (PSI) is a self-report inventory used to assess an individual’s problem solving confidence, problem solving approach-avoidance style, and problem solving personal control (Heppner, 1997). This inventory does not measure actual problem solving skills or performance.

**Problem solving processes** – the procedures used to “do” problem solving.

**Problem solving potential** – a student’s possible problem solving capability. This includes the following: ability to obtain new knowledge, ability to seek expert knowledge as needed, ability to apply a problem solving process to a specific problem, ability to correctly identify/define a problem and an awareness of the problem, ability to generate potential options, ability to analyze and evaluate potential options, ability to justify the proposed solution, ability to professionally communicate the solution, and technical knowledge.

**Problem solving process knowledge** – a student’s knowledge of an MBTI-type problem solving process. This is in contrast to the ability to apply the process. It consists of (1-S) looking at the situation, collecting the facts and defining the problem,
(2-N) generating possible solutions, (3-T) assessing the possible solutions, (4-F) assessing the human impacts, (5-E) consulting with the external world, (6-I) thinking alone about the problem, (7-J) organizing, planning, and being aware of schedules, and (8-P) looking for more information and at all aspects.

**Problem State** – The state in which the problem is identified and defined.

**Process** – a procedure or method that is definable and repeatable. In this study it is what is used to get from the problem state to the goal state.

**Process knowledge** – a student’s knowledge of a problem solving process. This is in contrast to the ability to apply the process. It consists of (1-S) looking at the situation, collecting the facts and defining the problem, (2-N) generating possible solutions, (3-T) assessing the possible solutions, (4-F) assessing the human impacts, (5-E) consulting with the external world, (6-I) thinking alone about the problem, (7-J) organizing, planning, and being aware of schedules, and (8-P) looking for more information and at all aspects.

**Psychological type** – this is a way to classify human behaviors based on theories. For this study, it is based on the results of the MBTI.

**Technology education** – the study of the man-made world.

**Technological problem solving** – solving problems that involve technology in some manner. In this study, this is assumed to be complex problems. Technological problem solving involves critically and creatively identifying, examining, evaluating, justifying, and recommending solutions to the world’s global problems.

**Technological problem solving potential** – a student’s possible problem solving capability. This includes the following: ability to obtain new knowledge, ability to
seek expert knowledge as needed, ability to apply a problem solving process to a specific problem, ability to correctly identify/define a problem and an awareness of the problem, ability to generate potential options, ability to analyze and evaluate potential options, ability to justify the proposed solution, ability to professionally communicate the solution, and technical knowledge.

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

*Using a process* – a measure of a student’s use of a problem solving process that is similar to the MBTI-type problem solving process.

*Using the same process as would teach* – a measure of a student’s use of a problem solving process that is the same or similar to the one a student would teach.
Limitations

The following were the limitations of this study:

1. The available classrooms for experimentation were limited to those that were offered in the current semester at the North Carolina State University in Technology Education and those that would benefit from instruction in problem solving.

2. The researcher did not have access to a specific class and had to merge the problem solving instruction in with an existing class syllabus.

3. The selection of subjects could not be randomized. The researcher conducted the experiment with an available technology education class that would benefit from problem solving instruction.

4. The sample size was small. Therefore, results of the study cannot be generalized beyond the specific population from which the sample was drawn.

5. The students were aware that the intervention was for research purposes. This may have caused them to modify some of their answers, which, as a result, may have caused the research to have validity complications.
Delimitations

The following were the delimitations of the study:

1. The study did not include the factor of knowledge and ability to apply heuristics due to its complexity.
2. The method for experimentation was exploratory and quite involved. Due to its exploratory nature and the amount of time involved in scoring of the solutions, no peer evaluation of the data was performed.
3. The study employed the use of vague and open-ended assignments which allowed the subjects to freely express their solutions without any influence from the researcher. However, this lack of specific direction may have contributed to inaccurate data and, thus, lead to inaccurate conclusions.
4. The researcher created the measurement system for assessing the technological problem solving potential because there were no known rubrics available. This measuring system has not gone through the vigorous process for insuring reliability and validity.
5. The researcher created the measurement system for assessing the technological problem solving process knowledge based on McCaulley (1987), but this has not gone through the vigorous process for insuring reliability and validity.
6. This study did not compare the proposed MBTI problem solving process (the MBTI-based process) to other problem solving processes.
7. This study did not predict the success of students in a class.
8. This study did not address problem solving for problems in which there is only one answer, such as problems of a mathematical nature.

9. This study did not address problem solving for non-technological problems.

10. This study did not address problem solving that is simplistic.

11. This study did not address the follow-up activities associated with problem solving such as implementing or evaluating the final solution after it has been produced.

12. This study did not investigate all of the factors that contribute to technological problem solving abilities.

13. This study required an extensive amount of written work by each student. In technology education, students are used to hands-on work instead of written work. This difference in expectations may contribute to inaccurate data.
Assumptions

The following were the assumptions of the study:

1. Technological problem solving is a complex system that can be broken down into subsystems and their inter-relationships.

2. It is essential to concurrently study as many factors influencing problem solving as possible because problem solving is a system and needs a systems approach to its research.

3. A student’s psychological type will not be affected by the intervention.

4. Each student did their best on all intervention activities, regardless of knowing that the results would be used for research.

5. Technological problem solving potential is comprised of nine subprocesses, namely ability to obtain new knowledge (Stice, 1999 & DeLuca, 1991), ability to seek expert knowledge as needed (Stice, 1999), ability to apply a problem solving process to a specific problem (Stice, 1999), ability to correctly identify/define the problem and an awareness of the problem (ITEA, 2000 & Stice, 1999), ability to generate potential options (Stice, 1999), ability to analyze and evaluate potential options (Hirsh, Kummerow, 1990 & Isaksen, Treffinger, 1985), ability to justify a proposed solution (Braukmann, Pedras, 1990), ability to professionally communicate the solution (Braukmann and Pedras, 1990 & Stice, 1999), and technical knowledge (Stice, 1999 & DeLuca, 1991).
6. The MBTI-type problem solving process was comprised of the each of
the eight preferences from the MBTI as defined by McCaulley (1987).

7. The MBTI-type problem solving process is the best problem solving
process for complex technological problems.

8. There does not exist a prior method for assessing technological
problem solving sub-systems and their inter-relationships.
Summary

In summary, there is an extensive focus from many prestigious organizations on the need for teaching and learning technological problem solving in our complex, global, technological society. This need should be filled in the technology education classroom since it is based on technological problem solving skills. However, there is a lack of a framework for educators to use when teaching problem solving skills. In addition, it is not clear what the specific factors or their inter-relationships are that comprise technological problem solving. There are many benefits to identifying these factors and their inter-relationships and creating a framework for educators to use for teaching technological problem solving in the technology education classroom. Therefore, this research is the beginning of the search for (1) understanding the factors that contribute to technological problem solving, (2) understanding the inter-relationships between these factors, and (3) proposing a problem solving process that can be used as a framework for teaching technological problem solving. Assumptions were made and limitations and delimitations were set, and these may have influenced the results of the research.
CHAPTER 2: LITERATURE REVIEW

This chapter is a review of the literature on the factors of technological problem solving and their inter-relationships.

Problems

Weith and Burns (2000) categorize problems into two types: those that can be solved in a given number of steps methodologically (such as a mathematical equation) and those that do not have a specific method and for which there are many uncertainties and often more than one possible solution. These two types of problems are termed incremental problems and insight problems, respectively, in a study conducted by Weith and Burns on Motivation in Insight versus Incremental Problem Solving. Weith and Burns (2000) refer to incremental problems as those that “require the solver to take a number of incremental steps in order to solve the problem” (para. 6).

Foshay (2003) sites the work of Newell and Simon in 1972 in which three types of problems were identified: well-structured, moderately-structured, and ill-structured. He includes a chart in his research that differentiates these three types of problems. Basically, well structured problems are those in which a step-by-step process produces one correct answer. This is equivalent to Weith and Burns’ incremental problem type. Moderately-structured problems include those with still one right answer but with specific constraints, some ambiguity, and some flexibility (or degrees of freedom), such as writing a letter or designing a spreadsheet. Ill-structured problems are those problems that have multiple solutions or may have no satisfactory
solution, such as the design of a new bridge. It is fair to conclude that ill-structured problems, during their problem solving process, will involve both moderately-structured and well-structured sub-problems as part of the overall ill-structured problem solution.

This study will focus on those problems in the ill-structured category. In technology education, well-structured problems include troubleshooting problems, while moderately-structured problems include design problems.

Johnstone (2001) classifies problems according to three items: information, goal, and method or process to get from the information to the goal. Information can be either complete or incomplete, the goal can either be clear or unclear, and the method can either be familiar or unfamiliar. Table 6 shows all permutations of the levels of problems (para. 4).

Table 6. Classification of Problems

<table>
<thead>
<tr>
<th>Type</th>
<th>Data</th>
<th>Method</th>
<th>Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>complete</td>
<td>familiar</td>
<td>clear</td>
</tr>
<tr>
<td>2</td>
<td>complete</td>
<td>unfamiliar</td>
<td>clear</td>
</tr>
<tr>
<td>3</td>
<td>incomplete</td>
<td>familiar</td>
<td>clear</td>
</tr>
<tr>
<td>4</td>
<td>complete</td>
<td>familiar</td>
<td>unclear</td>
</tr>
<tr>
<td>5</td>
<td>incomplete</td>
<td>unfamiliar</td>
<td>clear</td>
</tr>
<tr>
<td>6</td>
<td>complete</td>
<td>unfamiliar</td>
<td>unclear</td>
</tr>
<tr>
<td>7</td>
<td>incomplete</td>
<td>familiar</td>
<td>unclear</td>
</tr>
<tr>
<td>8</td>
<td>incomplete</td>
<td>unfamiliar</td>
<td>unclear</td>
</tr>
</tbody>
</table>

A Type 1 problem defined above is not really a problem but just a matter of learning how to apply a specific process to a set of given data to reach the only solution. However, the rest of the Types (2-8) have at least one or more items that are not known. Therefore, Johnstone (2001) proposes that “problem solving can be thought of as filling gaps between certainties” (para. 9). Johnstone believes that we
can teach methods to help narrow the gap, but we cannot teach how to really bridge the gap. He states for that to occur, there will need to be the following: “knowledge, experience, confidence, and the mental flexibility to ‘see’ new things” (para. 9).

Mayer (1992) defines problems as having the following conditions: (1) the problem is in some state presently (2) it is desired that the problem be in another state called the goal state, and (3) there is no direct path or method to accomplish the change that is obvious.

Jones (1998) identifies four types of problems: (1) simplistic - in which there is only one answer based on a factual question (2) deterministic - in which there is only one answer but it is determined by a formula, and all of the facts must be known (3) random - in which there are different answers but all possible answers are known and (4) indeterminate - in which there are different answers, and it is not possible to identify all the possible answers.

Vasu, Stewart, and Garson (1998) describe wicked problems as those problems whose “answers to the problem are less in the realm of the true or false, and more in the realm of good or bad” (p. 21). They associate these problems with the public sector and with problems such as poverty and say these “social problems are never solved. At best they are only resolved-over and over again” (p. 20). These are the same type of problems as technological problems because, more than likely, somewhere in the problem solving system, at least one element of technology is apparent.

In this study, the problems that are the focus for technological problem solving are those that are of the ill-structured, Types 2-8, indeterminate, and wicked types.
The Problem Solving System

Gredler (2001) describes problems as consisting of three components: “givens, a goal, and allowable operators” (p. 217). Givens include problem information. Goals include the desired outcome, and allowable operators are the “steps or procedures that will transform the givens into the goal” (p. 217). This is the same as describing problem solving as a system with the givens as input, the goals as output and the allowable operators as the processes used to get from the givens to the goals. Gredler (2001) describes the “subprocesses in problem solving” as being a representation of the problem, the planning, the overcoming of obstacles, and the executing of plans. The selection of the word subprocess implies that Gredler was thinking that problem solving is a system. Gredler also notes that “the development of certain complex problem-solving skills is not linear” (p. 225). She references studies that show that third and fourth year radiology residents perform worse than first and second year residents.

Problem Solving

Wu, Custer, and Dryenfurth (1996) state that “problem solving has evolved into a generic construction that covers a wide range of different types of activity” (p. 56). “The terms designing, troubleshooting, solving textbook problems, and experimenting are sometimes used interchangeably with problem solving” (Lavonen, Meisalo, Lattu, 2001, p. 21). This research is concerned about complex problems that span many disciplines, involve a wide variety of knowledge, and have many possible, successful solutions. These complex problems are typically ill-defined, complex, societal problems involving technology with impacts on and from societal systems.
such as politics, ethics, environmental, economic, and cultural. Typically problems of this magnitude involve many people from many disciplines. Determining a solution may take months or even years and involve major resources, including finances, people, materials, tools, etc. The cognitive skills for individuals involved in the problem will be critical thinking, creative thinking, and decision making. Other skills necessary for a successful solution will be the ability to communicate the proposed solution and its justification. Therefore, organization skills are necessary. Problem solving individuals will have to work within the guidelines of societal rules and values and be expected to provide a solution to an unmet need or want, given time, cost, and other societal constraints.

Huit (1992) defines problem solving as a “process in which we perceive and resolve a gap between a present situation and a desired goal, with the path to the goal blocked by known or unknown obstacles. In general, the situation is one not previously encountered, or where at least a specific solution from past experiences is not known” (para. 7).

In the report titled Setting Research Agendas in Science, Mathematics, and Technology Education: The National Research Council’s How People Learn, the American Association for the Advancement of Science (AAAS) discusses the issue of problem solving strategies. Specifically, the report states “… we need to know where students are in terms of this progression, particularly in areas of problem solving. What does this look like in technology education? What patterns exist in the growth of understanding and competency? … Instruction should be organized around meaningful
problems with appropriate goals” (Pellegrino, 2004, para. 17). Hence, there is a need to use real world problems in the classroom.

Johnson (1992) believes that “the most important job skills may be the ability to think creatively, solve problems, and make decisions” (para. 4). He states, “The impacts of technology on our society, culture, environment, and political system need to be analyzed and evaluated by citizens” (para. 5). He says that unless citizens have well-developed, intellectual skills and an understanding of technology, they will not be able to make the decisions necessary regarding technological issues. He states that these skills are not directly observable and become difficult for the teacher to evaluate if they have been obtained. Problem solving and decision making are two of the eight thinking processes he describes in his report. He also believes that people use various amounts of creative and critical thinking skills when they solve problems and make decisions. He recommends several goals for a technology education curriculum: (1) cognitive and meta-cognitive skills, as well as strategies, be taught to improve problem solving, decision making, and inquiry (2) knowledge from a variety of subject areas be obtained because of the interdisciplinary nature of technology and (3) problems be taken from real world situations and contexts because “learning occurs best when related to experience and transfers to situations similar to the conditions of learning” (para. 17). His report is based on the assumption that the most important future skill is the ability to think.

Problem Solving Potential Abilities

Problem solving abilities include those skills or behaviors necessary to solve a problem. “The development of problem solving abilities is pivotal to technological
literacy” (Custer, Valesey, and Burke, 2001, p. 5). DeLuca (1991) defines problem solving as a “process of resolving a known difficulty” (para. 3). He identifies that the acquisition of knowledge relative to the problem, the thinking skills necessary to process this knowledge and the ability to identify and apply the necessary processes to reach a solution are skills that are necessary when problem solving. DeLuca (1991) also identifies thinking abilities for problem solving that were pertinent to technology education. These thinking abilities are (1) prior technological knowledge, (2) related knowledge, such as math and science and (3) missing knowledge identification and acquisition ability.

Stice (1999) reports that Woods et al. in his 1975 article on *Teaching Problem Solving Skills* believed that successful problem solvers have some or all of the following abilities

1. awareness that a problem exists
2. basic knowledge relative to the problem
3. ability to obtain the necessary missing information
4. motivation to solve the problem
5. ability to communicate the solution
6. ability to work with others if necessary
7. an organized strategy
8. heuristics
9. ability to create, generalize, and simplify.

Stice (1999) emphasizes the need for a good strategy or method. He favors Polya’s strategy with Woods’ refinement. Stice suggests the following method: define
the problem, think about the problem, plan the solution, carry out the plan, and look back. Woods added the “think about the problem” step to Polya’s original process. It should be noted that Polya’s original process was specifically for mathematical problems.

McCade (1990) states that “problem solving is a higher level thinking skill” (para. 16). He says this type of thinking uses analysis, synthesis, and evaluation in addition to knowledge, understanding, and application, which he feels are the foundation upon which the higher level thinking can occur. He says that the lower levels of thinking are necessary and essential because they are the building blocks that support the higher levels of thinking. He references Bloom’s Taxonomy as supporting all of these types of thinking. He provides an example of an assignment he proposed that should be included in the assignments of technology education classrooms. The goal of his proposed assignment is to have students be able to “draw logical conclusions” from the information they collect. His scoring rubric includes the clarity of the facts and arguments that support the conclusion of the assignment, including the organization and presentation of the results and its content. The rubric also allows for the evaluation of how persuasive the argument is and how well it is written.

Newell and Simon (1972) analyzed human problem solving and formed a variety of theories. One such belief is that the behavior of the problem solver is related to the intelligence of the problem solver and the specific task environment (p. 788). Task environment is “an environment coupled with a goal, problem, or task…” (p. 55).
Problem Solving Process

DeLuca (1991) lists five types of problem solving processes that are used depending upon the problem type: troubleshooting, scientific, design, research and development, and project management. For each of these types, there is an associated method that is typically performed. Table 7 summarizes the problem type and associated process as identified by DeLuca (1991, para. 3):

Table 7. Problem Solving Processes

<table>
<thead>
<tr>
<th>Troubleshooting/Debugging</th>
<th>Scientific Method</th>
<th>Design</th>
<th>Research and Development</th>
<th>Project Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isolate the problem</td>
<td>Observe</td>
<td>Ideation / brainstorm</td>
<td>Conceptualize project</td>
<td>Identify project goal</td>
</tr>
<tr>
<td>Identify possible cause</td>
<td>Develop hypothesis</td>
<td>Identify possible solution</td>
<td>Select research procedure</td>
<td>Identify tasks to reach goal</td>
</tr>
<tr>
<td>Test</td>
<td>Experiment</td>
<td>prototype</td>
<td>Finalize research design</td>
<td>Develop plan to accomplish tasks</td>
</tr>
<tr>
<td>Implement solution</td>
<td>Draw conclusion</td>
<td>Finalize design</td>
<td>Develop proposal</td>
<td>Implement the plan</td>
</tr>
<tr>
<td>Test solution</td>
<td></td>
<td></td>
<td>Conduct research</td>
<td>Evaluate the plan</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Analyze result</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Report result</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Evaluate project</td>
<td></td>
</tr>
</tbody>
</table>

Robertshaw, Mecca, and Rerick (1978) state that there are four dependent interacting processes which make up the problem solving process from a systems perspective: (1) problem definition (2) alternative solutions generation (3) alternative solutions evaluation and (4) iterate. Robertshaw, Mecca, and Rerick state that there are several problems with the process: (1) there is no method to determine which solution is the best possible solution (2) the term “best” is subjective and depends
upon the person’s or group’s values and (3) these individual or group values change over time. They also state that even “good” solutions have bad things about them and, therefore, it is necessary to look at the entire solution. In addition, complex problems are usually composed of smaller, but still complex, problems.

In 1981, Hayes published the book *The Complete Problem Solver*, which contained a process for solving problems. The process consists of the following steps: (1) finding the problem, (2) representing the problem (3) planning the solution (4) carrying out the plan (5) evaluating the solution and (6) consolidating gains.

A popular problem solving process used in technology education is the IDEAL problem solver, which is usually used in design activities. The specific steps involved in the process are: (1) identify the problem (2) define and represent the problem (3) explore possible strategies (4) act on the strategies and (5) look back and evaluate the effects of your activities (Bransford and Stein, 1984).

Isaksen and Treffinger (1985) created a model for creative problem solving. The following is the process they developed:

1. Mess Finding – identify the problem
2. Data Finding – collecting information, knowledge, facts, feeling, opinions, and thoughts about the problem
3. Problem Finding – formulating the problem statement
4. Idea Finding – brainstorming as many ideas or alternatives as possible
5. Solution Finding – selecting best ideas based on criteria established by evaluating the strengths and weaknesses of each potential solution
The State of Queensland, specifically Dalby South State School, has issued a “Thinking Skills Program” which is based on Bloom’s Taxonomy. In the strategy document, they diagram a problem solving cycle: Their process is as follows:

1. State the problem
2. State the solution, as hoped, if the problem is solved
3. Create alternatives, including any and all
4. Select the best three alternatives
5. Analyze the consequences of each of the three alternatives
6. Select the final alternative
8. Evaluate – did it work?

Technological Problem Solving

Technological problem solving involves problems that have a technology connection, such as nuclear power plant issues, in comparison to a wholly psychological connection, such as marital issues. Wu, Custer, and Dyrenfurth (1996) state that “problem solving, and technological problem solving in particular, is clearly a critical survival skill in our technologically advanced world” (p. 55). They further claim that “it is clear that problems of various types exist and that not all problems are technological” (1996, p. 56).

Flowers (1998) takes a broad definition of problem solving that could be taught in technology education. He states that “we need a global citizenry that can entertain a wider variety of solutions than merely a new technological product” (para. 5). He believes that “problem solving and product design are not the same; the best
result of a sound problem solving process is often something other than a new product” (para. 5). He suggests that technology education take a different approach to teaching problem solving: (1) problem solving skills should be used to improve human conditions (2) solutions should be from a broad range that includes technical and non-technical domains and (3) solutions will need to consider laws, communications, and other social aspects. He suggests that the technology education teacher help students to become empowered, risk-taking individuals who are able to identify what is best, even if that excludes the development of a new technology. He suggests that technology education teachers pose situations to students, let them examine the situation and plan what is “best,” including determining both short term and long term consequences and costs. He defines “best” as best for the individual, culture, future generations, and environment.

Flowers (1998) says that students should consider “educational reform, personal lifestyles, new technology, and government action” (para. 14) when solving problems.

Design

Design is a specific type of activity that involves solving problems that have given requirements and constraints. These problems are either moderately-structured or ill-structured in that they typically lead to a solution, but there are multiple, potential solutions. The design process involves both creative and critical thinking and decision making activities. Koberg and Bagnall (1981) describe the following “design stages” as “the logical general sequence of events included in the design process” (p. 17): problem acceptance, problem analysis (including facts), problem
definition (including goal definition), ideation (including generating options), selection (including judging which option is best), implementation (including construction of selected option), and evaluation (including determining the effects of implementation).

The Standards for Technological Literacy (2000) describe the design process as “defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design, creating or making it, and communicating processes and results” (p. 97). Hailey, Erekson, Becker, and Thomas (2005) compared the design process from the Standards for Technological Literacy with a classical engineering design process. Hailey et al. state the classical engineering design process as “identify the need, define problem, search for information, identify constraints, specify evaluation criteria, generate alternative solutions, engineering analysis, optimization, decision, design specification and communication” (p. 25). Hailey et al. are part of the National Center for Engineering and Technology Education (NCETE) whose goal it is to integrate engineering design, problem solving, and analytical skills into the K-12 curriculum via technology education.

Solutions

Peterson (2001) references two studies (Glover, 1980 and Cropley, 1999) that identify two conditions that must be met for a product to be considered creative: it must serve a purpose, and it must be original.
McCaulley (1987) references Myers earlier work of 1980 in which Myers concludes that because of following the MBTI problem solving process, the solution selected should have been selected on a “sounder basis” because all of the facts, possibilities, consequences, and human values will have been considered.

Harris (2000) lists several criteria for evaluating a creative solution. One criterion is that the solution successfully solves the problem. Another criterion is that it is practical and meets the constraints. Other criteria on his list include the acceptability to users, the cost/benefit ratios, and the reliability, among others.

Nickols (2000) lists some measures of a good solution. One measure is that it is able to be implemented. Following implementation, a measure of a good solution is one that is effective, inferring that it solved the problem.

Technology

There is an abundance of definitions for technology. In the book Technically Speaking: Why All Americans Need to Know More About Technology, the National Academy of Engineering (2002) has a fairly comprehensive definition: the “tangible artifacts of the human-designed world (e.g., bridges, automobiles, computers, satellites, medical imaging devices, drugs, genetically engineered plants) and the systems of which these artifacts are a part (e.g., transportation, communications, health care, food production), as well as the people, infrastructure, and processes to design, manufacture, operate, and repair the artifacts” (National Academy Press, para. 3). They further state that “[most citizens] are not aware that modern technology is the fruit of a complex interplay between science, engineering, politics, ethics, law and other factors” (National Academy Press, section. context for technological literacy).
Technological Literacy

Several governmental and educational agencies have called for an educational requirement of technological literacy. The National Academy of Engineering (2002) believes that technological literacy would give “people the tools to participate intelligently and thoughtfully in the world around them” (National Academy Press, section. what is technological literacy). They further believe that “technological literacy is especially important for leaders in business, government, and the media, who make or influence decisions that affect many others, sometimes the entire nation” (National Academy Press, section. benefits).

Psychological Type

In order to understand people’s personalities, Isabel Myers adapted Swiss psychologist Carl Jung’s theory of personality types to help form the theory presently used in psychology. Isabel Myer’s mother, Katharine Briggs, together with Isabel Myers, studied Jung’s theories. Initially, the two thought that it would be valuable to be able to help women identify what kind of a job they would like most during war time when men were not available to work in industry. Together, they created the Myers-Briggs Type Indicator (MBTI), which they refined over the years (Myers and Myers, 1995). The MBTI has been used in a variety of ways. It has also been translated to sixteen languages.

Kummerow, Barger, and Kirby (1997) have adapted the MBTI for use in work environments. They provide a concise overview of the MTBI. The MBTI is divided into four categories: (1) how people get and use their energy (2) how people gather and take in information (3) how people make decisions and (4) how people organize
their lives. For each of these categories, there are two opposing preferences. Each person is somewhere on the continuum between the two extremes. Table 8 describes each category and the two opposing preferences (Kummerow, Barger, and Kirby, 1997, p. 10). When configured together, the preferences S, N, T, F, E, I, J, and P can be combined into sixteen types: ISTJ, ISTP, ESTP, ESTJ, ISFJ, OSFP, ESFP, ESFJ, INFJ, INFP, ENFP, ENFJ, INTJ, INTP, ENTP, ENTJ. There is an abundance of literature written on each of the sixteen types for different situations.
<table>
<thead>
<tr>
<th>Category</th>
<th>Preference</th>
<th>Preference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ways of Gathering</td>
<td>Sensing (S)</td>
<td>Intuition (N)</td>
</tr>
<tr>
<td>Information</td>
<td>- real, actual, or factual</td>
<td>- big picture, patterns, connections</td>
</tr>
<tr>
<td></td>
<td>- facts</td>
<td>- abstract</td>
</tr>
<tr>
<td></td>
<td>- realistic</td>
<td>- imaginative</td>
</tr>
<tr>
<td></td>
<td>- practical</td>
<td>- inferential</td>
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<tr>
<td></td>
<td>- based on experience</td>
<td>- theoretical</td>
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<td></td>
<td>- traditional</td>
<td>- original</td>
</tr>
<tr>
<td>Ways of Making</td>
<td>Thinking (T)</td>
<td>Feeling (F)</td>
</tr>
<tr>
<td>Decisions</td>
<td>- logical</td>
<td>- empathetic</td>
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<tr>
<td></td>
<td>- make decisions based on pros/cons</td>
<td>- makes decision by using emotions</td>
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<tr>
<td></td>
<td>- reasonable</td>
<td>- compassionate</td>
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<tr>
<td></td>
<td>- questioning</td>
<td>- uses likes and dislikes in decisions</td>
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<tr>
<td></td>
<td>- critical</td>
<td>- accommodating</td>
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<tr>
<td></td>
<td>- skeptical</td>
<td>- accepting</td>
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<tr>
<td>Ways of Getting and</td>
<td>Extraversion (E)</td>
<td>Introversion (I)</td>
</tr>
<tr>
<td>Directing Energy</td>
<td>- outward focus</td>
<td>- inward focus</td>
</tr>
<tr>
<td></td>
<td>- initiating</td>
<td>- receiving</td>
</tr>
<tr>
<td></td>
<td>- share thoughts/emotions with others</td>
<td>- keep feelings and interests to self</td>
</tr>
<tr>
<td></td>
<td>- interacting with people</td>
<td>- enjoy one on one relationship</td>
</tr>
<tr>
<td></td>
<td>- communicate by talking and listening</td>
<td>- communicate by writing and reading</td>
</tr>
<tr>
<td>Ways of Organizing</td>
<td>Judging (J)</td>
<td>Perceiving (P)</td>
</tr>
<tr>
<td></td>
<td>- goals, plan, carrying out plans</td>
<td>- gathers information</td>
</tr>
<tr>
<td></td>
<td>- systematic</td>
<td>- spontaneous</td>
</tr>
<tr>
<td></td>
<td>- planning with contingency</td>
<td>- likes surprise – go with flow</td>
</tr>
<tr>
<td></td>
<td>- long range planning</td>
<td>- keep options open,</td>
</tr>
<tr>
<td></td>
<td>- start early to avoid rush</td>
<td>- dislikes closed plans</td>
</tr>
<tr>
<td></td>
<td>- rely on routines</td>
<td>- wait until last minute</td>
</tr>
<tr>
<td></td>
<td>- methodical</td>
<td>- dislikes routines</td>
</tr>
<tr>
<td></td>
<td>- develop step by step methods</td>
<td></td>
</tr>
</tbody>
</table>

McCaulley (1987) defines problem solving as an “orderly way of taking in information and making decisions” (p. 37). In this article, McCaulley discusses the Myers-Briggs Type Indicator (MBTI) and its application as a Jungian model for problem solving. The Myers-Brigg Type Indicator has been used extensively in many areas to help people understand their psychological type as well as to help people with career decisions. It has other uses, as well. In this article, McCaulley proposes using the types as a model for problem solving. First, she gives a brief overview of each of
the four mental processes (S, N, T, F) and each of the four attitudes (E, I, J, P). and then she discusses combination of the sixteen psychological types. Next, she provides a section titled “How the Model Applies to Problem Solving.” It is in this section that she provides the rationale and model for problem solving based on the eight mental processes and attitudes of S, N, T, F, E, I, J, and P. She believes that the model she proposes “provides a framework for helping students individually and in groups to improve their problem-solving abilities” (p. 45). This model she proposes is based on a model described by Myers in 1980 in the booklet titled *Introduction to Type* (1980). Basically, Myers originally used just the SNTF as the model, whereas McCaulley has added the EIJP to the model. McCaulley (1987) does provide a few rules regarding the use of the model: (1) “use one process at a time” (2) “use each process consciously and with purpose” (3) “use each process in its own area” (4) “don’t let other processes interfere” and (5) “use the processes in the following order: sensing, intuition, thinking, feeling” (p. 44). In another section she describes how to use the model to teach problem solving. She believes that the two main goals of using this model are (1) “to improve students’ problem-solving skills” and (2) “to help students to gain respect for others whose minds work differently from their own” (p. 47). McCaulley (1987) argues that “students who learn to use the model in their daily activities will see the world more accurately, develop better alternatives, make fewer decisions that have unintended consequences, and feel more attuned to their own values and to what matters to other people” (p. 52). It should be noted that McCaulley worked closely with the developers of the Myers-Briggs Type Indicator for over ten years (as of the date of this article) and that she was a coauthor of the MBTI Manual.
There is an abundance of information on using the MBTI as a problem solving process in McCaulley’s article. Specifically, McCaulley discusses the model and the processes in detail. These details are provided below:

- “First use sensing (S) to face the facts, to be realistic, to find exactly what the situation is, to see your own actions, and to see other people’s actions.
- Second, use intuition (N) to discover all the possibilities, to see how you might change the situation, too see how you might handle the situation differently, and to see how other people’s attitudes might change.
- Third, use thinking (T) to make an impersonal analysis of the problem; to look at causes and their effects; to look at all the consequences, both pleasant and unpleasant; to count the full costs of possible solutions; and to examine misgivings you may have been suppressing, because of your loyalties to others or because you don’t like to admit you may have been wrong.
- Fourth, use feeling (F) to weigh how deeply you care about what your choice will gain or lose; to put more weight on permanent than on temporary effects, even if the temporary effects are more attractive right now; to consider how other people will feel, even if you think they are unreasonable; and weigh other people’s feelings and your own feelings in deciding which solution will work best” (p. 45).
- In the MBTI, a person has either a preference for S or N and for either T or F. Therefore, a person will prefer their own process (either S or N and either T or F) to the opposing process and they will find their own process easier than the opposing process. For example, if they are an S, then the opposing process is
N. This model proposed by Myers and then modified by McCaulley forces people to include in their problem solving model, processes that they ordinarily would not have considered. McCaulley (1987) says “what makes the hard steps hard is that they call for strengths of types opposite to your own” (p. 45).

- “When your problem is important, you may be wise to consult someone to whom these strengths come naturally” (p. 45).
- “…use extraversion (E) to see events in your environment that may influence the problem, to seek people who may have information about the problem, and to talk out loud about the problem as a way of clarifying your ideas.
- …use introversion (I) to consider ideas that may have a bearing on the problem, to look for external truths that may be obscured by current fads, and to take time alone to think deeply about the problem.
- …use judgment (J) to stay on track and not be diverted into side issues, to plan ahead so as not to be caught in a last-minute rush, and to push yourself and others toward a solution.
- …use perception (P) to make sure that you have looked at all aspects of the problem, to keep your eyes open to new developments that might affect the decision, and to avoid jumping to conclusions before the facts are in” (p. 45).
- “sensing and intuitive types attack problems from opposite directions: Sensing types move from the specific to the general, while intuitive types move from the grand design to the details” (p. 47).
McCauley also states, “The model can be used even when students have not answered the MBTI and even when they have not been formally introduced to type concepts (p. 49).

Hirsh and Kummerow (1998) provide a set of characteristics for each of the eight MBTI preferences. The following is a list of characteristics for each preference from their book (p.2-4):

1. E – Extraversion
   a. Talks about people and things
   b. Might not think before acting

2. I – Introversion
   a. Interested in ideas, thoughts, and impressions
   b. Likes to think before acting and may never act

3. S – Sensing
   a. Collects facts
   b. Practical
   c. Step-by-step approach
   d. Uses experience and standard ways to solve problems
   e. Presents evidence (facts, details, and examples) first
   f. Cites specific examples

4. N - Intuition
   a. Explores future possibilities
   b. Theoretical
   c. Interested in new, complex problems
d. Presents an overview of their work first

e. Presents global schemes with broad issues first

f. Refers to general concepts

5. T – Thinking

a. Logical

b. Brief and concise

c. Lists the pros and cons of each alternative

d. Critical

e. Objective

f. Goals and objectives are presented first

6. F – Feeling

a. Subjective

b. Wants harmony

c. Empathetic

d. Decisions are influenced by their own and other’s likes and dislikes

e. Interested in an alternative’s impact on people and values

f. Presents point of agreement first

7. J – Judging

a. Organized

b. Enjoys organizing and completing tasks

c. Decides quickly

d. Seeks structure and schedules

e. Interested in schedules, timetables, and deadlines
8. **P – Perception**
   
a. Gathers information

b. Flexible

c. Includes as much as possible

d. Postpones decisions

e. Resists tight deadlines and unchangeable schedules

Prior to Hirsh’s and Kummerow’s book, *Introduction to Type* was written by Myers (1998) and is now in its sixth edition. She included a one page section on Type and Problem Solving. Myers (1998) does list a process that can be used to solve problems, the process being very similar to that of McCaulley’s (1987). She does infer that better decisions would be made by using the four preferences (S,N,T and F). She does not discuss how to integrate E, I, J, and P into the process as McCaulley does, however.

Following Myers work on using the MBTI as a process in 1980, Lawrence published his *People Type & Tiger Stripes* in which he included a chapter on using MBTI as a process. He references the work of Myers on using MBTI as process. Today, this process he developed from Myers work is called the Zig-Zag Analysis. However, it still only uses the SNTF processes, and it is linear (Lawrence, 1993). He includes a brief one paragraph mention of EIJP processes but does not offer a diagram about how they fit within the Zig-Zag process. In their booklet titled *Introduction to Type in Organizations*, Hirsh and Kummerow (1990) have one page devoted to “Problem Solving Process Using Type Preference.” This booklet references a model
from Lawrence’s 1982 book *People Types and Tiger Stripes*. In this booklet, there are five questions that can be posed for each process (S, N, T, and F) during the problem solving procedure to insure that each process (SNTF) has been satisfactory and equally considered. These questions are of the same nature as the details discussed in McCaulley’s article. Example questions provided by Hirsh and Kummerow (1990) for the process used during the Sensing (S) phase are as follows: “What are the facts? What exactly is the situation? What has been done? What am I and others doing? How would an outsider look at this situation?” (p. 32). In 1998, Hirsh and Kummerow issued the third edition of this book. The section on problem solving has been modified, and now the model is circular, indicating that you can start at any point in the process and move to any other point in the process. The questions have been updated. Due to copyright restrictions, the questions cannot be reproduced in this document.

Not only is it important to consider the psychological type of the problem solvers, it is also important to consider the psychological type of the teacher who is teaching problem solving. DeLuca (1991) states that “problem solving activities implemented in technology education are characterized by the problem-solving processes and thinking skills that are taught” (para. 11). Hence, students learn the problem solving process that the teacher teaches. Since certain professions have a correlation to specific psychological types, it is hypothesized that a teacher’s psychological type or a majority of teachers within a profession will bias any problem solving method that is proposed or utilized and will most likely exclude those
processes that are not dominant either in their own psychological type or the typical psychological type of the majority within the field.

Wicklein and Rojewski (1995) studied the psychological types among technology education teachers. Their study found a relationship between psychological type and technology education orientation. Four psychological types ESTJ, ISTJ, ENTJ, and ENFJ accounted for 72% of all technology education professional in their study. Of that, 40% were either ESTJ or ISTJ. ENTJ and ENFJ accounted for 32%. Of the first group, STJ was dominant. Of the second group, ENJ was dominant. Industrial Arts educators had 72% in the types of ESTJ, ESFJ, ISTJ, or ISFJ with 46% comprised of ESTJ and ESFJ, while 26% were ISTJ and ISFJ. Of the first group, ESJ was dominant while the second group had ISJ as dominant. Basically, among industrial arts educators, SJ is dominant. Given that there is a pattern in the psychological types of technology educators, then it is necessary for educators to recognize this and then ensure that other processes are considered through following the MBTI proposed model offered by McCaulley to compensate for the lack of certain personality aspects when solving problems.

Felder, Felder, and Dietz (2002) performed an extensive study on the effects of psychological type on engineering student performance and attitudes. The researchers concluded that “…the MBTI is a useful tool for helping engineering instructors and advisors to understand their students and to design instruction that can benefit students of all types” (p. 1). In this study, the researchers had the students perform a self-assessment of creative problem solving ability, among other things. These students also had taken the MBTI, and their psychological type was known. The researchers
found that students who had an emphasis of N – intuitive as compared to S – sensing – rated themselves high on the creative problem solving ability, while the S students gave themselves very little to no ratings on having an excellent ability to creatively solve problems. This is consistent with the MBTI theory. Their study also found that, although P’s had higher SAT scores than J’s, the J’s had better Freshman grades than the P’s, suggesting that this finding is due to J’s persistence and task orientation in overcoming the challenges found in first year engineering classes.

MacPherson (1998) reports that “since problem-solving is a process that encompasses all facets of human existence, personality characteristics, such as perseverance, ingenuity, self confidence, and patience are common to both technological troubleshooting and general problem-solving” (para. 5). In his study on the factors affecting technological trouble shooting skills, he concluded that “the factors that influence general problem-solving ability also apply to the near transfer, troubleshooting subset of technological problems” (section. conclusion).

Reuther and Meyer (2002) conducted a study into the effect of personality type on the usage of a multimedia engineering education system. They found that “generally, the stronger a student prefers operating in a judging mode (and consequently the less they prefer operating in the perceiving mode), the more likely that the student will achieve a higher grade in the class” (para. 27).

Confidence

Foshay (2003) sites research conducted by Jonassen and Tessmer in 1996 in which “motivation and attitudinal aspects such as effort, confidence, anxiety, persistence and knowledge about self are important to the problem solving process”
Foshay concludes that “to solve problems, learners have to want to do so, and they have to believe they can” (2003, p. 5). Furthermore, Foshay cites another study by Jonassen in 1997 in which it was concluded that “expert problem solvers have a positive attitude and confidence that problems can be solved through persistent analysis” (2003, p. 7).

The National Academy of Engineering (2002) believes that “as people gain confidence in their ability to ask questions and think critically about technological developments, they are likely to participate more in making decisions” (National Academy Press, section. benefits). The National Academy of Engineering believes that this is important in our democratic society that requires decisions affecting society involve the citizens. If citizens participate more in the societal decision making process, then governmental leaders would be able to make better decisions based on the requirements voiced by the citizens. This supports the inclusion of confidence and motivation as two factors in the problem-solving abilities list.

Chang and Chang (2000) report that students “learn even more if they are aware of how they learn and how to use their strengths and develop their weak areas” (section. recommendations). They recommend that students be taught the Zig Zag problem-solving process method to help them understand their own problem-solving process since they were already given their MBTI psychological types. They conclude that for the Electrical Engineering master’s level class that “psychological types play an important role in student performance” (section. conclusions).

Heppner (1988) states in the PSI Manual that the Problem Solving Confidence scale is “defined as self-assurance while engaging in problem-solving activities. Low
scores on this scale indicate that individuals believe and trust their own problem-solving abilities” (p.1). A low score indicates a high confidence level. However, Heppner also notes that “those who substantially overestimate their skills may be …demonstrating serious problem-solving deficits” (1988, p.2). He continues, “False positive appraisals may also be related to the Type A personality pattern” (p.2). Further studies have revealed that those who have high confidence are also more motivated to solve problems, in comparison to those who have low confidence (Heppner, 1988). Heppner (1988) also notes that “scores on the PSI are not strongly related to …personality types as measured by the MBTI” (p.12).

Gelven and Steward (2001) conducted a study in which they used the PSI scores to measure a student’s self assessment of their problem solving self-efficacy. They used all three scales of the PSI to obtain a total PSI score. Their findings indicate that that post-test mean PSI scores were higher (higher scores actually mean there is lower confidence) than those of the pretest scores, possibly indicating that “[the students] understanding of problem solving increased and the post test score provided a more realistic awareness of their problem solving abilities” (para. 21).

MacPherson (1998) conducted a study and used the total three scale PSI scores to measure a student’s self assessment of his/her problem solving self-efficacy. A correlation was performed between the PSI and a student’s near transfer technological problem solving skills. His findings revealed a positive correlation, which is indicative of a negative relationship (because low PSI scores indicate high confidence levels and vice-versa).
Rigas and Elg (1997) examined confidence in decision making. Although they did not use the PSI to measure confidence, their findings indicate that “contrary to what was expected, confidence in one’s mental model and heuristic competence correlated negatively with performance variables” (para. 13).

Motivation and Problem Solving

Weith’s and Burns’ (2000) research showed that “motivation (in particular, interest) correlated with incremental problem solving but not with insight problem solving” (para. abstract). Their conclusion is that motivation needs to be taken into consideration when designing experiments. Weith and Burns reference studies done by Vollmeyer and Rheinberg in which “participants with higher motivation were more likely to use a systematic strategy for acquiring knowledge” (para. 4). Their findings suggest that “motivation only affected problems for which there was a process to be helped or to be disrupted” (para. 23). They indicate that “the critical motivation factor was “interest,” as predicted by previous research” (para. 24). Their results show a statistically significant correlation between “interest” and incremental problem solving scores.

Travers (1977) discusses motivation and the Yerkes-Dodson law. He says that the “problem solver should learn to operate at an optimum level of motivation” (p. 487). This is because too much motivation with difficult problems produces poor results. This is the essence of the Yerkes-Dodson law. This law states that “at the optimum level of arousal there might be a positive facilitating effect with simple tasks and a negative interfering effect with complex tasks” (p. 535). He states that “as drive
level increases, learning also increases, until the drive reaches an optimum level. If the drive is increased further, then performance deteriorates” (p. 351).

Dembo (1994) discusses student motivation by stating, “If [learners] believe they have the ability and knowledge, learners will work harder to attain difficult goals than when the standards are lower. As they work and attain difficult goals, they develop beliefs in their competence. However, if they don’t believe they have the ability to attain a goal, they are likely to have low expectations for success and not become involved in the task” (p. 151).

Interest and Motivation

Morgan (1974) discusses motivation as a factor involved in the success of problem solving. He lists motivation as one such factor, indicating that motivation is essential at the beginning and ending of the problem solving process. He believes that “once a person gets into a problem, he often becomes interested in solving it. And when people gain satisfaction from their solutions of problem, they may develop a general motivation for problem solving” (p. 180).

Critical and Creative Thinking Techniques

Huitt (1992) defines two sets of problem solving techniques: those that are critical thinking related and those that are creative thinking related. He defines the following as critical thinking techniques: analysis, backward planning, categorizing / classifying, challenging assumptions, evaluating / judging, inductive / deductive reasoning, thinking out loud, network analysis, plus-minus interesting, and task analysis. He then defines the following as creative thinking techniques: brainstorming,
imaging/visualization, incubation, role playing, bridging to new ideas starting with an incorrect statement, overload, random work technique, relaxation, synthesizing, taking another’s perspective, and values clarification. Huitt (1992) believes that these techniques can be infused into a problem solving process that is based on psychological types. In his article, he provides a chart showing the aspects of psychological types that are important to problem solving and decision making. In his chart, he describes the techniques that each psychological type would prefer. A list of the data from Huitt’s (1992) chart is shown below:

- Sensing: overload, inductive reasoning, random word technique
- Intuitive: classifying, deductive reasoning, challenging assumptions, imaging / visualization, and synthesizing
- Thinking: classifying, analysis, network analysis, and task analysis
- Feeling: listening to others’ values, values clarification
- Extrovert: brainstorming, thinking out loud, role playing
- Introvert: brainstorming privately, incubation
- Judging: evaluation, PMI technique, backward planning,
- Perception: brainstorming, random word technique, bridging to new ideas starting with an incorrect statement

For example, an extrovert would enjoy brainstorming, thinking out loud, or role playing. However, this chart can also be used to provide suggestions for which heuristics to use when in a certain part of the MBTI problem solving process as defined by McCaulley (1987). For example, if you are a P but you are in the J part of
the process, the chart suggests to use evaluation, PMI, or backward planning, which, as a P you might not have understood to do when in the J process.

Heuristics

A difference between a novice problem solver and an expert problem solver is that when the novice is unable to make progress, he/she just gives up or guesses, whereas the expert persists and uses heuristics to help overcome the impediment (Wankat & Oreovicz, 1993). Heuristics are methods which might work to overcome the impediment, but they are not guaranteed to work every time and in every situation. Wankat and Oreovicz provide a list of heuristics (1993, chapter 5):

1. simplify the problem
2. determine if the problem is correctly stated
3. relate the problem to another problem that is similar and one that was already solved
4. generalize the problem
5. trial and error
6. determine if the facts support the problem
7. change the way the problem is presented to another representation
8. ask questions about the problem
9. break the problem into parts and solve the parts that can be solved
10. listen to others who have knowledge of the problem
11. use PMI
12. use mixed scanning, alternating a big view of the problem with an in-depth view of a small piece of the problem
(13) alternate, working forward and backward
(14) take a break
(15) determine the hidden assumptions
(16) ask what are you doing? why are you doing it? how will it help you solve the problem?
(17) determine what the foundation of the problem is
(18) ask for help
(19) generate many ideas
(20) reverse the problem
(21) build on a random words
(22) think of something funny about the problem
(23) think of an analogy in nature
(24) use a list of prepared keywords.

Some of these are the same as Huitt’s (1992) creative and critical thinking techniques.

Communication and Problem Solving

In an article written by Braukmann and Pedras (1990), they make reference to the National Science Board Commission on Pre-College Education in Mathematics, Science and Technology in 1983 in which the commission reported the need to return to basics, including “communication and higher problem solving skills, and scientific and technological literacy – the thinking tools that allow us to understand the technological world around us…” (para. 3). Throughout the article, Braukmann and Pedras make reference to the need for leadership, communication, presentation, and
persuasion skills, stating that these skills are vital in all types of work environments. They propose a problem solving process with the following steps:

1. define the problem carefully and completely
2. establish criteria for a solution including goals, limitations, and consequences
3. research possible solutions
4. brainstorm all possible solutions
5. narrow the options (included in this section is the idea that communication is important in this step in order to learn how to persuade others. Also, the authors’ suggest that students be taught that a “better presented idea has as good a chance of prevailing in this arena as a better idea.” They continue, “A project development team that is armed with production drawings, decisions supported by research, and an organized presentation will be most persuasive” (para. 21).
6. create a working model
7. evaluate the end result

Cognitive Abilities

Brickell, Ferry, and Harper (2002) studied students’ cognitive strategies used in problem solving. Their research method included using the following cognitive strategies: clarification, application, analysis, synthesis, and evaluation. Their research concluded that posing questions during the problem solving process helped them to generate ideas.
Summary

A review of the literature reveals the need for teaching technological problem solving to meet the goals of technological literacy, which are based on the need for citizens to be able to live in a complex, technological, global society.

In addition, the literature shows that there is not a framework for problem solving that is detailed and specific and that considers human values and impacts. Most problem solving processes were invented for the sciences and therefore are specific to solving mathematical problems or design problems. These processes are not broad enough to work for complex technological-societal global problems.

There is insufficient research on what factors actually contribute to a person’s problem solving abilities. There are fragments of information in different studies, but the research lacks an agreed-upon set of factors. If these were known, then educational efforts could be focused on maximizing the effects of each factor for each person.

In regards to psychological type, there is an abundance of literature on the MBTI and other psychological type measures and their interpretations specific to certain situations. There is not much research on using the MBTI as a process as defined by McCaulley. However, the existing Zig-Zig process is available as a worksheet and is based on Myer’s work using the preferences S, N, T, and F as a linear process. This is also referenced in other literature.

There is a substantial amount of literature on creative thinking and critical thinking skills and how to enhance those using heuristics. However, the use of heuristics in problem solving is such a substantial issue that it is beyond the scope of this research to consider the effects of both on problem solving.
Literature exists that confirms the need for the ability to provide professional justification to the proposed solution to the problem. Hence, there is a need for communication skills when problem solving. There is some specific research on the teaching of problem solving skills, while there is a lot of research that supports the need for teaching problem solving.

A review of the literature supports the need for having both a better understanding of the factors and their inter-relationships that contribute to a person’s technological problem solving ability, as well as a need for a framework that can be used to teach technological problem solving. Therefore, it is necessary to answer the research questions regarding the inter-relationships between the factors of problem solving potential, problem solving confidence, problem solving process knowledge, psychological type, interest in solving the specific problem, motivation to solve the specific problem, desire to learn about problem solving, and desire to solve problems.
CHAPTER 3: RESEARCH DESIGNS and METHODS

The purpose of this study was to determine the relationships between the factors of technological problem solving potential (a set of consolidated factors), problem solving confidence, psychological type, knowledge of a MBTI-type problem solving process, GPA, problem interest, motivation, desire to solve problems, and desire to learn about problem solving. A review of the literature supported the need for having both a better understanding of the factors and their inter-relationships that contribute to a person’s technological problem solving ability, as well as a need for a framework that can be used to teach technological problem solving.

Hypotheses

This study explored the following null hypotheses:

Level 1: Relationships - potential with confidence, process, and psychological type

1. There is no relationship between problem solving confidence and technological problem solving potential.
2. There is no relationship between knowing an MBTI-type problem solving process and technological problem solving potential.
3. There is no relationship between psychological type and technological problem solving potential.

Level 2: Relationships between confidence, process, and psychological type

4. There is no relationship between problem solving confidence and knowing an MBTI problem solving process.
5. There is no relationship between psychological type and problem solving confidence.
6. There is no relationship between psychological type and knowledge of an MBTI-type problem solving process.

**Level 3: Changes in confidence, process knowledge, potential, problem solving approach, and desire to learn about problem solving as a result of the intervention**

7. There is no relationship between pre-test problem solving process scores and post-test problem solving process scores.

8. There is no relationship between pre-test problem solving confidence scores and post-test problem solving confidence scores.

9. There is no relationship between pre-test problem solving potential scores and post-test problem solving potential scores.

10. There is no relationship between a researcher’s calculated MBTI type student’s problem solving approach prior to the intervention as compared to a researcher’s calculated MBTI type student’s problem solving approach after the intervention.

11. There is no relationship between a student’s desire to learn about problem solving prior to the intervention as compared to a student’s desire to learn about problem solving after the intervention.

**Level 4: Relationship between psychological type and problem solving approach**

12. There is no relationship between psychological type and technological problem solving approach.

**Level 5: Relationships involving GPA**

13. There is no relationship between problem solving potential and GPA.

14. There is no relationship between problem solving confidence and GPA.

15. There is no relationship between process knowledge and GPA.
Level 6: Relationships involving motivation, interest, desire to learn about problem solving, and desire to solve problems

16. There is no relationship between problem solving potential and motivation to solve the specific problem.

17. There is no relationship between problem solving confidence and motivation to solve the specific problem.

18. There is no relationship between process knowledge and motivation to solve the specific problem.

19. There is no relationship between problem solving potential and interest to solve the specific problem.

20. There is no relationship between problem solving confidence and interest to solve the specific problem.

21. There is no relationship between process knowledge and interest to solve the specific problem.

22. There is no relationship between problem solving potential and desire to learn about problem solving.

23. There is no relationship between problem solving confidence and desire to learn about problem solving.

24. There is no relationship between process knowledge and desire to learn about problem solving.

25. There is no relationship between psychological type and desire to learn about problem solving.
26. There is no relationship between problem solving potential and liking to solve problems.

27. There is no relationship between problem solving confidence and liking to solve problems.

28. There is no relationship between process knowledge and liking to solve problems.

29. There is no relationship between psychological type and liking to solve problems.

30. There is no relationship between problem solving potential and using a process.

31. There is no relationship between problem solving confidence and using a process.

32. There is no relationship between process knowledge and using a process.

33. There is no relationship between psychological type and using a process.

34. There is no relationship between problem solving potential and “using the same process as would teach.”

35. There is no relationship between problem solving confidence and “using the same process as would teach.”

36. There is no relationship between process knowledge and “using the same process as would teach.”

37. There is no relationship between psychological type and “using the same process as would teach.”
Pilot Study

A pilot study was conducted to determine if the research methods would yield the expected results that are necessary to analyze and interpret the inter-relationships between factors involved in technological problem solving. The pilot study was conducted at North Carolina State University using the Graphic Communications class titled Foundations of Graphics – GC120. The pilot study was conducted for two sections of the class each day for three consecutive days over one and a half hours per day, for a total of four and one half hours for each of the two sections for the experiment. The researcher conducted the experiment. The class professor was not in town on the dates of the experiment. The researcher reviewed the experiment with the class professor prior to administering and obtained his approval. Both sections of GC120 received equal treatment. There was no control group. To start, one section had twelve students while the other section has ten students. Overall, ten students from both sections completed the entire pilot study. These students were from various disciplines and were very quiet and listened well. They did not seem to interact with each other possibly indicating that they did not know each other. One student was a technology education major. The students studied the Real World Problem (RWP) of Paris’ Charles de Gaulle Airport roof collapse. This problem was relevant because it was related to Computer Aided Design. As a result of the pilot study, the measuring devices for technological problem solving potential and process were modified and refined. Also, the pilot study revealed the need for reinforcement of the MBTI-type problem solving process (the intervention) via a new student activity. In addition, the intervention would need to be expanded to encompass more problem-solving material.
The pilot study revealed that the experimental method could be used to obtain the desired results, albeit very tedious in scoring the students’ solution to obtain their technological problem solving potential score.

Research Design

This study utilized the pre-experimental design method of one group pretest-posttest design. According to Campbell and Stanley (1963), this design has a lot of threats to potential invalidity, both internal and external. Internal validity problems are related to history, maturation, testing, instrumentation, possibly regression, and interaction of selection and maturation, while external validity problems are related to interaction of testing and X, interaction of selection and X, reactive arrangement possibly (p. 8). Selection and mortality are controlled for this research method. To control for the threats to internal validity, the following techniques were used:

- history threats – this threat was controlled by having the experiment conducted during three consecutive class sessions, namely Thursday, Tuesday, and Thursday again, hence no time for history to occur.

- maturation threats – this threat was controlled by having the experiment conducted in three consecutive class sessions, hence no time for maturation to occur.

- testing threats – this threat was controlled because the students were asked questions on the pre-tests in which there are no right or wrong answers, but only their analysis of the problem. For the post-test, a different problem was given.
• instrumentation threats – this threat was controlled by having no changes in the instrumentation.

• statistical regression threat – this threat was controlled because the experimental group was not selected based on having extreme scores. They were just selected due to class availability and class appropriateness.

• selection-maturation interaction threat – this threat was controlled because there was no multiple group to be concerned about.

The following discusses the external validity threats:

• interaction of testing and X threat – this threat was not controlled. This is the threat that the pretest, especially that of confidence and process have on the MBTI problem solving process treatment.

• interaction of selection and X threat – this threat was not controlled. The group selected to participate was taken from technology education based on the class where this subject matter would fit the best and where it might be used in other technology education programs at other universities.

• reactive arrangements threat – this threat was not controlled. The students were aware that the problem solving activity was for research purposes. However, they were not aware of what the research was investigating.

• random assignment of students was not practical and neither was the availability of a control group for two equivalent classes for which problem solving was normally introduced and to which this technological problem solving process would be appear as a natural part of the curriculum.
Population and Sample

The actual research was conducted at North Carolina State University in the technology education class titled Communications Technology - TED461. There were twenty-two students in the class. However, due to absences and other reasons, there were sixteen students who completed the entire three day workshop. This class contained either technology education or graphics communications majors, and it was a senior-level class. A student’s final course grade was not influenced by the results of any of the activities of the three-day experiment. This particular topic under investigation is typically taught in this class but not from this perspective and not to this extent. Most classes in technology education at NCSU have a hands-on approach to the curriculum. It should be noted that the research activities were not consistent with student’s expectations for technology education class activities, primarily from the perspective of extensive written work.

A request was submitted to the North Carolina State University Institutional Review Board (IRB) for the Use of Human Subjects in Research. Approval from the IRB was obtained prior to experimentation and is included in Appendix M. As necessary, individuals’ privacy was insured. The data that was obtained during the research was recorded and analyzed such that the students cannot be identified.

Instrumentation

This section contains information about the procedures that were used for developing the instruments to collect data. These instruments were pilot tested and revised as a result of the pilot test. The following instruments were used to collect the data:
1. **Myers-Briggs Type Indicator (MBTI)**

   - The Myers-Briggs Type Indicator (MBTI) is a self-report inventory used to assess a person’s psychological type preferences of extroversion or introversion, sensing or intuitive, thinking or feeling, and judging or perceiving. There are various instruments depending upon the situation. For example, there is a self-scored instrument – M – that has ninety-three items. All items are forced choice. It is available in sixteen languages. It can be used in team building, leadership, or individual development in organizations. It is also widely used for career development and other things, such as working relationships. This instrument is based on the theory of psychological type developed by Carl Jung. The test is standardized based on the results of 3200 adults in a random sample nationally.

   - For Form M, the internal consistency is 0.91 for the E-I section, 0.92 for the S-N section, 0.91 for the T-F section, and 0.92 for the J-P section.

   - An abundance of literature has been written about this instrument and it is widely used in research.

2. **Problem Solving Inventory (PSI)**

   - The Problem Solving Inventory (PSI) is a self-report inventory used to assess an individual’s problem solving confidence, problem solving approach-avoidance style, and problem solving personal control (Heppner, 1997). This inventory does not measure actual problem solving skills or performance. Heppner reports that it is noninvasive and non-threatening. It is written to a ninth-grade reading level and takes approximately ten to
fifteen minutes to complete. Scoring takes less than five minutes. It must be administered by a qualified person.

- Heppner reports that Nezu, Nezu, and Perri, 1989, reported that the PSI is one of the most widely-used, self-report inventories that measure a person’s problem solving aspects.

- This inventory was not developed for assessing a person’s technological problem solving confidence, approach-avoidance, and personal control. It was, however, adapted and studied in use in technological problem solving in a study conducted by Wu, Custer, Dryenfurth (1996).

- The PSI consists of thirty-five, six point Likert items, with items such as “When I make plans to solve a problem, I am almost certain I can make them work” to check the confidence level (Heppner, 1988, p. 2). To check for approach-avoidance style (the tendency to approach or avoid different problem solving activities), a question might ask, “When confronted with a problem, I consistently examine my feeling to find out what is going on in a problem situation.” Approach-avoidance is useful to know because it is related to attempts at defining the problem and trying to find solutions. To check for personal control (the belief that one is in control of one’s emotions and behaviors during problem solving), a question might ask, “I make snap judgments and later regret them.” Personal control is useful to know because it is related to the ability to find a solution to a problem. (Heppner, 1988, p. 2).
• Heppner (1997) reports the internal consistency to be 0.9 for the total inventory with each factor, respectively being 0.85, 0.84, and 0.72 as measured by alpha coefficients. Test-retest results for two weeks for the total inventory were 0.89 with each factor respectively being 0.85, and 0.88, 0.83.

• Students will not be informed of their PSI scores because this might affect their problem solving abilities scores.

• Heppner (1997) reports that the PSI has been used to assess the amount of change in a person due to an intervention from problem solving activities.

• The confidence factor of the PSI is scored on a scale from eleven to sixty-six, with an eleven representing high confidence and a sixty-six representing low confidence.

3. Two Real-World Problems (RWP) Questions

• These were two, real-world communications technology problems. The requirement was that the problem be related to video due to the class focus. The problem had to possess the following characteristics: have many facts, be an unsolved problem, have a situation with many choices for what the problem really is, have many solution options, have effects on people, have complex issues (political, economic, ethical, environmental, social, and cultural), be involved with technology, and be related to communication - specifically video. The first problem was the Monday Night Football lead-in that occurred on November 15, 2004, that featured Nicollette Sheridan and Terrell Owens. The second problem was issues associated with camera
phones. For the first problem, the students watched a rerun of the actual video. A small class discussion entailed prior to the students working on the problem individually. No specific problem was given. The students were asked to come up with a solution to the problem, although they were not given the problem. This is because it was essential to see if students would state what the problem was before providing the solution and to see if they generalized the problem or not. This information is useful and important in scoring many things, especially that of the influence of the MBTI type on the way they approached the problem. The students were handed an eight-page set of articles from the internet to be used in helping them with the problem. The problem instructions were vague so as to see how students solve problems. See Appendix A for the problem assignments. For each problem, the students wrote a solution on a blank page provided in their packet. Another blank page was provided in case they wanted to plan their solution or take notes. A student’s technological problem solving potential score was calculated using this solution. The scoring sheet is provided in Appendix B. For the second problem, students who had camera phones showed them in class and discussed good uses of camera phones. Then, there was a brief class discussion on the possible misuses of camera phones. Students were then given a four-page handout that included articles written about the camera phones, including recent legislation regarding fines and restrictions. The problem instructions were again vague, so as to see how students solve problems. The students wrote
a solution to the problem. A blank page was provided for them to take notes or act as a draft. Students’ technological problem solving scores were calculated for pre-test and post-test, using each solution respectively.

- Technological Problem Solving Potential was measured by calculating sub-scores for each subsystem that was identified in the literature as being “an ability.” The nine subsystems were as follows: ability to obtain new knowledge (Stice, 1999, DeLuca, 1991), ability to seek expert knowledge as needed (Stice, 1999), ability to apply a problem solving process to a specific problem (Stice, 1999), ability to correctly identify/define the problem and an awareness of problem (ITEA, 2000, Stice, 1999), ability to generate potential options (Stice, 1999), ability to analyze and evaluate potential options (Hirsh, Kummerow, 1990, Isaksen, Treffinger, 1985), ability to justify the proposed solution (Braukmann, Pedras, 1990), ability to professionally communicate the solution (Braukmann and Pedras, 1990, Stice, 1999), and technical knowledge (Stice, 1999, DeLuca, 1991). The subsystem that lists ability to analyze and evaluate potential options was split into two sections: those that are consequences and those that are human impacts. Thus, there were ten total subsystems. Appendix B contains the scoring sheet.

- Problem Solving Approach was determined by using a scoring sheet prepared using information from the MBTI Manual (Myers, MaCaulley, Quenk, and Hammer, 2003) and the Introduction to Type in
Organizations. The scoring sheet is included in Appendix G. The scoring sheet was a checklist of characteristics for each MBTI preference that could be potentially seen in a student’s solution statement. An item was checked on the checklist if a student’s solution exhibited that characteristic. There were eight sub-scores, matching each of the eight MBTI preferences. Percentages were calculated for each sub-score and sets of sub-scores (S-N, T-F, E-I, and J-P) were compared. A student’s researcher-calculated MBTI type was determined by selecting the higher score for each set of sub-scores categories. In the event of a tie, an I,N,F, or P was given, which is the method employed with the actual MBTI. After the researcher calculated a student’s problem solving approach (a researcher-calculated MBTI) for each problem, the results were compared against the actual MBTI, and for each preference that matched, 25% was awarded. The total awarded for each student was then calculated. This allowed the researcher to determine if a student’s psychological type influences the way that they approach a written solution to a problem. Also calculated was the percent match between the researcher-calculated MBTI for the first problem as compared to the researched calculated MBTI for the second problem. These two were compared at the MBTI preference level, and preferences that matched were given 25% for each match. This allowed the researcher to determine if the student changed his/her problem solving approach.
4. **Problem Solving Process Knowledge Questions**

- A questionnaire was given to the students to evaluate their MBTI-type problem solving process knowledge before the intervention and again after the intervention. The questionnaire is located in Appendix C. These two questions ask what process they used (if any) to solve each of the two real-world problems and what process they would teach to solve technological problems. The scoring sheet used to calculate the student’s scores is located in Appendix D. The sheet is based on what McCaulley (1987) listed as important in the MBTI-type problem solving process.

5. **Problem Solving Motivation and Interest Questions**

- Two questions based on a five-point Likert scale were given to the students, assessing their interest in each of the problems and their motivation in solving each of the problems. See Appendix E for the questions.

6. **Demographical / Intro / Final Collection Questions**

- Students were asked their age, GPA, gender, if they used a process for problem solving, if they liked to solve problems, if they were good at solving problems, and if they wanted to learn about problem solving. The instrument is located in Appendix F. Students were also asked four questions: what is the biggest societal problem affecting the U.S.? what is the biggest world problem? what communication technology problem is the most interesting to you? and what problem (from any discipline) concerns and/or interests you the most?
Data Collection Procedures

The researcher followed the *developmental perspective* – a teaching perspective used in adult education. Pratt (1998) states that “teaching from this perspective has more to do with good learning than with good teaching … The focus, then, is on the development of learners’ thinking, reasoning, and judgment rather than on the specific teaching performances” (p. 111). The theory is that a student’s prior knowledge is the key to learning and that prior knowledge must be activated. In addition, students must also be actively involved in developing personal meaning from the activities. Pratt (1998) suggests to “sequence your teaching to promote understanding. A good starting point is common sense and everyday experiences moving to abstraction, then back again to the application of theory in practice” (p. 138). The researcher followed this procedure by asking students to reflect often in different activities. This method of teaching was explained to the students at the onset of the workshop so that they understood that there was no right or wrong answers and so that they would try to undercover what they already knew about problem solving. This perspective fit nicely with the MBTI and the MBTI-type problem solving process that was taught because the belief was that if a student understood their MBTI type, then it would be easy to understand and remember a new process based on his/her MBTI type.
The following data collection procedures were scheduled as follows:

Day 1 – January 13

1. Introduction to Workshop 10 minutes 1:35-1:45
2. Introduce Problem A - video problem 5 1:45-1:50
3. Create Solution A to Problem A 80 1:50-3:10
4. Collect Solution A -
5. break 5 3:10-3:15
7. Demographics Form 10 3:35-3:45
8. PSI 15 3:45-4:00
9. Collect Forms -
10. break 5 4:00-4:05
11. Give MBTI 20 4:05-4:25
12. Collect MBTI -
13. Conclude Day 1 5 4:25-4:30

For Day 1, students received small packets of activities as needed. Each packet was collected prior to the future handouts to insure that previous results would not be changed as a result of other handouts. An introduction to the workshop was given. There were interactive class activities and discussions prior to viewing the video. Students then received the problem; the eight-page handout with details about the problem; blank worksheets for creating the solution; forms for collecting data about process knowledge, motivation, interest, GPA, desire to learn more about problem solving, desire to solve problems, and problem solving self-ability assessment; an
inventory for assessing their problem solving confidence (PSI); and the Myers-Briggs Type Inventory (MBTI). Please note the order in which students completed the forms. For example, students completed the solution to the problem and then afterwards answered if they liked to solve problems. This sequence could have influenced the student’s answers. This sequence was selected so that it would have the least impact on the problem solving potential scoring (the solution to the problem); this might have impacted the answers to the other questions.

Day 2 - January 18

1. Introduce Day 2 5 1:35-1:40
2. Return MBTI, Return Folders 5 1:40-1:45
3. Teach Process 60 1:45-2:45
4. break 5 2:45-2:50
5. Redo Solution A using Outline – RA 30 2:50-3:20
6. Compare Solution A to reworked Solution RA 20 3:20-3:40
7. Collect work -
8. Conclude Day 2 5 3:40-3:45

For Day 2, students received their original solutions back, their Myers-Briggs Type, instruction from the researcher about their Myers-Briggs Type as it relates to problem solving, a lecture about the MBTI-type problem solving process that they could use to solve technological problems, an outline of the MBTI process to complete using the first problem (video), and a comparison worksheet to compare their original solution to the one that was created using the outline.
Day 3 - January 20

1. Introduce Day 3 5 1:35-1:40
2. Examples 10 1:40-1:50
3. Introduce Problem B 5 1:50-1:55
4. Create Solution B to Problem B 50 1:55-2:45
5. Process Knowledge, Motivation/Interest Forms 15 2:45-3:00
6. PSI 10 3:00-3:10
7. Self-selected problem listing 5 3:10-3:15
8. Self-selected problem 30 3:15-3:45
9. Final form 5 3:45-3:50
10. Collect work 5 3:55-4:00
11. Conclude workshop 5 3:50-3:55

For Day 3, students received a lecture/class discussion on a recent community problem and how they could use the MBTI process to simplify the problem; a refresher summary of the MBTI process; an interactive class discussion about camera phones; the camera phone problem to work on; the handouts for providing their solution to the new problem; forms to identify process knowledge, motivation and interest; a confidence inventory (PSI); and a set of four questions regarding their personal problems (what is the biggest world problem, biggest US problem, most interesting communication technology problem, and most interesting or concerning problem to them). Students were then allowed to solve any one of the four problems. Students then answered the final form, indicating their desire to learn about problem solving, and a self-assessment asking if they are good at solving problems and if they
liked to solve problems. They then answered questions about what they learned during the three days. When all forms had been collected, the researcher concluded the three day workshop with a summary lecture of the important lessons that should have been learned. Please note the order in which students again completed the forms. For example, students completed the solution to the problem and then afterwards answered if they liked to solve problems. This sequence could have influenced the student’s answers. This sequence was selected so that it would have the least impact on the problem solving potential scoring (the solution to the problem) and this might have impacted the answers to the other questions.

The MBTI-problem solving process as derived from McCaulley (1987) is located in Appendix I.

Data Analysis

JMP statistical analysis software from SAS Institute Inc. was used to calculate statistical results. The alpha level was set to 0.05. It is assumed that all ratio and ordinal data is normally distributed. Agresti and Finlay (1997) state that “the assumption that the population distributions are normal with identical standard deviations is a stringent one that is never satisfied exactly in practice” (p. 445). Table 9 shows the statistical method used for each hypothesis. In a few instances, more than one statistical method was used to analyze a null hypothesis since different methods check for different relationships. Table 10 shows the data levels and the variables. Table 11 shows the independent and dependent variables by hypothesis level.
The following statistical methods were selected to assist with analyzing the null hypotheses:

1. Pearson Product-Moment Correlation was selected because this method indicates the degree of linear relationship between two variables.

2. $t$-test was selected because this method tests if two population means are equal to each other for small sample sizes.

3. Matched pairs ($t$-test for dependent samples) was selected because this method is a $t$-test for dependent samples and compares pre-test and post-test means for which the data is paired.

4. Fisher’s exact test was selected because this method is used instead of Chi-squared when the sample sizes are small to compare proportions to check for independence.

5. Signed rank test was selected because the data was not normally distributed, and so the use of a non-parametric test was necessary.

6. Spearman’s Rank Correlation was selected because it measures the degree of linear relationship for ordinal level data.

7. Least Squares Fit was selected because it explains the amount of variance on a response variance.
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<tr>
<th>Hypothesis</th>
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<td>1</td>
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<td>Matched Pairs, Least Squares Fit</td>
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<td>Spearman’s Rank Correlation</td>
</tr>
<tr>
<td>21</td>
<td>Spearman’s Rank Correlation</td>
</tr>
<tr>
<td>22</td>
<td>t-test</td>
</tr>
<tr>
<td>23</td>
<td>t-test</td>
</tr>
<tr>
<td>24</td>
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</tr>
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Table 9 Continued. Hypotheses and Statistical Methods

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>25</td>
<td>Fisher’s Exact Test</td>
</tr>
<tr>
<td>26</td>
<td>t-test</td>
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<tr>
<td>27</td>
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<tr>
<td>28</td>
<td>t-test</td>
</tr>
<tr>
<td>29</td>
<td>Fisher’s Exact Test</td>
</tr>
<tr>
<td>30</td>
<td>t-test</td>
</tr>
<tr>
<td>31</td>
<td>t-test</td>
</tr>
<tr>
<td>32</td>
<td>t-test</td>
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<tr>
<td>33</td>
<td>Fisher’s Exact Test</td>
</tr>
<tr>
<td>34</td>
<td>t-test</td>
</tr>
<tr>
<td>35</td>
<td>t-test</td>
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<td>36</td>
<td>t-test</td>
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<td>37</td>
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Table 10. Data Levels and Variables

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<tr>
<td>Process</td>
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<tr>
<td>Confidence</td>
<td>interval</td>
</tr>
<tr>
<td>Motivation to solve problem</td>
<td>ordinal</td>
</tr>
<tr>
<td>Interest to solve problem</td>
<td>ordinal</td>
</tr>
<tr>
<td>GPA</td>
<td>interval</td>
</tr>
<tr>
<td>Problem solving approach %</td>
<td>ratio</td>
</tr>
<tr>
<td>Interest to learn about problem solving</td>
<td>nominal</td>
</tr>
<tr>
<td>Like to solve problems</td>
<td>nominal</td>
</tr>
<tr>
<td>Uses a process</td>
<td>nominal</td>
</tr>
<tr>
<td>Uses same process as would teach</td>
<td>nominal</td>
</tr>
<tr>
<td>MBTI</td>
<td>nominal</td>
</tr>
<tr>
<td>Hypothesis Level</td>
<td>Independent variable</td>
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<tr>
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</tr>
<tr>
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<td>Process</td>
</tr>
<tr>
<td>3</td>
<td>Process</td>
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</tr>
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<td>4</td>
<td>Psychological type</td>
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<td>GPA</td>
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<td></td>
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<tr>
<td>6</td>
<td>Motivation, Interest</td>
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</tr>
<tr>
<td>6</td>
<td>Interest in learning about problem solving</td>
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<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Likes to solve problems</td>
</tr>
<tr>
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<td></td>
</tr>
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<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Uses a process, Use same process as would teach</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Data Analysis for Problem Solving Potential

Problem solving potential was assessed by first having students write solutions to each problem (Monday Night Football and camera phone) on a blank sheet provided to them. They also had a blank sheet to use for draft work. Each student’s solution was analyzed by reviewing his/her solution and then checking the appropriate boxes on the problem solving potential scoring sheet (located in Appendix B) for each item on the sheet that was exhibited in a student’s solution. Each student’s score was totaled, and then a percentage score was generated. This was done on the pre-test problem (Monday Night Football lead-in) and the post-test problem (camera phone).

Data Analysis for Problem Solving Process Knowledge

Problem solving process scores were calculated by having the students complete the process knowledge form and then checking the appropriate list items on the Problem Solving Process scoring sheet. For this data, if the student used any of the keywords located on the process scoring sheet, they received credit for having knowledge of that process element. If the student just listed a process name, they received credit for specific process elements, depending upon the process listed and its similarity to the items on the scoring sheet.

Data Analysis for Confidence

Confidence was scored using the Problem Solving Inventory (PSI). Only the confidence construct was scored. Scoring was done per the PSI Manual and template.
Data Analysis for Psychological Type

Psychological type was scored using the MBTI. The manual and the scoring template were used in determining a student’s MBTI type.

Data Analysis for Problem Solving Approach

Problem solving approach was scored using a researcher-developed scoring template that used the problem solution to determine a student’s problem solving approach (a researcher-calculated MBTI) for each problem. The scoring template is located in Appendix G. For each student, the researcher compared how the student actually approached the problem in his/her written solution and checked the appropriate items on the scoring sheet that corresponded with different characteristics found in MBTI preferences. Scoring was very lenient, so as to include rather than exclude possible points. The researcher calculated a pre and post MBTI type for each student based on the way they solved each problem. Then, each researcher-calculated MBTI was compared, preference by preference, to the student’s actual MBTI type. This determined if the MBTI played any role in the way that a student approached problem solving. The percent correct was calculated (0%, 25%, 50%, 75%, or 100%). In addition, the calculated MBTI’s were compared to each other to determine if there was any change in the way students approached a problem as a result of the intervention.

Data Analysis for Motivation

Motivation was assessed using three questions: a five-point Likert scale, indicating a student’s motivation for solving the specific problem, a question
regarding students interest in learning about problem solving (Yes / No), and a question about liking to solve problems (Yes / No).

Data Analysis for Interest

Interest was assessed using a five-point Likert scale, indicating a student’s interest in solving the specific problem.

Data Analysis for “Using a Process”

“Using a Process” was assessed by the process knowledge question that asked students if they used a process to find a solution to each problem. If the students answered that no process was used or answered using an informal and unscientific process, then “Used a Process” was given a “No.”

Data Analysis for “Uses Same Process as Would Teach”

“Using the Same Process as Would Teach” was assessed by comparing the results of the process knowledge questions (what process did you use to solve the problem and what process would you teach to high school students). If the same or similar process was used, this was assessed as a “Yes.” If the two processes were different, or if the students indicated that they did not use a process but listed a process that they would teach, then this assessed as a “No.”
Summary

Prior to the final study, a pilot study was performed. As a result of the pilot test, the scoring method for calculating problem solving potential and problem solving process knowledge was adjusted, a new method for measuring problem solving approach was created, and the intervention activities were modified. This study used a variety of statistical methods to determine the relationships between the factors involved in technological problem solving. An alpha level of 0.05 was established. JMP software licensed through North Carolina State University provided the statistical software for analysis.
CHAPTER 4: FINDINGS

This chapter contains the results of the data analyses. The objective of the study was to examine the relationships between the factors of technological problem solving potential, problem solving confidence, psychological type, knowledge of a problem solving process, GPA, problem interest, motivation, desire to solve problems, and desire to learn about problem solving.

Demographic Data

Tables 12, 13, and 14 show the demographics of the study sample. Table 14 shows the distribution of the MBTI types for the class. Please refer to the Psychological Type section in the Literature Review chapter for details.

Table 12. Sample Demographics- Gender and Class Standing

<table>
<thead>
<tr>
<th>Demographic</th>
<th>Sample (N=16)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
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<tr>
<td>Male</td>
<td>13</td>
</tr>
<tr>
<td>Female</td>
<td>3</td>
</tr>
<tr>
<td>Class Standing</td>
<td></td>
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<tr>
<td>Junior</td>
<td>7</td>
</tr>
<tr>
<td>Senior</td>
<td>9</td>
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Table 13. Sample Demographics – GPA and Age

<table>
<thead>
<tr>
<th>Demographic</th>
<th>M</th>
<th>SD</th>
<th>Range</th>
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</thead>
<tbody>
<tr>
<td>GPA</td>
<td>3.02</td>
<td>0.4457</td>
<td>2.4-3.9</td>
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<tr>
<td>Age</td>
<td>21.38</td>
<td>0.9574</td>
<td>20-23</td>
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</table>

N=16
Table 14. Sample Demographics – MBTI Distribution for the Class

<table>
<thead>
<tr>
<th>Demographic</th>
<th>Sample (N=16)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MBTI</td>
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<tr>
<td>ESFP</td>
<td>1</td>
</tr>
<tr>
<td>ESTJ</td>
<td>2</td>
</tr>
<tr>
<td>ESTP</td>
<td>5</td>
</tr>
<tr>
<td>INFJ</td>
<td>2</td>
</tr>
<tr>
<td>INTP</td>
<td>4</td>
</tr>
<tr>
<td>ISTP</td>
<td>2</td>
</tr>
<tr>
<td>MBTI S/N</td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>10</td>
</tr>
<tr>
<td>N</td>
<td>6</td>
</tr>
<tr>
<td>MBTI T/F</td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>13</td>
</tr>
<tr>
<td>F</td>
<td>3</td>
</tr>
<tr>
<td>MBTI E/I</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>8</td>
</tr>
<tr>
<td>I</td>
<td>8</td>
</tr>
<tr>
<td>MBTI J/P</td>
<td></td>
</tr>
<tr>
<td>J</td>
<td>4</td>
</tr>
<tr>
<td>P</td>
<td>12</td>
</tr>
</tbody>
</table>

Students were also asked to answer the following questions. (Appendix L contains each student’s answers). The answers provide a view of students’ concerns.

- What is the biggest societal problem affecting the U.S.?
- What is the biggest world problem?
- What communication technology problem is the most interesting to you?
- What problem (from any discipline) concerns and/or interests you the most?
Findings

This section contains the findings related to each of the hypothesis. It is organized by Level. Refer to Appendix J – Levels of Possible Relationships to look at a graphical representation of the levels. Each hypothesis is stated in the null form. The alpha level was set to 0.05.

**Level 1 - Relationships between confidence, process, and potential**

1. There is no relationship between problem solving confidence and technological problem solving potential.

   **H01a**: The correlation coefficients between the pre-test confidence scores and the pre-test problem solving potential scores are 0.

   **Findings**: Results of a Pearson product-moment correlation indicated a significant relationship between pre-test confidence scores and pre-test potential scores (0.5405, \( p = 0.0306 \)).

   **Note**: The PSI confidence scale ranges from eleven to sixty-six, with eleven indicating high confidence and sixty-six indicating low confidence. A positive statistical correlation with confidence is interpreted as a negative relationship due to the structure of the PSI confidence scoring method.

   **H01b**: The correlation coefficients between the post-test confidence scores and the post-test problem solving potential scores are 0.

   **Findings**: Results of a Pearson product-moment correlation did not indicate a significant relationship between post-test confidence scores and post-test potential scores (-0.1684, \( p = 0.5330 \)).
2. There is no relationship between process and technological problem solving potential.

\textbf{H0}_{2a}: The correlation coefficients between the pre-test knowledge of an MBTI-type problem solving process scores and the pre-test problem solving potential scores are 0.

\textbf{Findings: } Results of a Pearson product-moment correlation indicated a significant positive relationship between pre-test knowledge of an MBTI-type problem solving process scores and pre-test potential scores (0.5604, \( p=0.0239 \)).

\textbf{H0}_{2b}: The correlation coefficients between the post-test knowledge of an MBTI-type problem solving process scores and the post-test problem solving potential scores are 0.

\textbf{Findings: } Results of a Pearson product-moment correlation indicated a significant positive relationship between post-test knowledge of an MBTI-type problem solving process scores and post-test potential scores (0.5252, \( p=0.0444 \)) when one outlier was removed (\( n=15 \)).

3. There is no relationship between psychological type and technological problem solving potential scores.

\textbf{H0}_{3a}: There is no statistically significant difference between the means of the pre-test problem solving potential scores for students with MBTI preferences of S and students with MBTI preferences of N.

\textbf{Findings: } Results of a t-test for independent samples did not indicate a significant difference in mean pre-test potential scores for MBTI preferences of S (\( M = 26.2 \)) and MBTI preferences of N (\( M = 25.5 \)), \( t(14) = -0.110, \ p = 0.9140 \) (two-tailed).
Findings: Results of a t-test for independent samples did not indicate a significant difference in mean pre-test potential scores for MBTI preferences of T ($M = 24.62$) and MBTI preferences of F ($M = 31.67$), $t(14) = 0.919$, $p = 0.3737$ (two-tailed).

Findings: Results of a t-test for independent samples did not indicate a significant difference in mean pre-test potential scores for MBTI preferences of E ($M = 22.63$) and MBTI preferences of I ($M = 29.25$), $t(14) = -1.121$, $p = 0.2811$ (two-tailed).

Findings: Results of a t-test for independent samples did not indicate a significant difference in mean pre-test potential scores for MBTI preferences of J ($M = 20.75$) and MBTI preferences of P ($M = 27.67$), $t(14) = -1.005$, $p = 0.3317$ (two-tailed).

Findings: Results of a t-test for independent samples did not indicate a significant difference in mean post-test potential scores for MBTI preferences of S and students with MBTI preferences of N.
Findings: Results of a t-test for independent samples did not indicate a significant difference in mean post-test potential scores for MBTI preferences of S ($M = 44.7$) and MBTI preferences of N ($M = 44.17$), $t(14) = -0.088$, $p = 0.9310$ (two-tailed).

H$0_{3f}$: There is no statistically significant difference between the means of the post-test problem solving potential scores for students with MBTI preferences of T and students with MBTI preferences of F.

Findings: Results of a t-test for independent samples did not indicate a significant difference in mean post-test potential scores for MBTI preferences of T ($M = 43.00$) and MBTI preferences of F ($M = 51.00$), $t(14) = 1.112$, $p = 0.2848$ (two-tailed).

H$0_{3g}$: There is no statistically significant difference between the means of the post-test problem solving potential scores for students with MBTI preferences of E and students with MBTI preferences of I.

Findings: Results of a t-test for independent samples did not indicate a significant difference in mean post-test potential scores for MBTI preferences of E ($M = 46.5$) and MBTI preferences of I ($M = 42.50$), $t(14) = 0.694$, $p = 0.4988$ (two-tailed).

H$0_{3h}$: There is no statistically significant difference between the means of the post-test problem solving potential scores for students with MBTI preferences of J and students with MBTI preferences of P.

Findings: Results of a t-test for independent samples indicated a significant difference in mean post-test potential scores for MBTI preferences of J ($M = 54.00$, $n=4$) and MBTI preferences of P ($M = 41.33$, $n=12$), $t(14) = 2.163$, $p = 0.0484$ (two-tailed).
Level 2 – Relationships between psychological type, confidence, and process

4. There is no relationship between problem solving confidence and knowing an MBTI problem solving process.

**H0₄a:** The correlation coefficients between the pre-test confidence scores and the pre-test knowledge of an MBTI problem solving process scores are 0.

**Findings:** Results of a Pearson product-moment correlation did not indicate a significant positive relationship between pre-test confidence scores and pre-test process scores (0.3044, \( p = 0.2517 \)).

**H0₄b:** The correlation coefficients between the post-test confidence scores and the post-test knowledge of an MBTI problem solving process scores are 0.

**Findings:** Results of a Pearson product-moment correlation did not indicate a significant relationship between post-test confidence scores and post-test process scores (-0.1091, \( p = 0.6875 \)).

5. There is no relationship between psychological type and problem solving confidence.

**H0₅a:** There is no statistically significant difference between the means of the pre-test problem solving confidence scores for students with MBTI preferences of S and students with MBTI preferences of N.

**Findings:** Results of a t-test for independent samples did not indicate a significant difference in mean pre-test confidence scores for MBTI preferences of S \( (M = 22.10) \) and MBTI preferences of N \( (M = 20.67) \), \( t(14) = -0.400, \ p = 0.6952 \) (two-tailed).
**H0_{5b}:** There is no statistically significant difference between the means of the pre-test problem solving confidence scores for students with MBTI preferences of T and students with MBTI preferences of F.

**Findings:** Results of a t-test for independent samples did not indicate a significant difference in mean pre-test confidence scores for MBTI preferences of T ($M = 20.38$) and MBTI preferences of F ($M = 26.67$), $t(14) = 1.516$, $p = 0.1517$ (two-tailed).

**H0\textsubscript{5c}:** There is no statistically significant difference between the means of the pre-test problem solving confidence scores for students with MBTI preferences of E and students with MBTI preferences of I.

**Findings:** Results of a t-test for independent samples did not indicate a significant difference in mean pre-test confidence scores for MBTI preferences of E ($M = 22.38$) and MBTI preferences of I ($M = 20.75$), $t(14) = 0.469$, $p = 0.6461$ (two-tailed).

**H0_{5d}:** There is no statistically significant difference between the means of the pre-test problem solving confidence scores for students with MBTI preferences of J and students with MBTI preferences of P.

**Findings:** Results of a t-test for independent samples did not indicate a significant difference in mean pre-test confidence scores for MBTI preferences of J ($M = 21.75$) and MBTI preferences of P ($M = 21.5$), $t(14) = 0.062$, $p = 0.9514$ (two-tailed).
**H05c**: There is no statistically significant difference between the means of the post-test problem solving confidence scores for students with MBTI preferences of S and students with MBTI preferences of N.

**Findings**: Results of a t-test for independent samples did not indicate a significant difference in mean post-test confidence scores for MBTI preferences of S ($M = 33.9$) and MBTI preferences of N ($M = 23.00$), $t(14) = -2.073, p = 0.0571$ (two-tailed).

**H05f**: There is no statistically significant difference between the means of the post-test problem solving confidence scores for students with MBTI preferences of T and students with MBTI preferences of F.

**Findings**: Results of a t-test for independent samples did not indicate a significant difference in mean post-test confidence scores for MBTI preferences of T ($M = 30.62$) and MBTI preferences of F ($M = 26.33$), $t(14) = -0.581, p = 0.5703$ (two-tailed).

**H05g**: There is no statistically significant difference between the means of the post-test problem solving confidence scores for students with MBTI preferences of E and students with MBTI preferences of I.

**Findings**: Results of a t-test for independent samples indicated a significant difference in mean post-test confidence scores for MBTI preferences of E ($M = 35.38$) and MBTI preferences of I ($M = 24.25$), $t(14) = 2.224, p = 0.0431$ (two-tailed).
**H0**: There is no statistically significant difference between the means of the post-test problem solving confidence scores for students with MBTI preferences of J and students with MBTI preferences of P.

**Findings**: Results of a t-test for independent samples did not indicate a significant difference in mean post-test confidence scores for MBTI preferences of J ($M = 29.50$) and MBTI preferences of P ($M = 29.92$), $t(14) = -0.062$, $p = 0.9514$ (two-tailed).

6. There is no relationship between psychological type and knowledge of an MBTI-type problem solving process.

**H0**: There is no statistically significant difference between the means of the pre-test problem solving process scores for students with MBTI preferences of S and students with MBTI preferences of N.

**Findings**: Results of a t-test for independent samples did not indicate a significant difference in mean pre-test process scores for MBTI preferences of S ($M = 29.10$) and MBTI preferences of N ($M = 25.67$), $t(14) = -0.725$, $p = 0.4802$ (two-tailed).

**H0**: There is no statistically significant difference between the means of the pre-test problem solving process scores for students with MBTI preferences of T and students with MBTI preferences of F.

**Findings**: Results of a t-test for independent samples did not indicate a significant difference in mean pre-test process scores for MBTI preferences of T ($M = 26.23$) and MBTI preferences of F ($M = 34.67$), $t(14) = 1.523$, $p = 0.1500$ (two-tailed).
H0_{6c}: There is no statistically significant difference between the means of the pre-test problem solving process scores for students with MBTI preferences of E and students with MBTI preferences of I.

Findings: Results of a t-test for independent samples did not indicate a significant difference in mean pre-test process scores for MBTI preferences of E ($M = 27.88$) and MBTI preferences of I ($M = 27.75$), $t(14) = 0.027$, $p = 0.9790$ (two-tailed).

H0_{6d}: There is no statistically significant difference between the means of the pre-test problem solving process scores for students with MBTI preferences of J and students with MBTI preferences of P.

Findings: Results of a t-test for independent samples did not indicate a significant difference in mean pre-test process scores for MBTI preferences of J ($M = 24.00$) and MBTI preferences of P ($M = 29.08$), $t(14) = -0.974$, $p = 0.3464$ (two-tailed).

H0_{6e}: There is no statistically significant difference between the means of the post-test problem solving process scores for students with MBTI preferences of S and students with MBTI preferences of N.

Findings: Results of a t-test for independent samples did not indicate a significant difference in mean post-test process scores for MBTI preferences of S ($M = 36.4$) and MBTI preferences of N ($M = 36.33$), $t(14) = -0.012$, $p = 0.9903$ (two-tailed).

H0_{6f}: There is no statistically significant difference between the means of the post-test problem solving process scores for students with MBTI preferences of T and students with MBTI preferences of F.
**Findings:** Results of a t-test for independent samples did not indicate a significant difference in mean post-test process scores for MBTI preferences of T ($M = 36.38$) and MBTI preferences of F ($M = 36.33$), $t(14) = -0.008$, $p = 0.9940$ (two-tailed).

**H06:** There is no statistically significant difference between the means of the post-test problem solving process scores for students with MBTI preferences of E and students with MBTI preferences of I.

**Findings:** Results of a t-test for independent samples did not indicate a significant difference in mean post-test process scores for MBTI preferences of E ($M = 38.63$) and MBTI preferences of I ($M = 34.13$), $t(14) = 0.890$, $p = 0.3887$ (two-tailed).

**H06:** There is no statistically significant difference between the means of the post-test problem solving process scores for students with MBTI preferences of J and students with MBTI preferences of P.

**Findings:** Results of a t-test for independent samples did not indicate a significant difference in mean post-test process scores for MBTI preferences of J ($M = 42.00$) and MBTI preferences of P ($M = 34.5$), $t(14) = 1.325$, $p = 0.2063$ (two-tailed).

**Level 3 – Intervention Effects**

7. There is no relationship between pre-test problem solving process scores and post-test problem solving process scores.

**H07:** There is no statistically significant difference between the pre-test problem solving process scores and the post-test problem solving process scores.

**Findings:** Results of a t-test for dependent samples did not indicate a significant difference in pre-test process scores ($M = 27.81$) and post-test process scores ($M = 36.375$), $t(15) = 2.069$, $p = 0.0562$ (two-tailed).
**H0₇b:** There is no linear relationship between the pre-test problem solving process scores and the post-test problem solving process scores.

**Findings:** Results of a Least Squares Fit indicated a significant negative linear relationship between pre-test process scores ($r^2 = 0.2554$, $B = -0.5628$, $p=0.0458$) and post-test process scores.

**Note:** Table 15 shows the pre-test and post-test process scores to illustrate the large gains made by students with low process pre-test scores as compared to a loss by students with high process pre-test scores.

**Table 15. Process Pretest and Posttest Scores (lowest 5 and highest 5 pretest scores)**

<table>
<thead>
<tr>
<th>Number (lowest to highest)</th>
<th>Process pre-test scores</th>
<th>Process post-test scores</th>
<th>Gain / Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>55</td>
<td>45 Gain</td>
</tr>
<tr>
<td>2</td>
<td>14</td>
<td>27</td>
<td>13 Gain</td>
</tr>
<tr>
<td>3</td>
<td>18</td>
<td>36</td>
<td>18 Gain</td>
</tr>
<tr>
<td>4</td>
<td>18</td>
<td>50</td>
<td>32 Gain</td>
</tr>
<tr>
<td>5</td>
<td>23</td>
<td>55</td>
<td>32 Gain</td>
</tr>
<tr>
<td>12</td>
<td>36</td>
<td>27</td>
<td>-9 Loss</td>
</tr>
<tr>
<td>13</td>
<td>36</td>
<td>32</td>
<td>-4 Loss</td>
</tr>
<tr>
<td>14</td>
<td>36</td>
<td>32</td>
<td>-4 Loss</td>
</tr>
<tr>
<td>15</td>
<td>36</td>
<td>36</td>
<td>0</td>
</tr>
<tr>
<td>16</td>
<td>41</td>
<td>27</td>
<td>-14 Loss</td>
</tr>
</tbody>
</table>

8. There is no relationship between pre-test problem solving confidence scores and post-test problem solving confidence scores.

**H0₈a:** There is no statistically significant difference between the pre-test problem solving confidence scores and the post-test problem solving confidence scores.
Findings: Results of a t-test for dependent samples indicated a significant difference in pre-test confidence scores ($M = 21.56$) and post-test confidence scores ($M = 29.81$), $t(15) = 2.724$, $p = 0.0157$ (two-tailed).

Note: The PSI confidence scale ranges from eleven to sixty-six, with eleven indicating high confidence and sixty-six indicating low confidence.

$H_{0b}$: There is no linear relationship between the pre-test problem solving confidence scores and the post-test problem solving confidence scores.

Findings: Results of a Least Squares Fit did not indicate a significant linear relationship between pre-test confidence scores ($r^2 = 0.02753$, $B = 0.2766$, $p=0.5391$) and post-test confidence scores.

Note: Table 16 shows the pre-test and post-test confidence scores to illustrate the loss of confidence made by most students. The largest losses were students whose pre-test confidence levels were the highest (the lowest score numbers). The PSI confidence scale ranges from eleven to sixty-six, with eleven indicating high confidence and sixty-six indicating low confidence. Therefore, a post-test confidence score that is higher than the pre-test confidence score indicates a loss of confidence, whereas a post-test confidence score that is lower than the pre-test confidence score indicates a gain in confidence.
Table 16. Confidence Pretest to Posttest Scores

<table>
<thead>
<tr>
<th>Number (lowest to highest by confidence level)</th>
<th>Confidence pre-test scores</th>
<th>Confidence post-test scores</th>
<th>Gain / Loss of confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>32</td>
<td>31</td>
<td>1 Gain</td>
</tr>
<tr>
<td>2</td>
<td>29</td>
<td>32</td>
<td>-3 Loss</td>
</tr>
<tr>
<td>3</td>
<td>27</td>
<td>37</td>
<td>-10 Loss</td>
</tr>
<tr>
<td>4</td>
<td>27</td>
<td>22</td>
<td>5 Gain</td>
</tr>
<tr>
<td>5</td>
<td>27</td>
<td>29</td>
<td>-2 Loss</td>
</tr>
<tr>
<td>6</td>
<td>26</td>
<td>29</td>
<td>-3 Loss</td>
</tr>
<tr>
<td>7</td>
<td>25</td>
<td>26</td>
<td>-1 Loss</td>
</tr>
<tr>
<td>8</td>
<td>23</td>
<td>17</td>
<td>6 Gain</td>
</tr>
<tr>
<td>9</td>
<td>23</td>
<td>54</td>
<td>-31 Loss</td>
</tr>
<tr>
<td>11</td>
<td>21</td>
<td>44</td>
<td>-23 Loss</td>
</tr>
<tr>
<td>12</td>
<td>15</td>
<td>40</td>
<td>-25 Loss</td>
</tr>
<tr>
<td>13</td>
<td>13</td>
<td>24</td>
<td>-11 Loss</td>
</tr>
<tr>
<td>14</td>
<td>13</td>
<td>41</td>
<td>-28 Loss</td>
</tr>
<tr>
<td>15</td>
<td>12</td>
<td>21</td>
<td>-9 Loss</td>
</tr>
<tr>
<td>16</td>
<td>11</td>
<td>11</td>
<td>0</td>
</tr>
</tbody>
</table>

9. There is no relationship between pre-test problem solving potential scores and post-test problem solving potential scores.

H0a: There is no statistically significant difference between the pre-test problem solving potential scores and the post-test problem solving potential scores.

Findings: Results of a t-test for dependent samples indicated a significant difference in pre-test potential scores \((M = 25.94)\) and post-test potential scores \((M = 44.5)\), \(t(15) = 3.99, p = 0.0012\) (two-tailed).
**H0**: There is no linear relationship between the pre-test problem solving potential scores and the post-test problem solving potential scores.

**Findings**: Results of a Least Squares Fit did not indicate a significant linear relationship between pre-test potential scores ($r^2 = 0.0789$, $B = -0.2667$, $p=0.2919$) and post-test potential scores.

**Note**: Table 17 shows the pre-test and post-test potential scores to illustrate the large gains made by students with low potential pre-test scores as compared to a small gain by students with high potential pre-test scores.
Table 17. Potential Pretest and Posttest scores (lowest 8 and highest 6 pretest scores)

<table>
<thead>
<tr>
<th>Number (lowest to highest)</th>
<th>Potential pre-test scores</th>
<th>Potential post-test scores</th>
<th>Gain / Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>45</td>
<td>35 Gain</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>58</td>
<td>48 Gain</td>
</tr>
<tr>
<td>3</td>
<td>13</td>
<td>48</td>
<td>35 Gain</td>
</tr>
<tr>
<td>4</td>
<td>15</td>
<td>40</td>
<td>25 Gain</td>
</tr>
<tr>
<td>5</td>
<td>15</td>
<td>40</td>
<td>25 Gain</td>
</tr>
<tr>
<td>6</td>
<td>18</td>
<td>45</td>
<td>27 Gain</td>
</tr>
<tr>
<td>7</td>
<td>20</td>
<td>70</td>
<td>50 Gain</td>
</tr>
<tr>
<td>8</td>
<td>25</td>
<td>60</td>
<td>35 Gain</td>
</tr>
<tr>
<td>11</td>
<td>30</td>
<td>33</td>
<td>3 Gain</td>
</tr>
<tr>
<td>12</td>
<td>35</td>
<td>45</td>
<td>10 Gain</td>
</tr>
<tr>
<td>13</td>
<td>35</td>
<td>43</td>
<td>8 Gain</td>
</tr>
<tr>
<td>14</td>
<td>40</td>
<td>40</td>
<td>0</td>
</tr>
<tr>
<td>15</td>
<td>40</td>
<td>40</td>
<td>0</td>
</tr>
<tr>
<td>16</td>
<td>48</td>
<td>50</td>
<td>2 Gain</td>
</tr>
</tbody>
</table>

10. There is no relationship between a researcher’s calculated MBTI type student’s problem solving approach prior to the intervention as compared to a researcher’s calculated MBTI type student’s problem solving approach after the intervention.

**H0_{10a}:** There is no statistically significant difference between a researcher calculated MBTI type student’s problem solving approach scores before the intervention and a researcher calculated student’s problem solving approach scores after the intervention.
**Findings:** Results of a t-test for dependent samples did not indicate a significant difference in pre-test problem solving approach scores ($M = 68.75$) and post-test problem solving approach scores ($M = 67.19$), $t(15) = -0.2225$, $p = 0.8269$ (two-tailed).

11. There is no relationship between a student’s desire to learn about problem solving prior to the intervention as compared to a student’s desire to learn about problem solving after the intervention. See Table 18.

**H011a:** A student’s desire to learn about problem solving prior to the intervention is independent of their desire to learn about problem solving after the intervention.

**Findings:** Results of the Fisher’s Exact Test indicated a significant association between pre-intervention desire to learn about problem solving and post-intervention desire to learn about problem solving, *Fisher’s exact test, p = 0.0337* (two-tailed).

**Note:** Table 18 shows the contingency table for the number of students who do / do not desire to learn about problem solving both at pre-test and post-time time.

**Table 18. Contingency Table - Pre and Post Desire to Learn about Problem Solving**

<table>
<thead>
<tr>
<th></th>
<th>Post – Does not desire to learn about problem solving</th>
<th>Post - Desire to learn about problem solving</th>
<th>totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre - Does not desire to learn about problem solving</td>
<td>7</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Pre - Desires to learn about problem solving</td>
<td>4</td>
<td>5</td>
<td>9</td>
</tr>
</tbody>
</table>
Level 4 – Relationships between psychological type and problem solving approach

12. There is no relationship between psychological type as measured by MBTI and researcher calculated MBTI type technological problem solving approach

H0$_{12a}$: The pre-test mean score for matching the researcher calculated MBTI type student’s technological problem solving approach to his/her actual MBTI type is 0.

Findings: Results of a signed-rank test for $M=0$ indicated a significant difference from 0 for $M=0$ pre-test technological problem solving approach ($M=68.75$), $p=0.0000$ (two-tailed).

H0$_{12b}$: The post-test mean score for matching the researcher calculated MBTI type student’s technological problem solving approach to his/her MBTI type is 0.

Findings: Results of a signed-rank test for $M=0$ indicated a significant difference from 0 for $M=0$ post-test technological problem solving approach ($M=67.18$), $p=0.0000$ (two-tailed).

H0$_{12c}$: The mean score for matching the researcher calculated MBTI type student’s pre-test technological problem solving approach to his/her researcher calculated post-test technological problem solving approach is 0.

Findings: Results of a signed-rank test for $M=0$ indicated a significant difference from 0 for $M=0$ for researcher calculated pre-test to post-test technological problem solving approach ($M=67.18$), $p=0.0000$ (two-tailed).
Level 5 – Relationships involving GPA

13. There is no relationship between problem solving potential and GPA.

\textbf{H0}_{13a}: \text{ The correlation coefficients between the pre-test potential scores and GPA are 0.}

\textbf{Findings}: Results of a Pearson product-moment correlation did not indicate a significant relationship between pre-test potential scores and GPA (0.3557, \(p=0.1764\)).

\textbf{H0}_{13b}: \text{ The correlation coefficients between the post-test potential scores and GPA are 0.}

\textbf{Findings}: Results of a Pearson product-moment correlation did not indicate a significant relationship between post-test potential scores and GPA (0.0147, \(p=0.9570\)).

14. There is no relationship between problem solving confidence and GPA.

\textbf{H0}_{14a}: \text{ The correlation coefficients between the pre-test confidence scores and GPA are 0.}

\textbf{Findings}: Results of a Pearson product-moment correlation indicated a significant relationship between pre-test confidence scores and GPA (0.4986, \(p=0.0493\)).

\textbf{Note}: The PSI confidence scale ranges from eleven to sixty-six, with eleven indicating high confidence and sixty-six indicating low confidence. A positive statistical correlation with confidence is interpreted as a negative relationship due to the structure of the PSI confidence scoring method.

\textbf{H0}_{14b}: \text{ The correlation coefficients between the post-test confidence scores and GPA are 0.}
**Findings**: Results of a Pearson product-moment correlation did not indicate a significant relationship between post-test confidence scores and GPA (0.1619, \( p=0.5491 \)).

15. There is no relationship between process knowledge and GPA.

*H0\textsubscript{15a}*: The correlation coefficients between the pre-test process scores and GPA are 0.

**Findings**: Results of a Pearson product-moment correlation did not indicate a significant relationship between pre-test process scores and GPA (0.0557, \( p=0.8376 \)).

*H0\textsubscript{15b}*: The correlation coefficients between the post-test process scores and GPA are 0.

**Findings**: Results of a Pearson product-moment correlation did not indicate a significant relationship between post-test process scores and GPA (-0.0119, \( p=0.9650 \)).

**Level 6 – Relationships involving motivation, interest, desire the learn about problem solving, desire to solve problems**

16. There is no relationship between problem solving potential and motivation.

*H0\textsubscript{16a}*: The correlation coefficients between the pre-test potential scores and pre-test motivation scores are 0.

**Findings**: Results of a Spearman rank correlation did not indicate a significant relationship between pre-test potential scores and pre-test motivation (0.0242, \( p=0.9290 \)).
**H0_{16b}:** The correlation coefficients between the post-test potential scores and post-test motivation scores are 0.

**Findings:** Results of a Spearman rank correlation did not indicate a significant relationship between post-test potential scores and post-test motivation (-0.2347, \( p=0.3816 \)).

17. There is no relationship between problem solving confidence and motivation

**H0_{17a}:** The correlation coefficients between the pre-test confidence scores and pre-test motivation scores are 0.

**Findings:** Results of a Spearman rank correlation did not indicate a significant relationship between pre-test confidence scores and pre-test motivation (-0.2428, \( p=0.3648 \)).

**H0_{17b}:** The correlation coefficients between the post-test confidence scores and post-test motivation scores are 0.

**Findings:** Results of a Spearman rank correlation did not indicate a significant relationship between post-test confidence scores and post-test motivation (0.1095, \( p=0.6865 \)).

18. There is no relationship between process knowledge and motivation.

**H0_{18a}:** The correlation coefficients between the pre-test process scores and pre-test motivation scores are 0.

**Findings:** Results of a Spearman rank correlation did not indicate a significant relationship between pre-test process scores and pre-test motivation (0.3471, \( p=0.1878 \)).
18b: The correlation coefficients between the post-test process scores and post-test motivation scores are 0.

Findings: Results of a Spearman rank correlation did not indicate a significant relationship between post-test process scores and post-test motivation (\(-0.3104, p=0.2420\)).

19. There is no relationship between problem solving potential and interest.

H0_{19a}: The correlation coefficients between the pre-test potential scores and pre-test interest scores are 0.

Findings: Results of a Spearman rank correlation indicated a significant relationship between pre-test potential scores and pre-test interest (0.5740, \(p=0.0201\)).

H0_{19b}: The correlation coefficients between the post-test potential scores and post-test interest scores are 0.

Findings: Results of a Spearman rank correlation did not indicate a significant relationship between post-test potential scores and post-test interest (0.0131, \(p=0.9616\)).

20. There is no relationship between problem solving confidence and interest.

H0_{20a}: The correlation coefficients between the pre-test confidence scores and pre-test interest scores are 0.

Findings: Results of a Spearman rank correlation did not indicate a significant relationship between pre-test confidence scores and pre-test interest (0.3138, \(p=0.2366\)).
H0_{20b}: The correlation coefficients between the post-test confidence scores and post-test interest scores are 0.

Findings: Results of a Spearman rank correlation did not indicate a significant relationship between post-test confidence scores and post-test interest (0.0023, \( p=0.9933 \)).

21. There is no relationship between process knowledge and interest.

H0_{21a}: The correlation coefficients between the pre-test process scores and pre-test interest scores are 0.

Findings: Results of a Spearman rank correlation indicated a significant relationship between pre-test process scores and pre-test interest (0.7916, \( p=0.0003 \)).

H0_{21b}: The correlation coefficients between the post-test process scores and post-test interest scores are 0.

Findings: Results of a Spearman rank correlation did not indicate a significant relationship between post-test process scores and post-test interest (-0.2393, \( p=0.3720 \)).

22. There is no relationship between problem solving potential and desire to learn about problem solving.

H0_{22a}: There is no statistically significant difference between the means of the pre-test problem solving potential scores for students who desired to learn about problem solving and those students who did not desire to learn about problem solving.
Findings: Results of a t-test for independent samples did not indicate a significant difference in mean pre-test potential scores for students who desired to learn about problem solving ($M = 24.89$) and students who did not desire to learn about problem solving ($M = 27.29$), $t(14) = 0.388$, $p = 0.7042$ (two-tailed).

H022b: There is no statistically significant difference between the means of the post-test problem solving potential scores for students who desired to learn about problem solving and those students who did not desire to learn about problem solving.

Findings: Results of a t-test for independent samples did not indicate a significant difference in mean post-test potential scores for students who desired to learn about problem solving ($M = 46.8$) and students who did not desire to learn about problem solving ($M = 43.45$), $t(14) = -0.535$, $p = 0.6012$ (two-tailed).

23. There is no relationship between problem solving confidence and desire to learn about problem solving.

H023a: There is no statistically significant difference between the means of the pre-test problem solving confidence scores for students who desired to learn about problem solving and those students who did not desire to learn about problem solving.

Findings: Results of a t-test for independent samples did not indicate a significant difference in mean pre-test confidence scores for students who desired to learn about problem solving ($M = 21.33$) and students who did not desire to learn about problem solving ($M = 21.86$), $t(14) = 0.149$, $p = 0.8836$ (two-tailed).
H0_{23b}: There is no statistically significant difference between the means of the post-test problem solving confidence scores for students who desired to learn about problem solving and those students who did not desire to learn about problem solving.

Findings: Results of a t-test for independent samples did not indicate a significant difference in mean post-test confidence scores for students who desired to learn about problem solving ($M = 37.00$) and students who did not desire to learn about problem solving ($M = 26.55$), $t(14) = -1.860, p = 0.0841$ (two-tailed).

24. There is no relationship between process knowledge and desire to learn about problem solving.

H0_{24a}: There is no statistically significant difference between the means of the pre-test problem solving process scores for students who desired to learn about problem solving and those students who did not desire to learn about problem solving.

Findings: Results of a t-test for independent samples did not indicate a significant difference in mean pre-test process scores for students who desired to learn about problem solving ($M = 27.22$) and students who did not desire to learn about problem solving ($M = 28.57$), $t(14) = 0.288, p = 0.7779$ (two-tailed).

H0_{24b}: There is no statistically significant difference between the means of the post-test problem solving process scores for students who desired to learn about problem solving and those students who did not desire to learn about problem solving.
Findings: Results of a t-test for independent samples did not indicate a significant difference in mean post-test process scores for students who desired to learn about problem solving ($M = 36.4$) and students who did not desire to learn about problem solving ($M = 36.36$), $t(14) = -0.006$, $p = 0.9949$ (two-tailed).

25. There is no relationship between psychological type and desire to learn about problem solving.

$H_{0_{25a}}$: MBTI preference of S and N is independent of pre-test desire to learn about problem solving.

Findings: Results of the Fisher’s Exact Test did not indicate a significant association between MBTI preference S and N and pre-test desire to learn about problem solving, $Fisher’s$ $exact$ $test$, $p = 0.6329$ (two-tailed).

$H_{0_{25b}}$: MBTI preference of S and N is independent of post-test desire to learn about problem solving.

Findings: Results of the Fisher’s Exact Test did not indicate a significant association between MBTI preference S and N and post-test desire to learn about problem solving, $Fisher’s$ $exact$ $test$, $p = 1.0000$ (two-tailed).

$H_{0_{25c}}$: MBTI preference of T and F is independent of pre-test desire to learn about problem solving.

Findings: Results of the Fisher’s Exact Test did not indicate a significant association between MBTI preference T and F and pre-test desire to learn about problem solving, $Fisher’s$ $exact$ $test$, $p = 1.0000$ (two-tailed).

$H_{0_{25d}}$: MBTI preference of T and F is independent of post-test desire to learn about problem solving.
Findings: Results of the Fisher’s Exact Test did not indicate a significant association between MBTI preference T and F and post-test desire to learn about problem solving, *Fisher’s exact test, p* = 0.2143 (two-tailed).

**H0**25e: MBTI preference of E and I is independent of pre-test desire to learn about problem solving.

Findings: Results of the Fisher’s Exact Test did not indicate a significant association between MBTI preference E and I and pre-test desire to learn about problem solving, *Fisher’s exact test, p* = 1.0000 (two-tailed).

**H0**25f: MBTI preference of E and I is independent of post-test desire to learn about problem solving.

Findings: Results of the Fisher’s Exact Test did not indicate a significant association between MBTI preference E and I and post-test desire to learn about problem solving, *Fisher’s exact test, p* = 1.0000 (two-tailed).

**H0**25g: MBTI preference of J and P is independent of pre-test desire to learn about problem solving.

Findings: Results of the Fisher’s Exact Test did not indicate a significant association between MBTI preference J and P and pre-test desire to learn about problem solving, *Fisher’s exact test, p* = 1.0000 (two-tailed).

**H0**25h: MBTI preference of J and P is independent of post-test desire to learn about problem solving.

Findings: Results of the Fisher’s Exact Test did not indicate a significant association between MBTI preference J and P and post-test desire to learn about problem solving, *Fisher’s exact test, p* = 0.5467 (two-tailed).
Level 7 – Relationships involving other factors

26. There is no relationship between problem solving potential and desire to solve problems.

$H_{0_{26a}}$: There is no statistically significant difference between the means of the pre-test problem solving potential scores for students who desired to solve problems and those students who did not desire to solve problems on the pre-test.

**Findings:** Results of a t-test for independent samples indicated a significant difference in mean pre-test potential scores for students who desired to solve problems ($M = 19.72$) and students who did not desire to solve problems on the pre-test ($M = 39.60$), $t(14) = 4.957$, $p = 0.0002$ (two-tailed).

$H_{0_{26b}}$: There is no statistically significant difference between the means of the post-test problem solving potential scores for students who desired to solve problems and those students who did not desire to solve problems on the post-test.

**Findings:** Results of a t-test for independent samples did not indicate a significant difference in mean post-test potential scores for students who desired to solve problems ($M = 45.40$) and students who did not desire to solve problems on the post-test ($M = 42.00$), $t(12) = -0.464$, $p = 0.6507$ (two-tailed).

27. There is no relationship between problem solving confidence and desire to solve problems.

$H_{0_{27a}}$: There is no statistically significant difference between the means of the pre-test problem solving confidence scores for students who desired to solve problems and those students who did not desire to solve problems on the pre-test.
Findings: Results of a t-test for independent samples indicated a significant difference in mean pre-test confidence scores for students who desired to solve problems ($M = 19.00$) and students who did not desire to solve problems on the pre-test ($M = 27.20$), $t(14) = 2.679$, $p = 0.0180$ (two-tailed).

H0$_{27b}$: There is no statistically significant difference between the means of the post-test problem solving confidence scores for students who desired to solve problems and those students who did not desire to solve problems on the post-test.

Findings: Results of a t-test for independent samples did not indicate a significant difference in mean post-test confidence scores for students who desired to solve problems ($M = 28.20$) and students who did not desire to solve problems on the post-test ($M = 31.50$), $t(12) = -0.455$, $p = 0.6572$ (two-tailed).

28. There is no relationship between process knowledge and desire to solve problems.

H0$_{28a}$: There is no statistically significant difference between the means of the pre-test problem solving process scores for students who desired to solve problems and those students who did not desire to solve problems on the pre-test.

Findings: Results of a t-test for independent samples did not indicate a significant difference in mean pre-test process scores for students who desired to solve problems ($M = 25.64$) and students who did not desire to solve problems on the pre-test ($M = 32.60$), $t(14) = 1.488$, $p = 0.1589$ (two-tailed).

H0$_{28b}$: There is no statistically significant difference between the means of the post-test problem solving process scores for students who desired to solve problems and those students who did not desire to solve problems on the post-test.
**Findings:** Results of a t-test for independent samples did not indicate a significant difference in mean post-test process scores for students who desired to solve problems ($M = 36.80$) and students who did not desire to solve problems on the post-test ($M = 37.50$), $t(12) = 0.107$, $p = 0.9166$ (two-tailed).

29. There is no relationship between psychological type and desire to solve problems.

**H0$_{29a}$:** MBTI preference of S and N is independent of pre-test desire to solve problems.

**Findings:** Results of the Fisher’s Exact Test did not indicate a significant association between MBTI preference S and N and pre-test desire to solve problems, *Fisher’s exact test, p = 1.0000* (two-tailed).

**H0$_{29b}$:** MBTI preference of S and N is independent of post-test desire to solve problems.

**Findings:** Results of the Fisher’s Exact Test did not indicate a significant association between MBTI preference S and N and post-test desire to solve problems, *Fisher’s exact test, p = 1.0000* (two-tailed).

**H0$_{29c}$:** MBTI preference of T and F is independent of pre-test desire to solve problems.

**Findings:** Results of the Fisher’s Exact Test did not indicate a significant association between MBTI preference T and F and pre-test desire to solve problems, *Fisher’s exact test, p = 0.2143* (two-tailed).

**H0$_{29d}$:** MBTI preference of T and F is independent of post-test desire to solve problems.
**Findings:** Results of the Fisher’s Exact Test did not indicate a significant association between MBTI preference T and F and post-test desire to solve problems, *Fisher’s exact test, p = 0.1738* (two-tailed).

**H0**<sup>29e</sup>: MBTI preference of E and I is independent of pre-test desire to solve problems

**Findings:** Results of the Fisher’s Exact Test did not indicate a significant association between MBTI preference E and I and pre-test desire to solve problems, *Fisher’s exact test, p = 1.0000* (two-tailed).

**H0**<sup>29f</sup>: MBTI preference of E and I is independent of post-test desire to solve problems.

**Findings:** Results of the Fisher’s Exact Test did not indicate a significant association between MBTI preference E and I and post-test desire to solve problems, *Fisher’s exact test, p = 1.0000* (two-tailed).

**H0**<sup>29g</sup>: MBTI preference of J and P is independent of pre-test desire to solve problems

**Findings:** Results of the Fisher’s Exact Test did not indicate a significant association between MBTI preference J and P and pre-test desire to solve problems, *Fisher’s exact test, p = 1.0000* (two-tailed).

**H0**<sup>29h</sup>: MBTI preference of J and P is independent of post-test desire to solve problems

**Findings:** Results of the Fisher’s Exact Test did not indicate a significant association between MBTI preference J and P and post-test desire to solve problems, *Fisher’s exact test, p = 1.0000* (two-tailed).
30. There is no relationship between problem solving potential and using a process.

**H0**30a: There is no statistically significant difference between the means of the pre-test problem solving potential scores for students who use a process and those students who did not use a process on the pre-test.

**Findings:** Results of a t-test for independent samples did not indicate a significant difference in mean pre-test potential scores for students who used a process \((M = 20.333)\) and students who did not use a process on the pre-test \((M = 27.23)\), \(t(14) = 0.898, p = 0.3846\) (two-tailed).

**H0**30b: There is no statistically significant difference between the means of the post-test problem solving potential scores for students who use a process and those students who did not use a process on the post-test.

**Findings:** Results of a t-test for independent samples did not indicate a significant difference in mean post-test potential scores for students who used a process \((M = 44.92)\) and students who did not use a process on the post-test \((M = 43.25)\), \(t(14) = -0.247, p = 0.8086\) (two-tailed).

31. There is no relationship between problem solving confidence and using a process.

**H0**31a: There is no statistically significant difference between the means of the pre-test problem solving confidence scores for students who use a process and those students who did not use a process on the pre-test.

**Findings:** Results of a t-test for independent samples did not indicate a significant difference in mean pre-test confidence scores for students who used a process \((M = 19.00)\) and students who did not use a process on the pre-test \((M = 22.15)\), \(t(14) = 0.718, p = 0.4843\) (two-tailed).
H031b: There is no statistically significant difference between the means of the post-test problem solving confidence scores for students who use a process and those students who did not use a process on the post-test.

Findings: Results of a t-test for independent samples did not indicate a significant difference in mean post-test confidence scores for students who used a process ($M = 32.67$) and students who did not use a process on the post-test ($M = 21.25$), $t(14) = -1.907, p = 0.0773$ (two-tailed).

32. There is no relationship between process knowledge and using a process.

H032a: There is no statistically significant difference between the means of the pre-test problem solving process scores for students who use a process and those students who did not use a process on the pre-test.

Findings: Results of a t-test for independent samples did not indicate a significant difference in mean pre-test process scores for students who used a process ($M = 24.33$) and students who did not use a process on the pre-test ($M = 28.61$), $t(14) = 0.730, p = 0.4777$ (two-tailed).

H032b: There is no statistically significant difference between the means of the post-test problem solving process scores for students who use a process and those students who did not use a process on the post-test.

Findings: Results of a t-test for independent samples did not indicate a significant difference in mean post-test process scores for students who used a process ($M = 37.58$) and students who did not use a process on the post-test ($M = 32.75$), $t(14) = -0.824, p = 0.4235$ (two-tailed).

33. There is no relationship between psychological type and using a process.
**H0_{33a}:** MBTI preference of S and N is independent of pre-test using a process.

**Findings:** Results of the Fisher’s Exact Test did not indicate a significant association between MBTI preference S and N and pre-test using a process, *Fisher’s exact test, p = 0.5179* (two-tailed).

**H0_{33b}:** MBTI preference of S and N is independent of post-test using a process.

**Findings:** Results of the Fisher’s Exact Test did not indicate a significant association between MBTI preference S and N and post-test using a process, *Fisher’s exact test, p = 1.0000* (two-tailed).

**H0_{33c}:** MBTI preference of T and F is independent of pre-test using a process.

**Findings:** Results of the Fisher’s Exact Test did not indicate a significant association between MBTI preference T and F and pre-test using a process, *Fisher’s exact test, p = 0.4893* (two-tailed).

**H0_{33d}:** MBTI preference of T and F is independent of post-test using a process.

**Findings:** Results of the Fisher’s Exact Test did not indicate a significant association between MBTI preference T and F and post-test using a process, *Fisher’s exact test, p = 0.5286* (two-tailed).

**H0_{33e}:** MBTI preference of E and I is independent of pre-test using a process

**Findings:** Results of the Fisher’s Exact Test did not indicate a significant association between MBTI preference E and I and pre-test using a process, *Fisher’s exact test, p = 1.0000* (two-tailed).

**H0_{33f}:** MBTI preference of E and I is independent of post-test using a process.
Findings: Results of the Fisher’s Exact Test did not indicate a significant association between MBTI preference E and I and post-test using a process, 
*Fisher’s exact test, p = 1.0000* (two-tailed).

**H0**33g: MBTI preference of J and P is independent of pre-test using a process.

Findings: Results of the Fisher’s Exact Test did not indicate a significant association between MBTI preference J and P and pre-test using a process,  
*Fisher’s exact test, p = 0.1357* (two-tailed).

**H0**33h: MBTI preference of J and P is independent of post-test using a process.

Findings: Results of the Fisher’s Exact Test did not indicate a significant association between MBTI preference J and P and post-test using a process,  
*Fisher’s exact test, p = 1.0000* (two-tailed).

34. There is no relationship between problem solving potential and “using the same process as would teach.”

**H0**34a: There is no statistically significant difference between the means of the pre-test problem solving potential scores for students who “use the same process as would teach” and those students who would “not use the same process as would teach” on the pre-test.

Findings: Results of a t-test for independent samples did not indicate a significant difference in mean pre-test potential scores for students who “used the same process as would teach” (*M* = 31.00) and students who would “not use the same process as would teach” on the pre-test (*M* = 24.77), *t*(14) = -0.807,  *p* = 0.4334 (two-tailed).
There is no statistically significant difference between the means of the post-test problem solving potential scores for students who “use the same process as would teach” and those students who would “not use the same process as would teach” on the post-test.

Findings: Results of a t-test for independent samples did not indicate a significant difference in mean post-test potential scores for students who “used the same process as would teach” ($M = 46.29$) and students who would “not use the same process as would teach” on the post-test ($M = 44.00$), $t(12) = -0.344, p = 0.7370$ (two-tailed).

There is no relationship between problem solving confidence and “using the same process as would teach.”

There is no statistically significant difference between the means of the pre-test problem solving confidence scores for students who “use the same process as would teach” and those students who would “not use the same process as would teach” on the pre-test.

Findings: Results of a t-test for independent samples indicated no significant difference in mean pre-test confidence scores for students who “used the same process as would teach” ($M = 25.00$) and students who would “not use the same process as would teach” on the pre-test ($M = 20.77$), $t(14) = -0.978, p = 0.3446$ (two-tailed).

There is no statistically significant difference between the means of the post-test problem solving confidence scores for students who “use the same
process as would teach” and those students who would “not use the same process as would teach” on the post-test.

**Findings:** Results of a t-test for independent samples indicated a significant difference in mean post-test confidence scores for students who “used the same process as would teach” ($M = 35.00$) and students who would “not use the same process as would teach” on the post-test ($M = 22.14$), $t(12) = -2.467, p = 0.0297$ (two-tailed).

36. There is no relationship between process knowledge and “using the same process as would teach.”

**H0$_{36a}$:** There is no statistically significant difference between the means of the pre-test problem solving process scores for students who “use the same process as would teach” and those students who would “not use the same process as would teach” on the pre-test.

**Findings:** Results of a t-test for independent samples did not indicate a significant difference in mean pre-test process scores for students who “used the same process as would teach” ($M = 22.67$) and students who would “not use the same process as would teach” on the pre-test ($M = 29$), $t(14) = 1.104, p = 0.2881$ (two-tailed).

**H0$_{36b}$:** There is no statistically significant difference between the means of the post-test problem solving process scores for students who “use the same process as would teach” and those students who would “not use the same process as would teach” on the post-test.

**Findings:** Results of a t-test for independent samples did not indicate a significant difference in mean post-test process scores for students who “used the same
process as would teach” ($M = 41.57$) and students who “would not use the same process as would teach” on the post-test ($M = 32.42$), $t(12) = -1.727$, $p = 0.1098$ (two-tailed).

37. There is no relationship between psychological type and “using the same process as would teach.”

$H_{037a}$: MBTI preference of S and N is independent of pre-test “using the same process as would teach.”

**Findings:** Results of the Fisher’s Exact Test did not indicate a significant association between MBTI preference S and N and pre-test “using the same process as would teach,” *Fisher’s exact test, p* = 0.5179 (two-tailed).

$H_{037b}$: MBTI preference of S and N is independent of post-test “using the same process as would teach.”

**Findings:** Results of the Fisher’s Exact Test did not indicate a significant association between MBTI preference S and N and post-test “using the same process as would teach,” *Fisher’s exact test, p* = 1.0000 (two-tailed).

$H_{037c}$: MBTI preference of T and F is independent of pre-test “using the same process as would teach.”

**Findings:** Results of the Fisher’s Exact Test did not indicate a significant association between MBTI preference T and F and pre-test “using the same process as would teach,” *Fisher’s exact test, p* = 1.0000 (two-tailed).

$H_{037d}$: MBTI preference of T and F is independent of post-test “using the same process as would teach.”
Findings: Results of the Fisher’s Exact Test did not indicate a significant association between MBTI preference T and F and post-test “using the same process as would teach,” Fisher’s exact test, \( p = 1.0000 \) (two-tailed).

H0\(_{37c}\): MBTI preference of E and I is independent of pre-test “using the same process as would teach.”

Findings: Results of the Fisher’s Exact Test did not indicate a significant association between MBTI preference E and I and pre-test “using the same process as would teach,” Fisher’s exact test, \( p = 1.0000 \) (two-tailed).

H0\(_{37f}\): MBTI preference of E and I is independent of post-test “using the same process as would teach.”

Findings: Results of the Fisher’s Exact Test did not indicate a significant association between MBTI preference E and I and post-test “using the same process as would teach,” Fisher’s exact test, \( p = 0.2861 \) (two-tailed).

H0\(_{37g}\): MBTI preference of J and P is independent of pre-test “using the same process as would teach.”

Findings: Results of the Fisher’s Exact Test did not indicate a significant association between MBTI preference J and P and pre-test “using the same process as would teach,” Fisher’s exact test, \( p = 0.5286 \) (two-tailed).

H0\(_{37h}\): MBTI preference of J and P is independent of post-test “using the same process as would teach.”

Findings: Results of the Fisher’s Exact Test did not indicate a significant association between MBTI preference J and P and post-test “using the same process as would teach,” Fisher’s exact test, \( p = 0.5594 \) (two-tailed).
Summary

The findings suggest relationships between the factors of technological problem solving potential, problem solving confidence, psychological type, knowledge of a problem solving process, GPA, problem interest, motivation, desire to solve problems, and desire to learn about problem solving.
CHAPTER 5: SUMMARY, CONCLUSIONS, DISCUSSIONS, and RECOMMENDATIONS

Summary

Reich (1992), in his book The Work of Nations, portrays the future for citizens of the United States. He explains that “a nation’s real technological assets are the capabilities of its citizens to solve complex problems of the future – which depend, in turn, on their experience in solving today’s and yesterday’s [problems]” (1992, p. 163).

Given our global technological society and the complexity of current and future societal problems in this society, it is critical that the citizens, especially those involved in decision making at any level, be able to perform technological problem solving. Technological problem solving involves critically and creatively identifying, examining, evaluating, justifying, and recommending solutions to the world’s global problems.

The purpose of the study was to advance the knowledge base in technological problem solving so that the goal of technological literacy can be achieved by determining the relationships between factors that possibly influence problem solving abilities and by offering a framework for technological problem solving.

The objective of the study was to examine the relationships between the factors of technological problem solving potential, problem solving confidence, psychological type, knowledge of an MBTI-type problem solving process, GPA, problem-specific interest, problem-specific motivation, desire to solve problems, and desire to learn about problem solving.
Research Questions

The following were the research questions guiding the study. Please note, for readability, the words potential, confidence, and process have been simplified but all should be preceded by the words technological problem solving. Appendix J contains diagrams depicting the following levels of research questions.

1. What relationship does potential have with confidence, process knowledge, and psychological type?
2. What are the relationships between psychological type, confidence, and process?
3. Do confidence, process knowledge, potential, problem solving approach and desire to learn about problem solving change as a result of instruction?
4. What is the relationship between psychological type and problem solving approach?
5. What relationship does GPA have with confidence, process, and potential?
6. What relationship does problem-specific motivation, problem-specific interest, desire to learn about problem solving, and desire to solve problems have with confidence, process knowledge, and potential; and what relationship does desire to learn about problem solving and desire to solve problems have with psychological type?
7. What relationship does “using a process” and “using the same process as a person would teach” have with confidence, process, potential, and psychological type.
Null Hypotheses

Level 1: Relationships - potential with confidence, process, and psychological type

1. There is no relationship between problem solving confidence and technological problem solving potential.

2. There is no relationship between knowing an MBTI-type problem solving process and technological problem solving potential.

3. There is no relationship between psychological type and technological problem solving potential.

Level 2: Relationships between confidence, process, and psychological type

4. There is no relationship between problem solving confidence and knowing an MBTI problem solving process.

5. There is no relationship between psychological type and problem solving confidence.

6. There is no relationship between psychological type and knowledge of an MBTI-type problem solving process.

Level 3: Changes in confidence, process knowledge, potential, problem solving approach, and desire to learn about problem solving as a result of the intervention

7. There is no relationship between pre-test problem solving process scores and post-test problem solving process scores.

8. There is no relationship between pre-test problem solving confidence scores and post-test problem solving confidence scores.

9. There is no relationship between pre-test problem solving potential scores and post-test problem solving potential scores.
10. There is no relationship between a researcher’s calculated MBTI type student’s problem solving approach prior to the intervention as compared to a researcher’s calculated MBTI type student’s problem solving approach after the intervention.

11. There is no relationship between a student’s desire to learn about problem solving prior to the intervention as compared to a student’s desire to learn about problem solving after the intervention.

**Level 4: Relationship between psychological type and problem solving approach**

12. There is no relationship between psychological type and technological problem solving approach.

**Level 5: Relationships involving GPA**

13. There is no relationship between problem solving potential and GPA.

14. There is no relationship between problem solving confidence and GPA.

15. There is no relationship between process knowledge and GPA.

**Level 6: Relationships involving motivation, interest, desire to learn about problem solving, and desire to solve problems**

16. There is no relationship between problem solving potential and motivation for solving the specific problem.

17. There is no relationship between problem solving confidence and motivation for solving the specific problem.

18. There is no relationship between process knowledge and motivation for solving the specific problem.
19. There is no relationship between problem solving potential and interest for solving the specific problem.

20. There is no relationship between problem solving confidence and interest for solving the specific problem.

21. There is no relationship between process knowledge and interest for solving the specific problem.

22. There is no relationship between problem solving potential and desire to learn about problem solving.

23. There is no relationship between problem solving confidence and desire to learn about problem solving.

24. There is no relationship between process knowledge and desire to learn about problem solving.

25. There is no relationship between psychological type and desire to learn about problem solving.

26. There is no relationship between problem solving potential and liking to solve problems.

27. There is no relationship between problem solving confidence and liking to solve problems.

28. There is no relationship between process knowledge and liking to solve problems.

29. There is no relationship between psychological type and liking to solve problems.
Level 7: Relationships involving “using a process” and “using the same process as would teach”

30. There is no relationship between problem solving potential and “using a process.”

31. There is no relationship between problem solving confidence and “using a process.”

32. There is no relationship between process knowledge and “using a process.”

33. There is no relationship between psychological type and “using a process.”

34. There is no relationship between problem solving potential and “using the same process as a person would teach.”

35. There is no relationship between problem solving confidence and “using the same process as a person would teach.”

36. There is no relationship between process knowledge and “using the same process as a person would teach.”

37. There is no relationship between psychological type and “using the same process as a person would teach.”

Literature Review

A review of the literature reveals the need for teaching technological problem solving to meet the goals of technological literacy which are based on the need for citizens to be able to live in a complex technological global society.

In addition, the literature shows that there is not a framework (process) for technological problem solving in technology education that is detailed and specific and which considers human values and impact.
In regards to psychological type, there is an abundance of literature on the MBTI and other psychological type measures and their interpretations specific to certain situations, but there is not much research on using the MBTI as a process as defined by McCaulley (1987).

There is also little research on what factors actually contribute to a person’s success in technological problem solving. There are fragments in different studies, but there lacks an agreed-upon set of factors.

Therefore, the need for determining the factors that comprise technological problem solving and their inter-relationships, and the need for a framework for technological problem solving are all supported by the literature.

Methodology

This study utilized the pre-experimental design method of one group pretest-posttest design. A pilot study was conducted at North Carolina State University prior to the actual research. The actual research was conducted at North Carolina State University in the technology education class titled Communications Technology - TED461. There were twenty-two students in the class but due to absences and other circumstances, there were sixteen students who completed the entire three-day workshop. Only the data for these sixteen students was used. The instruments for data collection included the MBTI, the PSI, a questionnaire for recording the solutions to two real-world problems, a process knowledge form, a motivation/interest form, and a demographic/introduction/final form. Data was collected over a three-day, three-hour-per-day, classroom workshop. JMP statistical analysis software from SAS Institute Inc. was used to calculate statistical results. The alpha level was set to 0.05. Many
different statistical methods were used to test the null hypotheses: t-tests (both for dependent and independent samples), Pearson product-moment correlations, Spearman rank correlation, Fisher’s exact test, Signed rank test, and Least Squares Fit.

Summary of Significant Findings

The following is a list of the statistically significant findings in this research. (See Appendix J for a graphical form of the relationships).

Level 1: Relationships between Potential and Confidence, Process, and Psychological Type

**H01a Findings:** Results of a Pearson product-moment correlation indicated a significant relationship between pre-test confidence scores and pre-test potential scores ($0.5405, p=0.0306$).

**Note:** The PSI confidence scale ranges from eleven to sixty-six, with eleven indicating high confidence and sixty-six indicating low confidence. A positive statistical correlation with confidence is interpreted as a negative relationship due to the structure of the PSI confidence scoring method.

**H02a Findings:** Results of a Pearson product-moment correlation indicated a significant positive relationship between pre-test knowledge of an MBTI-type problem solving process scores and pre-test potential scores ($0.5604, p=0.0239$).

**H02b Findings:** Results of a Pearson product-moment correlation indicated a significant positive relationship between post-test knowledge of an MBTI-type problem solving process scores and post-test potential scores ($0.5252, p=0.0444$) when one outlier was removed ($n=15$).
**H03h Findings:** Results of a t-test for independent samples indicated a significant difference in post-test potential mean scores for MBTI preferences of J ($M = 54.00$) and MBTI preferences of P ($M = 41.33$), $t(14) = 2.163$, $p = 0.0484$ (two-tailed).

**Level 2 – Relationships between psychological type, confidence, and process**

**H05g Findings:** Results of a t-test for independent samples indicated a significant difference in post-test mean confidence scores for MBTI preferences of E ($M = 35.38$) and MBTI preferences of I ($M = 24.25$), $t(14) = 2.224$, $p = 0.0431$ (two-tailed).

**Level 3 – Intervention Effects**

**H07b Findings:** Results of a Least Squares Fit indicated a significant negative linear relationship between pre-test process scores ($r^2 = 0.2554$, $B = -0.5628$, $p=0.0458$) and post-test process scores.

**H08a Findings:** Results of a t-test for dependent samples indicated a significant difference in pre-test confidence scores ($M = 21.56$) and post-test confidence scores ($M = 29.81$), $t(15) = 2.724$, $p = 0.0157$ (two-tailed).

**Note:** The PSI confidence scale ranges from eleven to sixty-six, with eleven indicating high confidence and sixty-six indicating low confidence.

**H09a Findings:** Results of a t-test for dependent samples indicated a significant difference in pre-test potential scores ($M = 25.94$) and post-test potential scores ($M = 44.5$), $t(15) = 3.99$, $p = 0.0012$ (two-tailed).

**H010a Findings:** Results of a t-test for dependent samples did not indicate a significant difference in pre problem solving approach scores ($M = 68.75$) and post
problem solving approach scores ($M = 67.19$), $t(15) = -0.2225$, $p = 0.8269$ (two-tailed).

**H0\textsubscript{11a} Findings:** Results of the Fisher’s Exact Test indicated a significant association between pre-intervention desire to learn about problem solving and post-intervention desire to learn about problem solving, Fisher’s exact test, $p = 0.0337$ (two-tailed).

**Level 4 – Relationships between psychological type and problem solving approach**

**H0\textsubscript{12a} Findings:** Results of a signed-rank test for $M=0$ indicated a significant difference from 0 for $M = 0$ pre-test technological problem solving approach ($M = 68.75$), $p = 0.0000$ (two-tailed).

**H0\textsubscript{12b} Findings:** Results of a signed-rank test for $M=0$ indicated a significant difference from 0 for $M = 0$ post-test technological problem solving approach ($M = 67.18$), $p = 0.0000$ (two-tailed).

**H0\textsubscript{12c} Findings:** Results of a signed-rank test for $M=0$ indicated a significant difference from 0 for $M = 0$ for researcher calculated pre-test to post-test technological problem solving approach ($M = 67.18$), $p = 0.0000$ (two-tailed).

**Level 5 – Relationships involving GPA**

**H0\textsubscript{14a} Findings:** Results of a Pearson product-moment correlation indicated a significant relationship between pre-test confidence scores and GPA (0.4986, $p=0.0493$).

**Note:** The PSI confidence scale ranges from eleven to sixty-six, with eleven indicating high confidence and sixty-six indicating low confidence. A positive
statistical correlation with confidence is interpreted as a negative relationship due to the structure of the PSI confidence scoring method

**Level 6 – Relationships involving motivation, interest, desire the learn about problem solving, desire to solve problems**

**H0_{19a} Findings:** Results of a Spearman rank correlation indicated a significant relationship between pre-test potential scores and pre-test interest (0.5740, \( p=0.0201 \)).

**H0_{21a} Findings:** Results of a Spearman rank correlation indicated a significant relationship between pre-test process scores and pre-test interest (0.7916, \( p=0.0003 \)).

**H0_{26a} Findings:** Results of a t-test for independent samples indicated a significant difference in mean pre-test potential scores for students who desired to solve problems (\( M = 19.72 \)) and students who did not desire to solve problems on the pre-test (\( M = 39.60 \)), \( t(14) = 4.957 \ p = 0.0002 \) (two-tailed).

**H0_{27a} Findings:** Results of a t-test for independent samples indicated a significant difference in mean pre-test confidence scores for students who desired to solve problems (\( M = 19.00 \)) and students who did not desire to solve problems on the pre-test (\( M = 27.20 \)), \( t(14) = 2.679 \ p = 0.0180 \) (two-tailed).

**Note:** The PSI confidence scale ranges from eleven to sixty-six, with eleven indicating high confidence and sixty-six indicating low confidence.

**Level 7 – Relationships involving other factors**

**H0_{35b} Findings:** Results of a t-test for independent samples indicated a significant difference in mean post-test confidence scores for students who “used the same
process as would teach” ($M = 35.00$) and students who would “not use the same process as would teach” on the post-test ($M = 22.14$), $t(12) = -2.467$, $p = 0.0297$ (two-tailed).

**Note:** The PSI confidence scale ranges from eleven to sixty-six, with eleven indicating high confidence and sixty-six indicating low confidence.
Conclusions

The following are the conclusions from the research:

1. **Level 1 Conclusions:**

   a. The findings suggest that there is a linear relationship between problem solving confidence and problem solving potential. However, it should be noted that confidence scores are reversed. The PSI confidence scale ranges from eleven to sixty-six, with eleven indicating high confidence and sixty-six indicating low confidence. A positive statistical correlation with confidence is interpreted as a negative relationship due to the structure of the PSI confidence scoring method. So, the findings are that as confidence increases, potential scores decrease or alternatively, as potential scores increase, confidence decreases. However, this relationship was only observed prior to the intervention. After the intervention, these findings did not support this relationship any longer, possibly indicating that the intervention disrupted this relationship. Therefore, students with higher confidence have lower potential scores and those with lower confidence had higher potential scores. An explanation might be that overly confident students do not try as hard to solve the problem, or it may be that lack of confidence makes students work harder at solving problems. It might also be that overly confident students do not have enough awareness of what is involved in problem solving, hence their overconfidence. So, they obtain potential scores that are lower in comparison with their counterparts who
might have a better understanding of problem solving complexities (and yet have low confidence because of this realization).

b. The findings suggest that there is a linear relationship between knowledge of an MBTI-type problem solving process and problem solving potential. This relationship was observed both prior to the intervention, as well as after the intervention, indicating that the intervention did not appear to disrupt this relationship. This is not a surprise, given that the problem solving potential scores have one subsection entitled the “ability to apply a problem solving process.” In addition, the problem solving potential scores have many other subsections that directly map to a problem solving process, such as the ability to analyze solutions (consequences and human impacts), the ability to identify the problem, and the ability to generate potential solutions, among others.

c. The findings suggest that there is a difference between the psychological types of J and P on their problem solving potential post-test scores. The findings reveal that the mean potential scores for those of the MBTI preference J are higher than those of the MBTI type P. This finding was only noted after the intervention, suggesting that J’s might be more attracted to the intervention (which was highly focused on process skills) and that their MBTI type of J, with its fondness for structured and organized work, may have contributed to the higher problem solving potential scores. Please note that for this study, there were less J’s (n=4) than P’s (n=12).
2. **Level 2 Conclusions**

   a. The findings suggest that there is a difference between post-test confidence scores for MBTI preferences of E and I and that students who are E have a lower confidence score than those of I. A possible explanation for this finding might be because the intervention’s activities were composed primarily of an extensive amount of written material and that, while MTBI preferences of I do prefer to communicate in written form, E’s prefer to communicate verbally. Thus, E’s might have been overwhelmed or unimpressed with the problem solving process approach with its abundance of written material, and this may have changed their confidence scores.

3. **Level 3 Conclusions**

   a. A statistically significant negative linear relationship was found in pre-test to post-test process scores. Students having high pre-test process scores had lower post-test process scores; alternatively, those with low pre-test process scores had higher post-test process scores. The greatest gains were in students who had low pre-test scores. A possible explanation is that students who do not initially have knowledge of a formal process were able to easily integrate and learn about the new process, while those students who already knew a process were unable to integrate the new knowledge of a new process in with their existing process knowledge in this short amount of time. Perhaps another explanation might be that those who already knew a process tried to integrate the new process knowledge, but on the post-test they only listed new process knowledge and failed to
integrate the new knowledge with their old knowledge. It might be hypothesized that students who do not have prior process knowledge can more easily learn a new process. It may also be that the intervention did not allow sufficient time to integrate the new process knowledge with their existing process knowledge.

b. The findings suggest that there was a loss in problem solving confidence from pre-test to post-test, which most likely occurred as a result of the intervention. The mean loss was 8.25 points. The interpretation is that students had less confidence after the intervention as compared to before the intervention. This suggests that students observed what was involved in problem solving as a result of the intervention, and many might have realized problem solving was more involved than they originally thought. This new realization might have contributed to this finding. In addition, students may not have been able to sufficiently integrate the new process with their existing process knowledge, and this may have caused lower confidence.

c. The findings suggest that there was a gain in problem solving potential scores, which most likely occurred as a result of the intervention. The mean gain was 19.1%. This finding was expected and is consistent with an increase in problem solving process knowledge.

d. The findings suggest that a student’s MBTI type and the way they approach written problem solutions was not statistically different on either the pre-test or the post-test. This might imply that a student’s MBTI
influenced the way the student wrote the problem solution both prior to the intervention and afterwards.

e. The findings suggest that there is a relationship between a student’s desire to learn about problem solving prior to the intervention compared with after the intervention. The results show that four student’s who prior to the intervention indicated the desire to learn about problem solving no longer desired to learn about problem solving after the intervention. Also, all of the student’s who prior to the intervention did not want to learn about problem solving, still did not want to learn about problem solving after the intervention. It should be noted that prior to the intervention, seven out of the sixteen students did not want to learn about problem solving and after the intervention eleven out of sixteen did not want to learn about problem solving. The initial number of seven out of sixteen students who did not want to learn about problem solving is, in itself, a concern. A possible explanation is that the students who originally wanted to learn about problem solving felt they had learned all that they wanted to know and did not want to learn any more about problem solving, or possibly they decided they did not like problem solving. It is also possible that some students no longer desired to learn about problem solving because of all of the written activities associated with problem solving.

4. **Level 4 Conclusions**

a. The findings suggest that there is a relationship between a student’s MBTI preferences and their approach to problem solving. The researcher
calculated a MBTI type for each student based on their way they solved each problem. Then, this was compared, preference by preference, to their actual MBTI type. The percent matching exactly was calculated (0%, 25%, 50%, 75%, or 100%). These were totaled and averaged. The average for pre-test researcher calculated match to MBTI was 68.75% while the post-test researcher calculated match to MBTI type was 67.18%. The researcher then calculated the percent match between the pre and post test researcher calculated MBTI types and determined that those matched at 67.18%. This might indicate that it is possible to see their MBTI type in a student’s solution and that their MBTI type influences how they approach problems. A 67.18% match between pre and post researcher-calculated MBTI types indicates that students used the same approach both times 67.18% of the time, regardless of the intervention. The idea behind the intervention was that when they knew their MBTI type and knew an MBTI-type problem solving process, students would change the way they approached problems. However, 67.18% of the way they approached problems was the same for both pre and post researcher calculated MBTI types. In this study, it appears that problem solving approach was fairly stable, possibly due to insufficient time for the intervention to become effective or lack of reinforced activities. It is also possible that this relationship may be difficult to manipulate.
5. **Level 5 Conclusions**

   a. The findings suggest that there is a linear relationship between pre-test problem solving confidence and GPA. The data reveals that the higher the number for confidence, the higher the GPA. However, confidence scores are reversed; the higher the number, the lower the confidence. So, in fact, the relationship is such that the higher the confidence, the lower the GPA, or alternatively, the lower the confidence, the higher the GPA. Possible explanations for this is that students who have less confidence work harder and, hence, have higher GPA’s, or perhaps students who have a high GPA realize that there is much to learn and, hence, a more realistic confidence score. Another possibility is that those with low GPA’s have no awareness of the complexity involved in problem solving, so they are overly confident or just naïve. However, this relationship did not exist after the intervention. Instead, the intervention lowered the student’s overall confidence and there was no correlation or linear relationship between post-confidence scores and GPA. This suggests that students did realize the complexity of problem solving and lost confidence as a result; in some cases, such as with over-confidence, they gained a more realistic image of problem solving.

6. **Level 6 Conclusions**

   a. The findings suggest that there is a relationship between pre-test problem solving potential scores and interest in the problem being solved. However, the findings do not support this relationship on post-test results, therefore indicating that, as a result of the intervention, this relationship was
disrupted. An explanation for the pre-test findings is that if a student is interested in a problem, then he/she works harder towards solving it, hence the higher score in potential.

b. The findings suggest that there is a relationship between pre-test process scores and interest in the problem being solved; however, the findings do not support this relationship on post-test results, therefore indicating that as a result of the intervention, this relationship was disrupted. An explanation for the pre-test findings is that if students are interested in a problem, then they work harder towards solving it, and try to use more of a process (either consciously or unconsciously) to help them solve the problem hence the higher score in process.

c. The findings suggest that students, who on the pre-test indicated that they like to solve problems, have a lower score on pre-test problem solving potential than those who indicated that they do not like to solve problems. However, four out of the five who indicated that they do not like to solve problems also indicated that they are good at solving problems, even though they do not like to solve problems. This is consistent with their high score on problem solving potential, even though they do not like to solve problems. It is possible that even though some students do not like to solve problems, they are still good at solving problems, and in contrast, students who do like to solve problems may not always be good at solving problems.
d. The findings suggest that students who indicated on the pre-test that they like to solve problems have higher confidence than those who indicated that they do not like to solve problems. The difference in mean confidence was 8.2 points. An explanation is that problem solving confidence is related to liking to solve problems; if students have high confidence, maybe they like to solve problems, or maybe students like to solve problems and this gives them high confidence.

7. **Level 7 Conclusions**

a. The findings suggest that many students did not use the same process as they would teach. Further investigation revealed that students who used the same process as they would teach had lower confidence than those who did not use the same process as they would teach. This occurred on the post-test. The difference in mean confidence scores for the post-test was 12.86 points. A possible explanation is that students who are less confident are only able to focus on one process, while students who have higher confidence are able to focus on two different processes.
Discussion

Due to the small sample size, these findings cannot be generalized beyond this sample set. The following is a summary of the relationships that were found and possible explanations for the relationships:

1. Level 1: There appears to be a pre-test, linear relationship between confidence and problem solving potential, but it is a negative relationship in that as confidence increases, the problem solving potential score decreases. This was not expected. However, the intervention disrupted this relationship. Therefore, it appears that this relationship can be manipulated in the classroom. Several studies, including those done by Gelven and Steward (2001), MacPherson (1998), and Rigas and Elg (1997), have also found unexpected negative relationships between confidence and abilities of various problem solving elements. The findings of this study are consistent with the findings from these previous studies, and this suggests that the relationships between confidence and problem solving abilities/potentials may be consistently unexpected.

2. Level 1: There appears to be a linear relationship between knowledge of an MBTI-type problem solving process and problem solving potential, and it is a positive relationship in that as process scores increase, so do problem solving potential scores. This was expected. The intervention did not appear to dramatically change the relationship between the process and potential.

3. Level 1: There appears to be a relationship between psychological type and potential scores only for J and P MBTI preferences and only after the intervention.
It appears that J’s might have been more attracted to the intervention because it is structured and organized, as compared to P’s who do not prefer structure and organization. Since this relationship did not appear until after the intervention, it is highly likely that the intervention influenced this relationship. Therefore, it appears that this relationship can be manipulated in the classroom. Felder, Felder, and Dietz (2002) also found that J’s had better freshman grades than P’s, although P’s had higher SAT scores. They concluded that when compared to P’s, J’s may have more persistence and task orientation which helps them overcome the challenges of first year engineering courses. In Reuther and Meyer’s (2002) study, they found a difference in course grades between those of J and P.

4. Level 1: The findings did not identify any other relationships between a student’s MBTI type and their problem solving potential scores.

5. Level 2: The findings did not identify any relationship between confidence and knowledge of an MBTI-type problem solving process.

6. Level 2: There appears to be a possible relationship between psychological type and confidence scores for [E and I], but only after the intervention. It appears that E’s might have lower confidence since E’s generally do not prefer communicating in writing, and that was the medium used in the intervention. This suggests that confidence could possibly be manipulated in the classroom for E/I by this intervention.

7. Level 2: The findings did not identify any relationship between psychological type and knowledge of an MBTI-type problem solving process
8. Level 3: The intervention appears to have increased the problem solving potential scores on average as expected. Process scores, on the other hand, had a negative, linear relationship between pre-test and post-test. This may be due the complexity of integrating a new process within an existing process, or, alternatively, the ease of learning a process when a student already knows an existing process. Both the potential and process scores appear to be able to be manipulated in the classroom. In addition, the intervention also changed the confidence scores, lowering their mean significantly. Therefore, as a result of instruction, some students who were possibly overly confident became more aware of the extent of problem solving, and their confidence levels reflected their newly acquired realization. Therefore, confidence appears to be able to be manipulated in the classroom.

9. Level 3: The findings do not suggest that the intervention had any influence on changing a student’s problem solving approach. It is possible that psychological type is so engrained that it is difficult to change a student’s underlying approach to solving problems, and, thus, it remained stable in this study; another possible explanation is that longer time or more activities would be needed to manipulate this relationship.

10. Level 3: The intervention did appear to influence a student’s desire to learn about problem solving. It only influenced those who initially wanted to learn about problem solving and did not have any change on those who initially did not want to learn about problem solving. The reason for changing from wanting to learn about problem solving to not being interested in learning about problem solving is unknown. However, this change might be due to having learned enough, having
realized that they are no longer interested in learning about problem solving, having seen the type of work (written) and extent of work required, the pace of the intervention, or the method used in the intervention. Therefore, the desire to learn about problem solving can most likely be manipulated in the classroom.

11. Level 4: There appears to be a relationship between a student’s solution essay and their MBTI type. This appeared on both the pre-test and post-test solution. For the pre-test, almost 69% of a student’s actual MBTI type could be seen in his/her solution. For the post-test, it was 67%. Comparing the researcher-calculated MBTI type from the pre to the post solutions yielded a 67% exact match. This most likely means that a student’s MBTI does influence the way they approach written problems; even after an intervention, the same percentage can still be seen.

12. Level 5: The findings do not suggest any relationship between pre-test potential and GPA, pre-test motivation of the specific problem and GPA, pre-test interest and GPA, and pre-test process and GPA.

13. Level 5: The findings do not suggest any relationship between post-test potential and GPA, post-test motivation of the specific problem and GPA, post-test confidence and GPA, and post-test process and GPA.

14. Level 5: There appears to be a relationship between confidence and GPA; this relationship is negative and linear. This appears only on the pre-test. Since the post-test does not have the same findings, it appears that this relationship can be manipulated in the classroom. It is hypothesized that students who have little or no knowledge of problem solving feel overly confident until, perhaps, they are introduced via class instruction to the realities of problem solving.
15. Level 6: The findings do not suggest any relationship between pre-test potential and pre-test motivation of the specific problem, pre-test interest and pre-test motivation of the specific problem, pre-test confidence and pre-test motivation of the specific problem, pre-test confidence and pre-test interest, and pre-test process and pre-test motivation of the specific problem. It should be noted that motivation is motivation to solve the specific problem and interest is interest to solve the specific problem.

16. Level 6: The findings do not suggest any relationship between post-test potential and post-test motivation of the specific problem, post-test potential and interest, post-test confidence and post-test motivation of the specific problem, post-test confidence and post-test interest, post-test process and post-test motivation of the specific problem, and post-test process and post-test interest. It should be noted that motivation is motivation to solve the specific problem and interest is interest to solve the specific problem.

17. Level 6: There appears to be a relationship between problem solving potential scores and interest in the problem being solved on the pre-test. However, the findings did not suggest any relationship after the intervention. Therefore, it appears that this relationship can be manipulated in the classroom. It is logical to think that students who are interested in solving a problem would have better problem solving potential scores. Weith and Burns’ (2000) research on motivation and interest had related findings. Their results show a statistically significant correlation between “interest” and incremental problem solving scores (for those problems that there is a process to be followed). The findings in this study are
consistent with Weith and Burns’s research, except that in this study the relationship between “interest” in the specific problem and potential scores was not significant after the intervention (process) was taught, possibly indicating that students no longer thought the problems were of an incremental nature. However, it should be noted that this “interest” question was “interest” in solving the specific problem. Two other questions asked of students were, “Are you interested in learning about problem solving?” and “Do you like to solve problems?” The findings for each of these questions must also be examined when analyzing the findings about motivation and interest.

18. Level 6: There appears to be a relationship between problem solving process scores and interest in the problem being solved on the pre-test. However, the findings did not suggest any relationship after the intervention. Therefore, it appears that this relationship can be manipulated in the classroom. Students interested in solving a problem may consciously or unconsciously increase their effort to solve the problem, which may reveal using more techniques and, hence, more parts of a process to solve problems. Again referring to Weith and Burns’ (2000) research, their research references the research of Vollmeyer and Rheinberg in which “participants with higher motivation were more likely to use a systematic strategy for acquiring knowledge” (para. 4). The findings of this study might suggest that because the intervention was teaching a process to the students, then motivation or interest did not play a role in post-tests scores, since students, regardless of their motivation or interest, tried to use the process that was taught in the intervention. However, it should be noted that this “interest” question was
“interest” in solving the specific problem. Two other questions asked of students were, “Are you interested in learning about problem solving?” and “Do you like to solve problems?” The findings for each of these questions must also be examined when analyzing the findings about motivation and interest.

19. Level 6: There appears to be a relationship between students who like to solve problems and their scores on problem solving potential on the pre-test data. The data suggests that students who do not like to solve problems had a higher problem solving potential score than those who do like to solve problems. However, further data revealed that four of the five who indicated their dislike for solving problems also indicated that they were good at solving problems. Therefore, although a student indicates that he/she does not like to solve problems, this does not mean that he/she will have a good score on problem solving potential. Since this relationship does not appear on the post-test data, then it is most likely that this relationship can be manipulated in the classroom.

20. Level 6: There appears to be a relationship between pre-test confidence and students who indicate that they like to solve problems on the pre-test. This may be because students with high confidence feel that they can solve problems, or it may be that students like to solve problems and this gives them high confidence. This relationship was not found in the post-test data, indicating that the intervention most likely changed the relationship and that this relationship can be manipulated in the classroom.

21. Level 7: There appears to be a relationship between post test data for students who used the same process as they would teach and confidence. The findings indicate
that those who used the same process as they would teach had lower confidence than those who did not use the same process as they would teach. This result might be because students who are less confident are only using the one process, versus those who are more confident and are able to use two or more different processes.

22. Level 7: There does not appear to be any relationship between interest in learning about problem solving and potential scores, interest in learning about problem solving and process knowledge scores, interest in learning about problem solving and psychological type.

23. Level 7: There does not appear to be any relationship between liking to solve problems and knowledge of an MBTI-type problem solving process, or psychological type.

24. Level 7: There does not appear to be any relationship between using a process and problem solving potential, knowledge of an MBTI-type problem solving process, or psychological type.

25. Level 7: There does not appear to be any relationship between “using the same process as you would teach” and problem solving potential, knowledge of an MBTI-type problem solving process, or psychological type.
Relationships with Confidence

Table 19 shows the relationships found as a result of the research. A summary of the statistically significant findings is provided.

Table 19. Relationships with Problem Solving Confidence

<table>
<thead>
<tr>
<th>Confidence and</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>problem solving potential</td>
<td>Pretest 0.541 correlation p&lt;.05 (inverse relationship)</td>
</tr>
<tr>
<td>psychological type</td>
<td>Posttest E (low) I (high), p&lt;.05</td>
</tr>
<tr>
<td>GPA</td>
<td>Pretest 0.4986 correlation p&lt;.05 (inverse relationship)</td>
</tr>
<tr>
<td>desire to solve problems</td>
<td>Pretest like (high) dislike (low), p&lt;.05</td>
</tr>
<tr>
<td>using the same process would teach</td>
<td>Posttest yes (low) no (high), p&lt;.05</td>
</tr>
</tbody>
</table>

Relationships with Psychological Type

Table 20 shows the relationships found as a result of the research. A summary of the statistically significant findings is provided.

Table 20. Relationships with Problem Solving Psychological Type

<table>
<thead>
<tr>
<th>Psychological Type and</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>problem solving potential</td>
<td>Posttest J (high scores) P (low scores) p&lt;.05</td>
</tr>
<tr>
<td>confidence</td>
<td>Posttest E (low) I (high), p&lt;.05</td>
</tr>
<tr>
<td>problem solving approach</td>
<td>Pretest (69%) posttest(67%) match to MBTI</td>
</tr>
</tbody>
</table>
Relationships with Problem Solving Process Knowledge

Table 21 shows the relationships found as a result of the research. A summary of the statistically significant findings is provided.

Table 21. Relationships with Problem Solving Process Knowledge

<table>
<thead>
<tr>
<th>Process Knowledge and</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• problem solving potential</td>
<td>Pretest (0.5604) posttest (0.5252) correlation p&lt;.05</td>
</tr>
<tr>
<td>• interest in solving the specific problem</td>
<td>Pretest (0.7916) p&lt;.001</td>
</tr>
</tbody>
</table>

Relationships with Problem Solving Potential

Table 22 shows the relationships found as a result of the research. A summary of the statistically significant findings is provided.

Table 22. Relationships with Problem Solving Potential Type

<table>
<thead>
<tr>
<th>Potential and</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• psychological type</td>
<td>Posttest J (high scores) P (low scores) p&lt;.05</td>
</tr>
<tr>
<td>• confidence</td>
<td>Pretest 0.5405 correlation p&lt;.05(inverse relationship)</td>
</tr>
<tr>
<td>• problem solving process knowledge</td>
<td>Pretest (0.5604) posttest (0.5252) correlation p&lt;.05</td>
</tr>
<tr>
<td>• interest in solving the specific problem</td>
<td>Pretest (0.5740) correlation p&lt;.05</td>
</tr>
<tr>
<td>• liking to solve problems</td>
<td>Pretest yes (low scores), no (high scores) p&lt;.001</td>
</tr>
</tbody>
</table>
Discussion about Pre-Test Only Relationships Disrupted by Intervention

Table 23 shows the relationships that may have been disrupted as a result of the intervention, which might indicate that they can be manipulated in the classroom.

Table 23. Pre-Test Only Relationships Disrupted by Intervention

<table>
<thead>
<tr>
<th>Relationships Disrupted by the Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Potential and</td>
</tr>
<tr>
<td>a. Interest in the specific problem</td>
</tr>
<tr>
<td>b. Desire to solve problems</td>
</tr>
<tr>
<td>c. Confidence</td>
</tr>
<tr>
<td>2. Confidence and</td>
</tr>
<tr>
<td>a. Potential</td>
</tr>
<tr>
<td>b. Desire to solve problems</td>
</tr>
<tr>
<td>c. GPA</td>
</tr>
<tr>
<td>3. Process Knowledge and</td>
</tr>
<tr>
<td>a. Interest in the specific problem</td>
</tr>
</tbody>
</table>

Discussion about Post-Test Only Relationships Initiated by Intervention

The findings suggest that the intervention may be responsible for the relationships shown in Table 24. These relationships might be manipulated in the classroom.

Table 24. Post-Test Only Relationships Initiated by Intervention

<table>
<thead>
<tr>
<th>Relationships Initiated by Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Potential and</td>
</tr>
<tr>
<td>a. Psychological type (J, P)</td>
</tr>
<tr>
<td>2. Confidence and</td>
</tr>
<tr>
<td>a. Psychological type (E, I)</td>
</tr>
<tr>
<td>b. Using same process as would teach</td>
</tr>
<tr>
<td>3. Psychological type and</td>
</tr>
<tr>
<td>a. Potential</td>
</tr>
<tr>
<td>b. Confidence</td>
</tr>
</tbody>
</table>
Discussion about Relationships that Remained Constant

The findings suggest that the following relationships were noted both prior to and after the intervention and this might infer that these relationships are not easily manipulated.

1. psychological type and problem solving approach
2. potential and process knowledge

Discussion – Considerations

The following are considerations for some of the findings. Although the findings cannot be generalized, there are some interesting relationships to note.

1. Students with lower confidence had higher potential scores and those with higher confidence had lower potential scores. This might infer that students with less confidence work harder on solving problems or students with higher confidence do not work as much on solving a problem.

2. As process scores increased, it was noted that potential scores increased, which might infer that process knowledge contributes to problem solving potential because potential includes the application of what a student knows in process knowledge. Table 25 shows how the potential factors might map to their counterpart in process knowledge. Therefore, potential scores reflect a student’s ability to apply their problem solving process knowledge. Theoretically, a problem solving process should encompass everything that the potential factors identify as necessary to achieve problem solving success. A process should, therefore, be as
complete as possible, which would allow for the removal of unnecessary sub-processes, if need be.

<table>
<thead>
<tr>
<th>Potential factor</th>
<th>MBTI – type process knowledge equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ability to obtain new knowledge</td>
<td>S: Facts</td>
</tr>
<tr>
<td>Ability to seek expert knowledge</td>
<td>E: External World</td>
</tr>
<tr>
<td>Ability to identify/define problem</td>
<td>S: Facts: Problem</td>
</tr>
<tr>
<td>Ability to generate solutions</td>
<td>N: Possible Solutions, Options</td>
</tr>
<tr>
<td>Ability to analyze and Evaluate Options</td>
<td>T, F: Consequences and Human Impacts</td>
</tr>
<tr>
<td>Ability to justify proposed solution</td>
<td>S, T, F</td>
</tr>
<tr>
<td>Ability to professional communicate solution</td>
<td>J,P: Judgment / Perception</td>
</tr>
<tr>
<td>Technical knowledge</td>
<td>I: Internal World</td>
</tr>
<tr>
<td>Ability to apply problem solving process</td>
<td>Apply MBTI process</td>
</tr>
</tbody>
</table>

3. Psychological type may play a role in how a student approaches and solves a problem. Specifically, J and P were found to have an influence on potential scores after the students were taught the MBTI-type process. A process might be more attractive to J’s than to P’s because J’s like more structure and organization and a process contains both features. Psychological type also was found to have differences noted between [E and I] on confidence levels after the intervention. This may infer that once a student knows his/her MBTI type and knows what it means, their confidence is altered by their knowledge of what strengths and weaknesses their MBTI indicates. Psychological type also appears to influence how a student approaches and solves problems and seems to be stable and difficult.
to manipulate, even after the intervention explained each MBTI type strengths and weaknesses and how each MBTI type should also focus on the opposing MBTI preference.

4. Learning a new problem solving process when a student already uses a problem solving process or knows a problem solving process appears to negatively influence their process knowledge score. This may be because it is difficult to integrate a new process with an existing process and change a student’s thinking using this type of intervention and / or in such short duration as this intervention. However, if a student does not use or know a formal problem solving process and learns about a new problem solving process, it appears that this increases his/her process knowledge score.

5. Confidence scores decreased on average after the intervention (which taught about an extensive problem solving process, among other problem solving-related ideas). It might be possible to infer that students who do not know much about problem solving may exhibit a false, positive overconfidence, which is altered by the intervention. Confidence scores also have a negative correlation with GPA, inferring that those with higher GPA’s have a lower confidence, or rather those with low GPA’s have higher confidence. A possible explanation is that students with low GPA’s (high confidence) were unaware of what problem solving entailed, and those with high GPAs (low confidence) were aware of the complexity of problem solving. Either way, after the intervention, there was no longer any linear relationship.
6. The desire to learn problem solving was altered by the intervention, possibly due to the approach of the intervention. It is also possible that once students learn what they think they need, then they are no longer interested in learning more. None of the students who were not interested in learning about problem solving became interested in learning about problem solving.

7. Although students may indicate that they like to solve problems or do not like to solve problems, this does not accurately reflect their potential scores. Those who do not like to solve problems also indicated (80%) that they are good at solving problems. Findings suggest that those who do not like to solve problems had higher potential scores than those who like to solve problems. In contrast, even if a student indicates that they like to solve problems, it does not reflect their problem solving potential. Also indicated in the study was that students who like to solve problems also had higher confidence levels. An explanation is that students whose confidence is high like to solve problems.

8. Study results also suggest that many students can list a process to teach, but when asked if they used a process to come up with their solution, pre-test data revealed that most did not. Post-test data revealed that those who indicated that they used the same process as they would teach had lower confidence than those who listed two different processes (one that they use and one that they would teach). A possible explanation is that students who are less confident are only able to handle one process, while those with higher confidence can handle more than one process.
Please note the order in which the students completed the activities. Some results may be influenced by the order in which students completed the activities. An effort was made to minimize the impact on the potential scores, but this may have affected the other results.

Figure 1 shows the relationships found as a result of the research. A plus sign (+) indicates that there is a normal relationship; REV indicates a reverse relationship.
Figure 1. Relationships Found
Discussion - Summary

This research studied the relationships between the factors of problem solving potential (nine factors of abilities – to obtain new knowledge, to seek expert knowledge, to apply a problem solving process, to identify/define the problem, to generate potential options, to analyze and evaluate potential options, to justify the proposed solution, to professionally communicate the solution, and technical knowledge), motivation (motivation to solve the specific problem, interest in learning about problem solving, and desire to solve problems), problem acceptance and concern (interest in solving the problem), confidence, knowledge of a problem solving process (including “using a process” and “using the same process as would teach”), intellectual abilities and potential (GPA), and psychological type (including problem solving approach). The findings suggest that there are many relationships between these factors of problem solving. Because problem solving can be viewed as a complex system, understanding its sub-systems and their inter-relationships is vital to understanding the problem solving system.

It should be noted that due to the use of the developmental perspective of teaching and the belief that students must uncover prior knowledge through reflection, the activities for this research were most likely very laborious to students who were not expecting this type of activities. This might account for some of the findings. The researcher acknowledges and appreciates the efforts of all students who participated.
Recommendations for Practice

Although the results of the research cannot be generalized, the following are some ideas that educators might consider when teaching problem solving:

1. Educators should be alert to the possibility that when teaching a new problem solving process, students who already have knowledge of another process may not show an immediate gain in knowing the new process and may need several activities over time to allow for this integration to occur. This is perhaps due to the complexity of integrating new processes with old processes. However, students who do not possess existing process knowledge are likely to show a significant increase in their process knowledge immediately.

2. Educators should be aware of the possibility that when teaching a new process, students’ confidence levels may show a decrease immediately following instruction. This might be due to a variety of reasons, including having to integrate new processes with old processes, students’ initial inexperience with problem solving, or students’ initial over-confidence. The largest decreases in confidence are likely to occur in students whose confidence levels were high initially.

3. Educators should be aware that students with high confidence may have lower problem solving scores, in contrast to students with lower confidence who might have higher problem solving scores. Students with low confidence may work harder or students with high confidence may not work as hard to solve problems. Also, look for students with low GPA’s who might be overly confident because they are naïve.
4. Educators who are interested in improving a student’s problem solving skills might teach a problem solving process, which is likely to increase his/her problem solving skills.

5. Educators should be aware of the possibility that a student’s MBTI preference of J or P may influence his/her problem solving skills during and after students are taught a problem solving process. This might be due to the fact that a problem solving process is a structured method, and J’s prefer structure, while P’s prefer more freedom. Therefore, educators trying to teach problem solving processes might notice a difference in students who will learn the process versus those who are not fond of processes. This difference may account for differences in problem solving skills where processes are important, specifically if students are expected to use the new process.

6. Educators should be aware that some MBTI preferences, such as E, might have lower confidence levels for problem solving than the opposing preferences of I after they are taught an MBTI-type problem solving process and if they know their MBTI type. Knowing their MBTI type and a related problem solving process might influence their feelings about their ability to solve problems.

7. Educators should be aware that even though some students like to solve problems, they may not be good at solving problems, while other students who do not like to solve problems are good at solving problems. A student’s likes and dislikes for problem solving may not accurately reflect his/her abilities.

8. Educators should be aware that a student who is interested in solving the specific problem may be more likely to use more parts of a process, either consciously or
unconsciously, than those who are not interested in solving a specific problem. In addition, students who are interested in solving a specific problem are likely to have higher skills scores that those who are not interested.

9. Educators should notice that students may be able to list a problem solving process that they would teach to others, but they may not be able to use that same process or another process. After solving a problem, students most likely will not be able to state what process they used unless they were made aware before they solved the problem that they should be using a process. Also, they should have most likely used the process at least once before.

10. Educators should be aware that during group problem solving activities students working in groups may experience differences of opinion on the approach to solving problems because of each student’s MBTI preferences. Students should be made aware that different people approach problem solving differently and they need to learn to respect and listen to the opinion of others whose approach is different from theirs. Students should be made aware that other students have strengths in solving problems that they may or may not possess and that it is beneficial to seek the advice of others while solving problems.

11. Educators should realize that a student’s desire to learn about problem solving might be negatively affected by the method used to teach problem solving.
Recommendations for Further Study Based on Findings

The following are recommendations for further study that are related to the findings of this study:

1. Future studies should investigate further the relationship between confidence and potential, specifically to determine if confidence levels are negatively correlated with potential levels.

2. Future studies should investigate the relationship between interest in solving a problem and both process knowledge and potential to determine if interest has a positive correlation.

3. Future studies should investigate the relationship between knowledge of a process and potential scores to determine if knowing a process will increase potential scores.

4. Future studies should investigate the relationships of if and why students do not use the same process they would teach and whether or not there is any relationship to confidence levels in determining how and why students learn and use processes.

5. Future studies should investigate if a student’s approach to finding a solution has any effect on his/her potential scores to determine if a student’s approach should be modified in order for him/her to be a better problem solver.

6. Future studies should investigate if a student’s MBTI preference, specifically the J versus P preference, has any effect on potential scores before and after a process has been taught to determine if J’s have better scores than P’s because of the organization of processes.
7. Future studies should investigate if the MBTI-type problem solving process is comprehensive enough for technological problem solving or if there is a better process to act as a framework for educators.

8. Future studies should investigate if students who like to solve problems have higher potential scores than those who do not like to solve problems to determine if liking to solve problems accurately reflects skills.

9. Future studies should investigate if GPA is negatively correlated with confidence levels to understand if this relationship exists and how it might influence success in learning about problem solving.

10. Future studies should investigate why students do not want to learn about problem solving.

11. Future studies should investigate the preferences of [S and N] and [E and I] to determine if there is any difference in problem solving confidence levels.

12. Future studies might incorporate other factors that might have not been identified in this study, such as regional, cultural, or gender differences in the approach to solving a problem.

13. Future studies should investigate the relationship of pre-test process scores to post-test process scores to understand if there is a negative linear relationship and if so, why.

14. Future studies should investigate the relationship of pre-test confidence scores to post-test confidence scores to understand if there is loss of confidence when learning a complex process and if so, why.
Recommendations for Further Study Based on Limitations/Delimitations

The following recommendations are based on the limitations and delimitations listed in Chapter 1:

1. Future studies could be expanded by conducting the research in a variety of technology education classrooms at a variety of universities/colleges. This would increase the ability to generalize the findings.

2. Future studies could be conducted as part of an actual class and integrated to allow for shorter time per day but for a longer timeframe.

3. Future studies should add additional intervention activities over a longer length of time to determine if more intervention activities would reveal more relationships or if more factors could be manipulated.

4. While it is the goal of all research to have random samples, it is difficult in practice to achieve. However, conducting the study in other disciplines’ classrooms to compare the results to technology education would be beneficial to understanding the technology education-specific findings, as well as in generalizing the findings.

5. Future studies should be conducted on students who are not aware that the intervention is for research purposes. Therefore, if the intervention is part of a class and given by the actual instructor, the findings may change.

6. Future studies should include the factor of knowledge and ability to apply heuristics in its investigation. Even one factor missing from the study might compromise the results.
7. Future studies should have a committee approve the instrumentations and scoring methods for problem solving potential, problem solving process knowledge, and problem solving approach. Reliability and validity for the instruments need to be conducted. Future studies would benefit from having a committee score each student’s solution (measuring potential, process, and problem solving approach).

8. Future studies should make the instructions for the actual problem more specific; for example making students take a specific role when solving a problem may be helpful, although this might influence the findings.

9. Future studies might check if the findings can predict the success of a student in a specific class.

10. Future studies, if integrated into the classroom activities, might allow students to select a problem (in which they might have an influence), solve the problem, and then carry out the solution to see how the results compare with what they anticipated would happen in their analysis.

11. Future studies might use other methods for data collection such as group work, observation, and interviews to gather information from individuals who are not intrigued by written work.

12. Future studies should create better methods to measure each of the factors and measure each factor over longer periods of time and at different intervals, as in a time series study.
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Appendix A

Real World Problem Assignment
You have been informed by your manager that you are going to determine the solution to the communications technology problem given to you. You must make every effort to provide the best solution to your management. Your management will present your solution to an organization that will decide whether or not to accept your company’s proposed solution among many proposed solutions being submitted by other companies. You must assume that both your manager and the reviewing organization do not have any knowledge of the problem; therefore your solution must be complete, justified, organized, and presentable to the organization on one sheet of paper. It can contain drawings and sketches as well as words. It should provide a convincing and professional solution to the problem. You must be as complete and detailed as time allows. A separate sheet can be used to take notes and organize your thoughts prior to completing the final solution sheet. You may use any resource including consulting with others and the Internet as long as you note who you consulted with. You will have **80 minutes** in class to complete the assignment. Please hand in all written notes even if they are not organized or well-written. Include all doodles and sketches as well.

Please **hand in (1) one sheet with the complete solution justified, organized, and presentable** to the judging organization and **(2) all of the draft work as well.**
You have been informed by your manager that you are going to determine the solution to the communications technology problem given to you. You must make every effort to provide the best solution to your management. Your management will present your solution to an organization that will decide whether or not to accept your company’s proposed solution among many proposed solutions being submitted by other companies. You must assume that both your manager and the reviewing organization do not have any knowledge of the problem; therefore your solution must be complete, justified, organized, and presentable to the organization on one sheet of paper. It can contain drawings and sketches as well as words. It should provide a convincing and professional solution to the problem. You must be as complete and detailed as time allows. A separate sheet can be used to take notes and organize your thoughts prior to completing the final solution sheet. You may use any resource including consulting with others and the Internet as long as you note who you consulted with. You will have 60 minutes in class to complete the assignment. Please hand in all written notes even if they are not organized or well-written. Include all doodles and sketches as well.

Please hand in (1) one sheet with the complete solution justified, organized, and presentable to the judging organization and (2) all of the draft work as well.

You might take the position of an employee of one of the following: Korean phone maker Samsung Electronics, Verizon Wireless, Microsoft, Bellsouth ISP, the US Military, a health club, a hospital, a school, the court system, a government agency, a store, or any other position you can imagine that could involve a camera phone. Your problem will be dependent upon which position you assume.
Appendix B

Problem Solving Potential Scoring
Appendix B – Problem Solving Potential Scoring

Pre/Post Problem     Code __ Number __ Potential Ability Score ___ / 40 = { ___%}

1. __Ability to identify problem
   __The problem is defined
   __Why it is a problem is mentioned
   __Who does the problem affect is mentioned
   __Whose problem is it is mentioned
   __Who should fix the problem is mentioned
   __Goal of solving the problem is mentioned

2. __Ability to obtain new knowledge
   __1 fact listed about problem
   __1 more fact listed about problem

3. __Ability to generate potential solutions
   __A solution is provided
   __Solution solves problem
   __Solution is practical
   __Solution could be implemented
   __Alternative solution is mentioned

4. __Analyze solutions - consequences
   __Causes of the problem are given
   __Pros / cons of the proposed solution are given
   __Assumptions of the proposed solution are given
   __Limitations of the proposed solution are given
   __Costs of the solution are mentioned
   __Alternative solutions are analyzed

5. __Analyze solutions – human impacts
   __Feelings or opinions of self are mentioned
   __Feelings or opinions of others are mentioned
   __What is best for all people are considered
   __The effect on people is mentioned

6. __Ability to seek expert knowledge
   __References experts and their ideas
   __Quotes sources
   __Discusses environmental events related to problem

7. __Technical knowledge
   __Words like “think” and “believe” are used
   __Uses related ideas that impact the problem

8. __Ability to apply problem solving process
   __Problem is given
   __Solution is given
   __Solution evaluation is given
   __All aspects are considered (SNTF)

9. __Ability to justify proposed solution
   __Solution has facts
   __Solution has consequences
   __Solution has impacts
   __All details support solution

10. __Ability to professionally communicate solution
    __Solution is organized
    __Solution is presentable
    __Solution is meaningful
    __Solution is complete

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Appendix C

Problem Solving Process Knowledge Form
Appendix C – Problem Solving Process Knowledge Form

Directions: You may use any resource to answer the following questions:

1. You have just evaluated a real world problem. Please identify if you used a process in order to get your solution. You may draw the process or write it out. If you did not use any specific process or method, please indicate that as your answer. If you used sub-processes, heuristics, or algorithms for any part of the problem or anything that you think is an important or interesting technique, please indicate what you used. Please be as specific as possible. (7 minutes).

2. How long have you known this process?

3. Where did you learn this process from?

4. You are a high school technology education teacher. You are teaching Introduction to Technology Education. You must teach students a process that they can use so that they can solve a real world problem. You have one class period which is 60 minutes to teach the process. Please create an outline of what you would teach and why. You can also state how you might teach the students if you have extra time. Please be as specific as possible. (7 minutes).
Appendix D

Problem Solving Process Scoring
Appendix D – Problem Solving Process Scoring**

Pre/Post Process Knowledge Code __ Number __ Process Knowledge Score ___ / 22 = { ___% }

1. __ Facts
   __ Problem
   __ Facts

2. __ Possible solutions, Options
   __ Solution, options, or possibilities
   __ Creation of more than one solution

3. __ Consequences
   __ Causes
   __ Analysis, consequences, pros/cons
   __ Limitations, Assumptions
   __ Selecting best options
   __ Costs

4. __ Human Impacts
   __ Feelings or opinions of self
   __ Feelings or opinions of others
   __ What is best for all people
   __ The effect on people

5. __ External World
   __ Seek information from others
   __ Environmental events related to problem

6. __ Internal World
   __ Think about the problem
   __ Ideas that impact the problem

7. __ Judgment
   __ Organization, plans or schedules
   __ Time

8. __ Perception
   __ Collect as much information as possible
   __ Look at all aspects of the problem
   __ Look for new information

**derived from McCaulley (1987)

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Appendix E

Problem Solving Motivation and Interest Form
Appendix E – Problem Solving Motivation and Interest Form

1. How confident are you that the solution you just provided to the real world technology problem will satisfactorily solve the problem given the time you were allowed?

<table>
<thead>
<tr>
<th>not confident</th>
<th>somewhat confident</th>
<th>confident</th>
<th>very confident</th>
<th>extremely confident</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

2. How confident are you that the solution you just provided to the real world technology problem is the best solution available for that particular problem?

<table>
<thead>
<tr>
<th>not confident</th>
<th>somewhat confident</th>
<th>confident</th>
<th>very confident</th>
<th>extremely confident</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
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<td>5</td>
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</tbody>
</table>

3. How confident are you that you have considered all the necessary factors when you solved the real world technology problem?

<table>
<thead>
<tr>
<th>not confident</th>
<th>somewhat confident</th>
<th>confident</th>
<th>very confident</th>
<th>extremely confident</th>
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<td>1</td>
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<td>5</td>
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</table>

4. How interesting was this real world problem to you?

<table>
<thead>
<tr>
<th>not interesting</th>
<th>somewhat interesting</th>
<th>interesting</th>
<th>very interesting</th>
<th>extremely interesting</th>
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</table>

5. How motivated were you to solve this real world problem at this time?

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<tr>
<th>not motivated</th>
<th>somewhat motivated</th>
<th>motivated</th>
<th>very motivated</th>
<th>extremely motivated</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
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</table>

6. When solving problems, is it **more** important for you to: select one of the following
   - a) gather all of the facts
   - b) come up with many possible solutions

7. When solving problems, is it **more** important for you to: select one of the following
   - a) list all of the logical consequences
   - b) consider what is best for everyone involved

8. When solving problems, is it **more** important for you to: select one of the following
   - a) talk with others about the problem
   - b) think alone about the problem

9. When solving problems, is it **more** important for you to: select one of the following
   - a) make a decision as soon as possible
   - b) delay making a decision until the last possible minute
Appendix F

Demographics Into/Final Form
Appendix F – Survey of Demographics/Intro/Final Information

Pre-test

<table>
<thead>
<tr>
<th>Question</th>
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<th>No</th>
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<td>1. Name</td>
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<tr>
<td>2. Date</td>
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<tr>
<td>3. Gender</td>
<td>Male</td>
<td>Female</td>
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<tr>
<td>4. Age</td>
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<tr>
<td>5. Major</td>
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<tr>
<td>6. GPA</td>
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<tr>
<td>7. Freshman</td>
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<tr>
<td>8. Have you had a class in problem solving?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>9. Are you interested in learning about problem solving?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>10. Do you like to solve problems?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>11. Are you good at solving problems?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>12. Do you use a process/model for solving problems?</td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>If yes, please briefly describe/draw the process</td>
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<tr>
<td>13. Do you know your personality type?</td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>If yes, please describe test taken and result:</td>
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</table>
Post-test

1. Name
2. GPA

3. Are you interested in learning about problem solving?  Yes  No
4. Do you like to solve problems?  Yes  No
5. Are you good at solving problems?  Yes  No

6. What did you learn about technological problem solving?

7. Do you think you will use the MBTI problem solving process or any part of it to solve new problems? Why or why not?

8. Was this information useful in any way? Yes or No. Please explain.

9. What were the strengths of the workshop?

10. What were the weaknesses of the workshop?

11. What could be done to improve the workshop?

12. What is 1 thing you learned in this workshop

13. Please provide any other comments / suggestions below:

Thank you for participating in this workshop.
Appendix G

Problem Solving Approach Scoring Sheet
Appendix G - Problem Solving Approach Scoring sheet**

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**Sensing**

- Problem is what happened
- Asks what or how
- Short term solution
- No solution
- Traditional
- Step by step
- Details first
- Evidence
- What is said

**Intuitive**

- Problem is generalized
- New solution
- >1 solution
- Asks why
- Relationships
- Broad issues / general
- Theoretical
- Possibilities
- No details
- Future oriented

**Thinking**

- Define problem gather evidence
- Assumptions, limits
- Brief / concise
- Costs mentioned
- Logical but impossible
- Think / believe
- Critical
- Pros / cons
- Effects
- Causes

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**Derived from Introduction to Type in Organizations Hirsh/Kummerow (1998) and MBTI Manual – Myers (2003) et al.**
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<td>Time to be open</td>
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**Derived from Introduction to Type in Organizations Hirsh/Kummerow (1998) and MBTI Manual – Myers (2003) et al.**
Appendix H

Problem Solving Approach Matching Sheet
## Appendix H - Problem Solving Approach Matching Sheet

<table>
<thead>
<tr>
<th>code</th>
<th>Actual MBTI</th>
<th>Calculated MBTI</th>
<th>Matched Percent Exact Match</th>
<th>Total % that can be Seen in Problem Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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</tbody>
</table>

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Appendix I

The MBTI Problem Solving Process
Appendix I – The MBTI-Problem Solving Process

The following is the MBTI process as derived from McCaulley (1987) and Lawrence (1993).

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Appendix J

Levels of Possible Relationships
Appendix J – Levels of Possible Relationships

**Level 1**

- Psychological Type
  - MBTI
  - S,N,T,F,E,I,J,P

- Problem Solving Potential
  - Solution Statement: 0%-100%

- Problem Solving Process Knowledge
  - Prob. Solv. Proc. Questions: 0%-100%

- Confidence
  - PSI
  - 1-66: Low
  - 11-16: High
  - 66 - 100: Low
Appendix K

Relationships Found
Appendix K – Relationships Found

Level 1 – Relationships Found

Psychological Type
MBTI
S.N.T.F.E.I.J.P

Problem Solving Potential
Solution Statements
0%-100%

Problem Solving Process Knowledge
0%-100%

Confidence
PSI
11-66
11-High
66-Low
Level 4 – Relationships Found

Psychological Type
MBTI
S,N,T,F,E,I,J,P

Problem Solving Approach
Solution Statement
S, N, T, F, E, I, J, P

PRE/POST
Level 5 – Relationships Found

Psychological Type
MBTI
S,N,T,F,E,I,J,P

Problem Solving Potential
Solution Statement
0-100%

Problem Solving Process Knowledge
0%-100%

Confidence
PSI
11-66
11 - High
66 - Low
Level 6 – Relationships Found

Psychological Type
MBTI
S,N,T,F,E,I,J,P

Interest 1-5

Problem Solving Potential
Solution Statement
0-100%

Problem Solving Process Knowledge
0%-100%

Desire to solve problems Y/N

Confidence
PSI
11-66
11 - High
66 - Low

Motivation 1-5
Level 7 – Relationships Found

Psychological Type
- MBTI
- S,N,T,F,E,I,J,P

Problem Solving Potential
Solution Statement
0-100%

Using Same Process as would Teach Y/N

Problem Solving Process Knowledge
  0%-100%

Confidence
- PSI
  11-66
  11 - High
  66 - Low

POST
Psychological Type

Problem Solving Potential
Solution Statement
0-100%

Confidence
PSI
11-66
11 - High
66 - Low

Psychological Type
MBTI
S,N,T,F,E,I,J,P

Problem Solving Approach
Solution Statement %

PRE/POST

J/P POST

E/I POST
PRE Relationships

Problem Solving Approach
Solution Statement
%

Psychological Type
MBTI
S,N,T,F,E,I,J,P

Problem Solving Potential
Solution Statement
0-100%

Interest
1-5

Problem Solving Process Knowledge
0%-100%

Confidence
PSI
11-66
11 - High
66 - Low

GPA
0.0-4.0

Desire to solve problems
Y/N
Appendix L

Student’s Answers to Questions
Appendix L – Student’s Answers to Questions

Table 26. Results. What is the biggest societal problem affecting the U.S.?

<table>
<thead>
<tr>
<th>What is the biggest societal problem affecting the U.S.?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poverty</td>
</tr>
<tr>
<td>Hunger in the US. Yet foreign aid more looked at.</td>
</tr>
<tr>
<td>Education</td>
</tr>
<tr>
<td>US Liberals</td>
</tr>
<tr>
<td>Materialism</td>
</tr>
<tr>
<td>Oversensitivity</td>
</tr>
<tr>
<td>Ignorance and Arrogance</td>
</tr>
<tr>
<td>Bush – healthcare, war, and economy</td>
</tr>
<tr>
<td>People failing to take responsibility for their actions</td>
</tr>
<tr>
<td>Parenting – the lack of</td>
</tr>
<tr>
<td>Ignorance and apathy</td>
</tr>
<tr>
<td>Corruption in the government</td>
</tr>
<tr>
<td>Too much political correctness</td>
</tr>
<tr>
<td>Weak, lazy people</td>
</tr>
<tr>
<td>Nuclear proliferation</td>
</tr>
<tr>
<td>The rich are getting richer, the poor are getting poorer</td>
</tr>
</tbody>
</table>

Table 27. Results. What is the biggest world problem?

<table>
<thead>
<tr>
<th>What is the biggest world problem?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hunger</td>
</tr>
<tr>
<td>Fighting → world peace</td>
</tr>
<tr>
<td>Poverty</td>
</tr>
<tr>
<td>Overpopulation</td>
</tr>
<tr>
<td>Overpopulation in poor countries</td>
</tr>
<tr>
<td>Poverty and Hunger</td>
</tr>
<tr>
<td>Discrimination</td>
</tr>
<tr>
<td>UN</td>
</tr>
<tr>
<td>Consuming the earth</td>
</tr>
<tr>
<td>Hate</td>
</tr>
<tr>
<td>The descent into socialism</td>
</tr>
<tr>
<td>Poverty from overpopulation and lack of education</td>
</tr>
</tbody>
</table>
Table 28. Results. What communication technology problem is the most interesting to you?

<table>
<thead>
<tr>
<th>What communication technology problem is the most interesting to you?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computers – New and out of date quickly</td>
</tr>
<tr>
<td>Why does Alltel drop my calls / static on the line</td>
</tr>
<tr>
<td>Media makes mountains out of molehill</td>
</tr>
<tr>
<td>News media used as propaganda</td>
</tr>
<tr>
<td>Why my cell phone doesn’t work at my house</td>
</tr>
<tr>
<td>FCC regulations</td>
</tr>
<tr>
<td>Camera phones and privacy</td>
</tr>
<tr>
<td>How to control the content on the internet – safe for everyone and non censor</td>
</tr>
<tr>
<td>The misuse of the press for political gain</td>
</tr>
<tr>
<td>Digital privacy</td>
</tr>
<tr>
<td>Ugly cell phone towers</td>
</tr>
<tr>
<td>Email viruses</td>
</tr>
<tr>
<td>Illegal copying of movies and music</td>
</tr>
<tr>
<td>How well people can get in touch with people</td>
</tr>
<tr>
<td>How communication technology is invading</td>
</tr>
<tr>
<td>Privacy</td>
</tr>
<tr>
<td>Mass distribution of biased news</td>
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</table>

Table 29. Results. What problem (from any discipline) concerns and/or interests you the most?

<table>
<thead>
<tr>
<th>What problem (from any discipline) concerns and/or interests you the most?</th>
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</thead>
<tbody>
<tr>
<td>Overpopulation in orphanages</td>
</tr>
<tr>
<td>Trash</td>
</tr>
<tr>
<td>Substandard housing</td>
</tr>
<tr>
<td>Liberal teachers passing their feelings to students</td>
</tr>
<tr>
<td>Drivetrain on my bicycle</td>
</tr>
<tr>
<td>Pollution / hybrid cars</td>
</tr>
<tr>
<td>The lack of parenting</td>
</tr>
<tr>
<td>Politicians with power</td>
</tr>
<tr>
<td>Lack of professionalism around universities</td>
</tr>
<tr>
<td>Too much dependence on High Technology</td>
</tr>
<tr>
<td>Terrorism</td>
</tr>
<tr>
<td>Spread of Islam</td>
</tr>
<tr>
<td>People getting along in America</td>
</tr>
<tr>
<td>People</td>
</tr>
<tr>
<td>Problem with a need for cars that run off a new form of energy in the future</td>
</tr>
<tr>
<td>Overpopulation and pollution leading to little or no National Forest for recreation</td>
</tr>
</tbody>
</table>
Appendix M

IRB Approval Form
Appendix M - IRB Exemption Approval

North Carolina State University is a land-grant university and a constituent institution of The University of North Carolina

Office of Research and Graduate Studies

Sponsored Programs and Regulatory Compliance

Campus Box 7514
1 Leazar Hall
Raleigh, NC 27695-7514

919.515.7200
919.515.7721 (fax)

From: Debra A. Paxton, Regulatory Compliance Administrator
North Carolina State University Institutional Review Board
Date: January 7, 2005
Project Title: The Influence of Confidence, Psychological Type, and Knowledge of an MBTI-Type Problem Solving Process on Technological Problem Solving Abilities in Technology Education
IRB#: 001-05-1

Dear Ms. Burt:

The research proposal named above has received administrative review and has been approved as exempt from the policy as outlined in the Code of Federal Regulations (Exemption: 46.101.b.1). Provided that the only participation of the subjects is as described in the proposal narrative, this project is exempt from further review.

NOTE:

1. This committee complies with requirements found in Title 45 part 46 of The Code of Federal Regulations.

For NCSU projects, the Assurance Number is: FWA00003429; the IRB Number is: IRB00000330

2. Review de novo of this proposal is necessary if any significant alterations/additions are made.

Please provide your faculty sponsor with a copy of this letter. Thank you.

Sincerely,

Debra Paxton
NCSU IRB