Abstract

KATSIOLoudis, PETROS JOSEPH. Identification of Quality Indicators of Visual-based Learning Material in Technology Education Programs for Grades 7-12. (Under the direction of Dr. Aaron Clark.)

The purpose of this study was to identify the quality indicators of visual-based learning material in technology education for grades 7-12. A three-round modified Delphi method was used to answer the following research questions: RQ1: What indicators should quality visual-based learning material in technology education have to be effective and efficient in transmitting information for grades 7-12? RQ2: What are the indicators of the learner’s characteristics that impact the selection of visual-based learning material in technology education for grades 7-12? The quality indicators were determined by consensus reached by a panel of 21 educational experts randomly selected from participants in two NSF funded projects that piloted and field-tested visual learning material in technology education courses. The two funded projects were VisTE and TECH-Know. In the first round, the panel was provided with examples of quality indicators. The example indicators in the first round instrument derived from the literature review. The first round of the modified Delphi method used an open-ended questionnaire format in which the experts were asked to keep, reject, modify or add a new characteristic. The responses generated by the first round contributed to the development of the Round II instrument. In the second round, panelists were asked to value and rank from lowest to highest the items identified on Round I on a 5 point Likert-scale. In Round III the experts’ panel was asked to accept or reject the quality indicators derived by the second round. Based on an analysis of data collected on Rounds I, II and III conclusions were drawn and 18 quality indicators were found.
IDENTIFICATION OF QUALITY INDICATORS OF VISUAL-BASED LEARNING MATERIAL IN TECHNOLOGY EDUCATION PROGRAMS FOR GRADES 7-12

by

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Dedication

This dissertation is dedicated to my father Joseph, my mother Joanna and my two sisters Antonia and Irene. Also to my friends: Michael and Julia Kritiotis, Jim and Cathy Gregorakis. To each one I am grateful for your help and support.
Biography

Petros Joseph Katsioloudis was born in Nicosia, Cyprus. He is one of the three children of Joseph and Joanna Katsioloudi. Joseph is a technology education teacher, and Joanna is an accountant for Cyprus Airways.

Petros received a Bachelor of Science and a Master of Education from California University of Pennsylvania. His undergraduate degree is in Science and Technology and his master’s degree is in Technology Education. Petros also received a Gunsmith certificate of trade from the Pennsylvania Gunsmith School.

Outside his academic activities Petros hobbies include spear gun fishing, scuba diving, hunting and part-time gunsmithing.
Acknowledgments

The researcher would like to express his appreciation to the faculty members at North Carolina State University for assisting him during his educational pursuit: Dr. Aaron Clark, Dr. V. William DeLuca, Dr. W. James Haynie III, Dr. Dianne Chapman, Dr. Jeremy Ernst, Dr. Joe Busby and Dr. Terri Varnado.
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Chapter One: Introduction

In learning environments throughout education, the visual elements of courses, lessons, and presentations play an important role in learning. Well-conceived and rendered visuals help any audience understand and retain information (Wileman, 1993).

According to Clark and Mathews (2000), the use of visual technology enhances learning by providing a better understanding of the topic as well as motivating the students. Visualization methods are widely credited for simplifying the presentation of difficult subjects as well as aiding cognition; their use in the power engineering industry and education is enjoying significant growth. (Idowu, Brinton, Hartamn, Nehard, Abraham & Boyer, 2006). Even though the success by which content visualization will facilitate the learner’s acquisition of information is related to the individual’s level of perceptual and associative learning in the content area, the individual must have sufficient experience and maturity to realize that using visualization is merely an attempt to represent reality vicariously (Dwyer, 1978). Much of intended visual communication or self-expression is not perceived, or often misunderstood, especially if it is complex (Lantz, 2000). In addition to the individual’s experience, the visualization itself plays an important role in the learning process.

If all visual-based learning materials were equally effective in facilitating student achievement of all kinds of educational objectives, there would virtually be no problem associated with this type of instruction (Dwyer, 1978). However, this is not the case since there are many different types of visuals, differing in the amount of realistic detail they contain. For example, at the present time, educators, when faced with a choice of selecting one type of visualization from an array of available materials, have no way of knowing
whether one type of visual is any more effective than another in transmitting certain types of information (Dwyer, 1978). The lack of quantifiable measures of quality and benchmarks will undermine information visualization advances, especially their evaluation and selection (Chaomei, 2005).

The significance of this dilemma is brought into focus when one becomes aware of the amount of visual-based learning materials that are being used today in the private and public educational sector. “As might be expected, the types of visual-based materials used for instructional purposes are the ones that have become most readily available” (Dwyer, 1978, p. 4).

However, the extensive use of a certain type of visual-based material does not necessarily justify its effectiveness and efficiency. The profusion of visual displays of information without an educated guide to meanings discerned from the information has led to a groundswell of movements seeking to develop metrics and quantifiable quality measures (Idowu, Brinton, Hartmann, Nehard, Abraham & Boyer, 2006).

Need for Study

The importance of knowing how to select the best type of visual-based learning materials is recognized throughout higher education; however, with the exception of some descriptive literature, few studies have been conducted to identify the essential indicators of visual-based learning materials used in technology education courses for the middle school and high school grades. The reason this study is being emphasized for grades 7-12 is because, technology education is mainly offered for grades 7-12 due to federal funding guidelines such as the Carl D. Perkins Vocational and Technical Education Act that provides federal funds "…to help provide vocational-technical education programs and services to
youth and adults in middle school, high school and college level " (U.S. Department of Education, 2003).

Since the early 1980s there has been very little research to use when selecting specific types of visuals that will be most effective and efficient in facilitating student achievement of designated learning objectives.

What is urgently needed is systematic research efforts focused on three basic areas designed to provide data on: (a) what specific individual difference variables in learners actually make a difference in student achievement in the teaching learning process, (b) which of these individual difference variables interact significantly with different kinds of visualization used to complement oral/printed instruction, and (c) what is the extent of the range within specific individual difference variables that are accommodated by the use of specific types of visualization (Dwyer, 1978, p. 5).

Once we can describe what makes a particular visual successful to us, we can apply this knowledge to the design of completely new visuals (Lantz, 2000, p. 19). In instruction, an image may be studied for a long time by the viewer and still be unsuccessful (Lantz, 2000, p.20).

Therefore, it is essential to identify the indicators of quality visual-based learning materials for technology education curricula. Moreover, it is important to validate these indicators through involvement of educational members in the field of visual learning and technology education. Technology education experts who have knowledge related to visual learning and practical experience, involved in the creation of related materials, are a useful source of information to develop and validate the indicators of visual-based learning materials for technology education.
Purpose of the Study

Presently, educators, when faced with a choice of selecting one type of visual-based learning material from a plethora of available materials, have difficulty knowing whether one type of visual-based materials is any more effective than another in transmitting certain types of information. As a result, these differences have been found to have differential effects on the achievement level of students (Dwyer, 1972a). In terms of technology education, the availability of many different types of visual-based learning materials is confusing and may make the selection of the most effective impossible.

Therefore, the purpose of this study will be to identify those indicators in visual-based learning material to provide effective knowledge transmission in technology education materials for middle school and high school grades (7-12).

Significance of the Study

The study data are essential in making informed decisions about choosing specific indicators (see definitions) of visual-based learning material for most effective and efficient student achievement of designated learning objectives. It is expected that the indicators identified by this study will be beneficial to technology educators developing visual-based learning material. In the future, this study also will provide information to authors of visual-based learning material and can serve as a guide for future middle and high school material.

Research Questions

The major emphasis of this study involved determining the indicators that visual-based learning material used in technology education for grades 7-12 must have to transmit information effectively and also the indicators of the learner’s characteristics to be exposed
to such material. To achieve this task two research questions were proposed dealing with visual-based learning material:

1. What indicators must visual-based learning material in technology education for grades 7-12 have to be effective in transmitting information?

2. What are the indicators of the learner’s characteristics that impact the selection of visual-based learning material in technology education for grades 7-12?

Assumptions

The following assumptions will be considered throughout the process and procedures used within the study:

1. There is a need to establish quality indicators to be used as benchmarks in technology education visual-based learning material for grades 7-12.

2. Teachers, grant participants and other experts will respond to the data-collecting instrument in a non-biased way.

3. Teachers, grant participants and other experts participating in the study will be knowledgeable of visual-based learning material in technology education.

4. Teachers participating in the study will have at least three years of teaching experience in middle or high school and will have served as full-time technology education teachers.

5. Teachers, grant participants and other experts responding to the data collecting instruments will understand all directions.

6. All information gathered will be accurate and current related to visual-based learning material in technology education.
7. Quality indicators will be validated through three rounds of a modified Delphi process using a panel of experts in technology education.

8. Teachers, grant participants and other experts participating in the study own a computer with Internet connection and email accounts.

Limitations

1. The potential limitations of this study are biases introduced by the methods used to select participants, design questionnaires, and process results (Lang, 1998).

2. Information generated for this study about the indicators that a visual-based learning material must have is linked fundamentally to panel members’ personal values, concepts, ideas, experience, and quality opinions (Woudenberg, 1991).

3. For this study, the web-based modified Delphi method was used for collecting information and achieving consensus. Therefore, participation was limited to individuals who have Internet access.

4. Due to distance, costs and time constraints, three data-collecting instruments and three follow-up emails were used to gather information for the modified Delphi method.

5. Respondents in this study were limited to individuals who were identified by predetermined criteria.

6. Respondents in this study were limited to individuals who were identified by the PI’s of two NSF-funded grants.
Research Methodology

The procedures for this research study began with a proposal for conducting the study and a review of literature to acquire information related to the subject and subject matter. The study used a modified Delphi method for identifying the quality indicators of supplemental technology education visual-based learning material for the middle and high school grades. The approach used in this study to achieve its purposes was the online modified Delphi methodology. Many existing research studies in the area of information technology utilize the Internet and the World Wide Web as media to collect consensus data (Nesbary, 2000). This study involved three rounds to achieve consensus among a group of experts in visual-based learning material who were experienced technology teachers involved in pilot and field-testing for visual-based learning material grants. The number of rounds depended on reaching consensus among panel members. Most Delphi studies find that more than three rounds do not add significant value (Clayton, 1997). All data was gathered via a web site created to host the study and the World Wide Web as a primary mode of communication using Web-based instruments. Upon completion of the modified Delphi method, the indicators of visual-based learning material for middle and high school technology education courses were identified.

A review committee of three individuals who represented the background areas of the expert panel also was randomly selected to review all material and modifications made by the researcher before being sent to the experts for the different rounds, as suggested by Delbecg, Van de Van, and Gustafson (1975), and Mayers and Booker (1990). Having the review panel
also helped to prevent bias by the researcher during the editing and modifications made to the instruments between rounds. The review panel also participated as a test-piloting group to ensure the instrument being used for a given round was reader-friendly and easily understood (Meyers & Booker, 1990).

The instrument for Round I of the modified Delphi method was developed from information found in the literature of review. Examples of quality indicators were established and placed in a survey instrument. Once the review panel approved the instrument, the expert panel was given access to the instrument on the web through a username and password. An email also was sent to panel members after two weeks as a reminder to complete and return the instrument. Results from Round I were tabulated, with like indicators collapsed together. Participants remained anonymous to each other, avoiding influences of reputation, authority or affiliation. This enabled panel members to change their opinions without losing face (Martino, 1993).

Round II of the modified Delphi method included the rating and ranking of indicators from Round I. The instrument was developed and sent to the review panel for verification. The indicators were placed in random order. This round consisted of rating each indicator from the previous round. Indicators with a mean of 3.01 or higher from a Likert scale of 1-5 were kept for the next round. Also, the Kruskal-Wallis One-Way Analysis of Variance by Ranks test was conducted to see if any statistical significance could be seen in the rankings through the collected indicators in this round. In conjunction with the Kruskal and Wallis Test the Spearman’s Rank-Order Correlation Coefficient also was employed to identify whether correlation between subjects’ scores on two variables had a different value than zero. In addition, the Mann-Whitney U Test was employed with ordinal data in a
hypothesis-testing situation involving a design with two independent samples and testing for significant difference between the two medians.

Round III consisted of ranking the information gathered from Round II. Indicators kept from this round were those that ranked in the upper 50 percent above the statistic mean from Likert scale. Those indicators were kept since each was ranked highest by the expert panel, and, therefore, had the highest consensus. In Round III each expert panel member was asked to approve the final outcomes as established from Round II of the modified Delphi method. Once the review panel approved, the third and final round access was given to the experts to complete the instrument. Expert panel members were asked to accept or reject each indicator kept from Round II. The Mann-Whitney U nonparametric test was employed with ordinal (rank-order) data in a hypothesis-testing situation involving a design with two independent samples and testing for significant difference between the two medians.

To simplify and make clearer the sequence of the methodology of this study, Figure.1 was created with a graphical representation of the process.
Figure 1. Outline of Methodology
Definition of Terms

**Delphi Method** – “Delphi may be characterized as a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem” (Linstone & Turoff, 2002).

**Modified Delphi Method** – “It utilizes rounds of a survey, with questions dropping off, new questions being added, and participants being able to see anonymous responses from other participants. Unlike the original Delphi, a modified Delphi method provides panelists with opportunity to provide their comments between the rounds” (Murray & Hammons, 1995).

**Visual-based Learning Material** –“Learning material that includes various types of visual aids such as pictures, animations, drawings and prototypes that can be used effectively to teach facts, data, directions, processes, and invisible concepts that are often complex or elusive” (Wileman, 1993).

**Technology Education** –“Provides a wholesome change in learners by enhancing the understanding of how technology is changing the human-made world and the natural environment. It allows learners to experience the activities and habits of a designer, scientist, technologist, engineer, architect, producer, historian, and social critic as they engage in technological problems and issues of the present and future” (ITEA, 1995).

**ITEA** –“The International Technology Education Association is the largest professional educational association, principal voice, and information clearinghouse devoted to enhancing technology education through technology, innovation, design, and engineering experiences at the K-12 school levels. Its membership encompasses individuals and
institutions throughout the world in more than 45 countries with the primary membership in North America” (ITEA, 1995).

**Web-Based Delphi** – “Web-Based Delphi, a kind of Technology-Enhanced Delphi, is an electronic form of Delphi using the Internet and the World Wide Web as a primary data collection” (Andrews & Allen, 2002),

**Interquartile Range (IQR)** – The absolute value of the difference between the 25th and the 75th quartiles, with smaller values indicating higher degrees of consensus.

**Expert** – “An expert is someone who has acquired extensive knowledge that affects what they notice and how they organize, represent, and interpret information in their environment” (Council, 2000).

**Visualization Indicators** – “Indicators of visualization that determine the relative effectiveness with which different kinds of Visual material facilitate student achievement of different types of educational objectives” (Dwyer, 1978).

**TECH-Know** – “The TECH know Project is based on 20 technology-based problems issued by the Technology Student Association (TSA). The problems cover a wide variety of topics in construction, communication, manufacturing, and transportation technology. The competition engages students in hands-on, problem-based learning and is based upon fundamental science, mathematics, and technology concepts” (TECH-Know, 2004).

**VisTE** – “Visualization in Technology Education is a National Science Foundation funded project, that promotes technological literacy by linking to the Standards for Technological Literacy through the study of visualization, science, and technology. Over a three-year period, the project team has developed, piloted, and evaluated 12 units for
technology education in grades 8-12” (VisTE, 2005).

**Visualization** – “Visualization is the process of constructing methods that are able to synthesize interesting and informative images from data sets in order to simplify the process of interpreting the data” (Olsson, 2004).

**Visual Literacy** – “The individual’s ability to analyze, discuss, gain meaning, interpret, and express self through various visual forms, such as advertising, dance, word poetry, paintings, photographs, cartoons, etc. . .’’ (Golubieski, 2003).

Chapter Summary

Being able to satisfy students with different learning styles by promoting efficient knowledge transmission has been a challenge for the last 50 years. Educators from around the globe are trying to identify the most competent instructional material to achieve this task. The challenge is even greater for technology education material that relates to visual learning since only a limited amount of research exists. Therefore, it is of great importance to conduct a study that will identify the quality indicators of visual-based learning material in technology education to help educators choose the most appropriate material for specific learning environments. Through a three-round modified Delphi method, this study attempted to identify those quality indicators. More research will be needed beyond this study to facilitate the goal of improving the quality of visual-based learning material in technology education for grades 7-12.

In conclusion, this study was designed to offer a product to start the assessment development process for visual-based technology education material for grades 7-12.
Chapter Two: Literature Review

Figure 2. Outline of Literature Review
Learning Styles

As defined by Light and Cox, learning is “an active and meaningful construction of facts, ideas, concepts, theories, and experiences in order to work and manage successfully in a changing world of contexts” (Light & Cox, 2001). Learners make the most out of information when they can select information and organize it into representations that make sense to them (Jonassen, 1999; Mayer & Moreno, 2000; Mayer, 1996; Mayer, 1999b; Wittrock, 1990). Those sense-making indicators that determine individual differences in learning are the learning styles. Learning styles can be defined broadly as “the characteristic behaviors of learners that serve as relatively stable indicators of how they perceive, interact with, and respond to the learning environment” (Keefe, 1979).

Many researchers have proclaimed the significance of identifying preferred teaching styles and preferred learning styles. Claxton and Ralston (1978, in Miller, 1982) alluded to this significance:

The research findings on learning styles offer substantial promise to teachers, counselors, and the students themselves in terms of finding better ways for students to learn. But while matching learning style with instructional mode apparently facilitates positive interpersonal relations, and while it would seem to point the way for increased learning, the empirical data that support this idea are rather scarce. Such a significant gap in the research must be filled if knowledge about learning styles is to become a significant force in improving college and university teaching (p. 36).

However, identifying and defining the vast number of learning styles can become an enormous task. Cornett (1983) said the myriad of labels and categories used in identifying
the different areas of style can be overwhelming for educators. Corbett and Smith (1984) stated:

Learning style is a complex construct involving the interaction of numerous elements; thus, at the outset, the experimenter is faced with the difficult task of having to decide which dimensions of learning style to elucidate and which interactions might be meaningful, in a practical sense, in understanding their contribution to achievement (p. 212).

According to Kelly (1997), there are two major benefits to understanding one’s learning style. First, it helps people to understand areas of weakness and second, it helps people to realize their strengths. This gives students the opportunity to become more proficient. Using a learning style inventory helps students to understand their learning styles, and as stated by Knox (1986), “make transitions to higher levels of personal and cognitive functioning “ (p.25). In addition to being beneficial to the student, knowing a student’s learning style can benefit the teacher as well. It allows the teacher to cover materials in a way that best fits the diversity of the classroom (Kelly, 1997). According to DeBello (1985), Giannitti (1988), and Miles (1987), students learn more and like learning better when taught using their identified learning styles.

The Institute of Learning Styles reports that there are no fewer than seven perceptual learning styles. Perceptual learning styles are characterized as the methods that individuals use to extract information from their environment (The Institute of Learning Styles, 2007). The seven perceptual learning styles are print, aural, interactive, visual, haptic, kinesthetic, and olfactory. Kolb’s (1993) research suggests that individuals possess
preferences for learning that favor some learning abilities over others. He reports that there are four basic learning modes: concrete experience, reflective observation, abstract conceptualization, and active experimentation that describe the learning preferences of everyone.

Kolb’s Learning Styles

Visual-based learning material for technology education programs uses only one form among all learning styles: the visual learning. However, for a comprehensive, well-rounded study, the familiarization with all learning styles is of great importance. One of the leading researchers for learning styles was Kolb who created the Learning Style Inventory, where he explains in great detail all known learning styles and their indicators.

The Learning Style Inventory (LSI) was created by Kolb (1984) to “assess individual orientations toward learning” (p.67). He developed this instrument with four design objectives. First, “the test should be constructed in such a way that people would respond to it in somewhat the same way as they would a learning situation” (p.67). Second, “a self-description format was chosen for the inventory” (p.68). Kolb stated that a person giving a description of his/her self image would be more powerful than not providing a personal image. Third, “the inventory was constructed with the hope that it would prove to be valid – that the measures of learning styles would predict behavior in a way that was consistent with the theory of experiential learning” (p.68). And fourth, Kolb wanted the inventory to be straightforward, brief and practical in order for those being tested to get meaning out of the inventory and have feedback on their learning styles. Using the four learning modes, Kolb developed four basic styles of learning as shown in Table 1.
Table 1

*Kolb’s Learning Styles*

<table>
<thead>
<tr>
<th>Learning Mode</th>
<th>Personal Characteristics</th>
<th>Learning Style</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete Experience</td>
<td>More of a risk taker</td>
<td>Accommodator</td>
</tr>
<tr>
<td>+</td>
<td>Performs well when</td>
<td></td>
</tr>
<tr>
<td>Active Experimentation</td>
<td>required to react to immediate circumstances</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Solves Problems intuitively</td>
<td></td>
</tr>
<tr>
<td>Reflective Observation</td>
<td>Exceles in inductive reasoning</td>
<td>Assimilator</td>
</tr>
<tr>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abstract Conceptualization</td>
<td>Concerned with abstract concepts rather than people</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Strong ability to create theoretical models</td>
<td></td>
</tr>
<tr>
<td>Abstract</td>
<td>Strong in practical application of ideas</td>
<td>Converger</td>
</tr>
<tr>
<td>Conceptualization</td>
<td>Can focus on hypothetatic reasoning on specific problems</td>
<td></td>
</tr>
<tr>
<td>+</td>
<td>Unemotional</td>
<td></td>
</tr>
<tr>
<td>Active Experimentation</td>
<td>Has narrow interests</td>
<td></td>
</tr>
</tbody>
</table>

The Learning Style Inventory measures “a person’s relative emphasis” on questions regarding each of the four modes of the learning process (Kolb, 1984, p.68). In addition, there are two combination scores that measure whether a person emphasizes action over reflection and abstractness over concreteness (Kolb). Based on Kolb’s four learning modes, Table 2, states the definition of each mode (p.68, 69).
Understanding one’s preferred learning style has two benefits: It helps us understand our areas of weakness, giving us the opportunity to work on becoming more proficient in the other modes or it helps us realize our strengths, which might be useful in certain social situation, such as deciding on a career (Kelly, 1997, p. 3).

<table>
<thead>
<tr>
<th>Learning Mode</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete Experience</td>
<td>Focuses on being involved in experiences and dealing with immediate human situations in a personal way. It emphasizes feeling as opposed to thinking; a concern with the uniqueness and complexity of present reality as opposed to theories and generalization; an intuitive, artistic approach as opposed to the systematic, scientific approach to problems.</td>
</tr>
<tr>
<td>Reflective Observation</td>
<td>Focuses on understanding the meaning of ideas and situations by carefully observing and impartially describing them. It emphasizes understanding as opposed to practical application; a concern with what is true or how things happen as opposed to what will work; and emphasis on reflection as opposed to action.</td>
</tr>
<tr>
<td>Abstract conceptualization</td>
<td>Focuses on using logic, ideas, and concepts. It emphasizes thinking as opposed to feeling; a concern with building general theories as opposed to intuitively understanding unique, specific areas; a scientific as opposed to an artistic approach to problems.</td>
</tr>
<tr>
<td>Active Experimentation</td>
<td>Focuses on actively influencing people and changing situations. It emphasizes practical applications as opposed to reflective understanding; a pragmatic concern with what works as opposed to what is the absolute truth; an emphasis on doing as opposed to observing.</td>
</tr>
</tbody>
</table>

*Table 2
*Kolb’s Definition of four Learning Modes*
Therefore, in the case of visual-based learning material development, it is essential to be familiar with all learning styles, including visualization, since some students will have more than one preferred learning style.

Preferred Sensory Modalities

Learning styles are categorized by sensory modalities, which include visual, auditory, tactile and kinesthetic. Barbe and Swassing (1979) were the first researchers to develop a standardized performance measure of learning style based on modality strength. Modalities are defined as the channels through which individuals receive and retain information. The educationally relevant modalities are visual, auditory, kinesthetic and reading.

Modality strength and a modality preference are not the same. A modality strength means superior functioning in one or more perceptual channels. A modality preference is just a preference and is usually measured by self-report instruments (Barbe & Milone, 1981). Auditory learners use their voices and their ears as the primary mode for learning. Some learners find their visual modality is stronger in helping them understand and remember new concepts. Some people learn better when they touch and are physically involved in what they are learning. Many successful learners can function in more than one modality. An individual’s dominant modality is that channel through which information is processed more proficiently. Many people also process a second modality (Guild & Garger, 1998).

The first learning modality, visual awareness, refers to how a student processes information through reading written materials and/or seeing others demonstrate concepts in class. Next, the auditory learner responds most effectively when listening to verbal directions
or musical performances. Finally, the third sensory channel expressed in students is a
kinesthetic awareness. Kinesthetic learners explore the environment with their entire body, in
activities such as playing musical instruments, using creative movement, and dancing
(Cambell & Kassner, 1995).

The basic question in instruction is how to proceed in order to facilitate the
acquisition of essential background information by individuals who have not had the
opportunity to benefit from first-hand experience or other forms of experiential learning
(Dwyer, 1978). The answer to this question is not a simple one since there are many objects,
situations, and processes that are not easily accessible to the student. However, the strategy
commonly used to fulfill the need for concrete personal experience and to facilitate learning
has been to integrate visual-based learning by trying to reproduce the conditions and
environment of certain learning conditions as closely as possible to real life settings. To
achieve the task of learning environment reproduction, teachers use tools such as animation
software, visualizations and visual-based learning material.

Teaching and Learning Style Research in Technology Education

Industrial arts teachers demonstrated a high preference for working with things and
preferred direct experience as opposed to the lecture approach of instruction (Reed, 2000).
These findings reflect the unique history and support the theoretical base of technology
education (Anderson, 1926; Bennett, 1926, 1937; Martin, 1995; International Technology
Education Association, 1985, 1988, 1991; Technology for All Americans Project,

To describe the psychological preferences of technology education teachers,
Wicklein and Rojewski (1995) conducted a research study. Given to 254 International
Technology Education Association (ITEA) members, the Myers-Briggs Type Indicator (MBTI) was administered in an attempt to distinguish technology teachers from the general population and from secondary educators. Wicklein and Rojewski found that 69 percent of their sample was practical, realistic, and preferred to solve problems conceptually through structured investigation and inquiry. Comparing the results to the general population, Wicklein and Rojewski’s (1995) sample demonstrated a greater preference for a sensing-judgment temperament type and a lower preference for a sensing-perception temperament.

Kuskie and Kuskie (1999) created a learning style instrument for use in secondary technology education classrooms. Specifically, the Learning Channels Inventory (LCI) was designed "(a) to enhance the learning of technology curriculum, (b) to consider how students might most effectively learn and use the technology equipment, and (c) to expand the instructional methods of the technology teacher" (Kuskie and Kuskie, 1999, p. 77). The LCI is a paper and pencil test that measures visual, auditory, and psychomotor preferences. After conducting the study, Kuskie and Kuskie noted that using a variety of visual, auditory or psychomotor activities can enhance individual and cooperative learning.

Similar to Kuskie and Kuskie, Tappenden (1983) examined the learning styles of secondary vocational education and non-vocational education students. Tappenden used the Learning Style Inventory (LSI) created by Dunn, Dunn and Price (1984). According to Reed (2000), Tappenden found that vocational and non-vocational students have significantly different learning styles.

Tappenden, and Kroon (1985) also used the LSI inventory to investigate the effect
of matching the perceptual strengths of technology education students with instructional materials that complemented their strongest perceptual inclinations. Using a sample of 65 technology education students and 65 non-technology education students, Kroon gave the LSI test to identify preferred learning style. Based on the results Kroon concluded that technology education students preferred tactual (related to the sense of touch) activities but did not prefer kinesthetic (related to the sense of motion) activities.

The research on teaching and learning styles in technology education demonstrates support for a variety of teaching methods and emphasizes the differences between the learning styles of technology education teachers, the general population, and secondary teachers. One of the learning styles used in technology education is the visual (Reed, 2000).

History of Visual Pedagogy

During the second half of the twentieth century, the world was marked by the global expansion of the communications media and the burgeoning visual culture, radically altering the dissemination and production of information and knowledge. In the educational world, however, visual media culture was perceived as a threat to literacy but also was touted as a potentially powerful tool for educators (Goldfarb, 2002).

Visual pedagogy takes as its starting point a blind spot, perhaps even a bias, in critical pedagogy that dates back to Freire’s foundational work and extends forward into the body of work known as critical pedagogy that was produced in the last three decades of the twentieth century (p. 3). The bias that Goldfarb is writing about is that visual learning is only a basis, a primitive and also untrustworthy form of knowledge transmission and production. Freire’s Pedagogy of the Oppressed put forth the argument that to acquire literacy is not simply to learn the techniques of reading and writing but to gain the ability to think critically.
and to use language – in the forms of reading, writing and speech-as politicized action. (Freire, 1968).

However, Freire wrote during a period when technologies of the word were being transformed through new media forms such as television and computers in public education. These media supplemented the hallowed forms they embodied, and his followers viewed written word with electronic and digital image and text as seductive techniques of institutional and bureaucratic control. Therefore, the visual media were disparaged for their perceived status as pedagogical tools for global capitalism (Goldfarb, 2002, p.3).

The transition from voice and writing to media and a visual logic of knowledge production occurred not only in the elite western institution but also in the third world settings that were the basis for Freire’s early ideas about pedagogy. From the late 1950’s through the 1970’s, the third world was tapped as a testing ground for educational-technology systems that would transform educational philosophy and practice in United States schools and institutions in the 1980’s and 1990’s (Goldfarb, 2002, p.4). One of Freire’s followers, David Trend, has noted the role of media technology in furthering critical pedagogy within and beyond schools and started experiments in U.S public schools in the 1970’s. Hands-on work with media technology, he suggests, made it possible for students to understand and engage in the technological means of knowledge production and reproduction (Goldfarb, 2002, p.5). However, in the 1980’s, Trend explains, the period when students engaged in the means of production was short-lived (Trend, 1992). Political reasons such as the Reagan administration policies and budget cuts resulted in a climate where hands-on student participation in educational media process and production was reduced to simple classroom media viewing (Goldfarb, 2002, p.5).
Despite political reasons and interests, the desire for cost-efficient ways to educate large numbers of people for the benefit of serving larger and more diverse populations in a globalizing economy was one factor that motivated the testing of educational media both locally and at a distance. Another view that held sway was that language difference and illiteracy could be surmounted using graphic and visual symbols to introduce “more complex” discursive forms. This concept also was supported by Jean Piaget’s popular theories of child psychology, which consider symbolic language acquisition as a more primitive, basic precursor to the complexities of learning written language (Goldfarb, 2002, p.6). However, literature challenges the belief that the visual occupies lower levels of knowledge than writing forms. The philosophy, for example, of the electronic classroom intersects in a complex way with the philosophy of hands-on media production training. As Ira Shor (1970) explains, a pedagogical philosophy of vocationalism under the name of career education blossomed in the U.S. public school system in the early 1970’s. Hands-on experience with media was one of the career skills worth cultivating in public school workforce training. Technological know-how did not replace book learning but rather it was a class-based view of media production’s potential to transform politics of difference in schools (Goldfarb, 2002, p.6).

Visual Literacy

Before I begin describing the theoretical roots, I would like to establish a baseline from which to work regarding the discipline of visual literacy, which is a general term containing the subcategories of visual thinking, visual learning, and visual communication. The following diagram, was created by Allen Brizée (2003) and outlines what I believe is the clearest explanation of this discipline.
The umbrella term, visual literacy, encompasses visual thinking, visual learning and visual communication (Brizee, 2003). In the broader terms then, visual literacy in this diagram is the overall discipline with subcategories related to the use of visuals from the most rudimentary (visual thinking), to the acquisition of information through visuals (visual learning), to the use of visuals to convey data (visual communication). The reason this diagram is presented in this study is to provide a clear baseline for the parameters visual-based learning material needs to cover to be efficient as it relates to knowledge transmission.
Rudolph Arnheim in his landmark text, *Visual Thinking*, re-ignited the debate between educators on the subject of visual cognition and its influence on our thinking and learning process (Arnheim, 1969). According to Arnheim, our thinking process is heavily influenced by our visual interaction with the world around us and the key elements of our cognitive abilities are tied to visual thinking. Therefore, educators must re-integrate visual learning at the elementary school stages of education rather than splitting visual thinking away from the study of letters and numbers (Brizee, 2003, p. 7).

Arnheim claims that visual thinking is an essential step in human cognition and that this visual cognitive process contributes to our ability to think. Detailing this process, Arnheim explains the innate cognitive qualities of visual thinking when he states:

> At early organic levels, the stimulus compels the reaction. When a strong light enters the visual field, the infant turns toward it as though directed by an outer controlling power …this is the prototype of a cognitive response unconditionally surrendered to the object of attention. The response is steered by the stimulus rather than by the initiative of the observer (p. 21).

From Arnheim’s 1969, statement above we can see the connection between a natural response and the development of thinking abilities. Regardless of the importance of the visual sense, western culture, for the most part, relegates visual learning to the disciplines of art, graphic design, and architecture rather than integrating visual thinking in reading and writing—this in spite of the fact that every discipline uses visual thinking. We use visuals as a primary source of information; yet, as natural as visual learning seems to be, our culture splits education into two separate areas known as text/numerals and art (Brizee, 2003, p. 8).

Based on Plato’s skepticism, mistrust of the senses, and especially the visual sense
deep-seated uncertainty within western philosophy which even now profoundly affects our teaching. In our earliest classes, we play with and use brightly colored blocks, large images of animals and fire engines, and more recently, striking computer graphics to discover the world around us. Visual thinking and learning is an intricate part of our cognitive process, and Arnheim states that we should re-integrate it into our education systems (Brizee, 2003).

**Visual Learning**

Visual Learning is the “permanent change in behavior brought about through visual simulation either from the environment or through self-imposed imagery, often on a one-trial or single exposure nature (Imeokratia, 1995 p.45). Using pictorial information in learning and instruction has a long tradition. According to Schnotz (2002) in the seventeenth century when Comenius published his “Didacta Magna,” he “emphasized that envisioning information is extremely important for effective learning” (p. 101). Learning from verbal and pictorial information has generally been considered as (potentially) beneficial to learning. The acquisition and application of image categories are basic operations underlying the organization of human knowledge.

Cognitive scientific research on problem-solving processes found that the use of visual illustrations can facilitate problem solving, offering assistance at all phases of the process (Schnotz, 2002 p. 117). Larkin and Simon (1987) found that, for certain types of tasks, the use of visual representations and illustrations can have advantages over the use of other representations in all three phases of the human information processing system: search, recognition, and inference. Therefore certain characteristics contained in visual illustrations can play an important role in learning improvement.
Spatial Visualization

The term “visualization” is used often in many different ways, so it is often difficult to understand or interpret the true intent of its use (Koch, 2006). From the late 1800’s to the 1970’s, two major factors were identified: spatial visualization and spatial orientation (McGee, 1979; Smith & Strong, 2001). McGee (1979) defined spatial visualization as “an ability to mentally manipulate, rotate, twist, or invert pictorially presented visual stimuli” (p. 3) and that spatial visualization involves recognition, retention, and recall.

On the other side, spatial orientation “involves the comprehension of the arrangement of elements within a visual stimulus pattern, the aptitude for remaining unconfused by the changing orientations in which a configuration may be presented…” (McGee, 1979, p. 4).

Even though, today, visualization is considered to be an essential element of intelligence measurement, that did not always exist, and until recently it had not received the same emphasis as verbal skills. Spatial visualization and spatial orientation are shown to be more highly correlated with technical, vocational, mathematical, and occupational domains than verbal ability (Bertoline & Wiebe, 2003; Elliot & Smith, 1983; Gillespie, 1994).

According to the International Dictionary of Spatial Tests (Elliot & Smith, 1983), there are three distinct phases of spatial visualization research. Phase one was from 1901-1983, when researchers attempted to identify a single spatial factor. Phase two, from 1938-1961, was when researchers began trying to identify different spatial factors with two distinct areas evolved—one related to the ability to recognize spatial configurations and another related to mentally manipulating them. The third phase, from 1961-1982, attempted to determine
relationships of spatial abilities with other factors such as age, sex, ability, and previous experience (Gillespie, 1985; Strong & Smith, 2001). There is a possibility also for a fourth phase, one that focuses on computer technology and its relationship to spatial visualization skills (Strong & Smith, 2001).

Koch (2006) states that research supports the idea that visualization can be learned and improved through practice. Gillespie (1995) studied the effects of tutorials in teaching solid modeling on visualization. In his experiment, Gillespie examined students enrolled in an engineering graphics course at the University of Idaho. Sixty-seven participants, 41 of whom completed the study, were divided into three groups. Each group was pre-tested using three tests: a mental rotations test; a paper folding test; and a rotated block test. Gillespie developed the rotated block instrument similar to the “Purdue Spatial Visualization Test/Test of Rotations” (PSVT/TR). One group was treated with 10 weeks of 17 modules on solid modeling. The two control groups received traditional 2D graphics instruction. All groups improved their scores from pre-test to post-test, and the treatment group improved significantly over the two control groups.

Knowing that visualization can be learned and improved through practice is very important for visual-based learning material development. There is now hope for learners who do not have visual learning as a primary modality, to benefit from visual-based learning material too, since all they have to do is go through a series of instruction and practice to improve their visual skills.

After Gillespie’s study in 1995, solid modeling technology and software have
changed a great deal. The software at that time typically involved the use of wireframes, Boolean operations, and oftentimes confusing movement of a user coordinated systems (UCS) icon. Modern solid modeling software is simpler and more efficient to use (Kurland, 1994).

The images were more realistic with rendered representations and more realism in them. According to Devon, Engel, Foster, Sathianathan, and Turner (1994), this makes visualization easier and accelerates or improves the advantages of using solid modeling. However, according to a study conducted by Haynie (1978), it was concluded that realistic and enhanced photographs were relatively equal in their instructional effectiveness and that they should occupy approximately the same position for visual learning. To reach that conclusion, Haynie used five treatment groups for his study: Group I, control, saw no visuals; Group II saw abstract line drawings; Group III saw detailed, shaded drawings; Group IV saw realistic photographs; and Group V saw enhanced photographs—a photograph that is made by using special lighting techniques and other special techniques to ensure adequate visibility (Haynie, 1978, p. iii). The results of this study have great benefits for visual-based learning material development since they set the foundations of the kind of visuals that need to be present in such material to promote more efficient student learning and understanding.

Frey and Baird (2000) studied the effects of using rapid prototyping (RP) on visualization. RP is the production of a physical part directly from a CAD file through an additive process often termed 3D printing. After conducting the study, Frey and Baird found no significant difference when rapid prototyping was used. Their data showed that increases
in scores on the Minnesota Paper Forms Board Test (MPFBT) were related to increased
drafting experience. In the study, students were divided into four groups based on levels of
experience or exposure to drafting and CAD: 1) no drafting experience; 2) some drafting
experience; 3) CAD experience; and 4) rapid prototyping experience. Of the 68 students
studied, those with no drafting experience scored the lowest on the visualization test. Those
with manual drafting experience scored slightly higher, and students with CAD and solid
modeling scored the highest. Again the results of this study indicate the type of material that
needs to be imbedded when developing visual-based learning material. However, this study
only cover a small percentage of different types of visual aids, therefore more studies are
necessary.

Devon, Engel, Foster, Sathianathan, & Turner (1994) examined the effects of solid
modeling software on 3-D visualization skills. Using the “Mental Rotations Test” developed
by Vandenburg and Kuse (1978) -to measure visualization skills, it was concluded that the
students had significant gains in visualization. This demonstrated that using solid modeling
increased the students’ visualization scores over using 2D CAD. In the same study it also
examined the effect associated with the amount of mechanical drawing or CAD experience
that participants had in high school. No significant difference was found regarding the
amount of mechanical drafting or CAD experience in high school, which is consistent with
studies by Baenninger and Newcombe (1989) and Sexton (1990 as cited by Devon et al.
(1994) but is contradictory to other studies (Frey & Baird, 2000). Concluded from the study
above and beneficial for visual-based learning material development is the fact that 3-D
visualizations promote better understanding and improvement of visual skills. Therefore, according to the study more 3-D visualizations than 2-D should be used in the development of visual-based learning material.

Godfrey (1999) has also conducted a study related to 3-D visualization skills using solid modeling among 76 engineering and technology students. The control group received 2D CAD instruction and the treatment group received solid modeling instruction. The PSVT/VR was used at weeks 9 and 16 of the treatments. No significant differences were reported between the groups, but there were differences at the 9-week and 16-week intervals. The solid modeling group showed gains in the first 9 weeks and the 2-D group showed gains in the period from week 9 to 16. According to Godfrey this suggests a logical teaching progression going from solid or 3-D modeling to the more abstract 2-D CAD. Godfrey’s study is important for visual-based learning material development since it supports a sequence of presentation of visualizations according to their level of complexity. Knowing the correct sequence of visual material presentations can increase the performance and validity of the visual-based instructional material.

Importance of Visualization

According to Haynie (1978), the value of visual illustrations in instruction has been known for some time and several researchers such as Bell, Cain, & Lamorlaux (1941); Dwyer (1965); Gropper (1962); McCowen, (1940); Murray (1960); Vernon (1945, 1946); Wiman & Meierhenry (1969); and Wise (1939) have found that using visual aids can improve student achievement in specific learning objectives (p. 10). Several studies were conducted to compare the effectiveness of various media and methods. Haynie mentions that
early studies of the type criticized by Lumsdaine and May (1965) include Brown (1928) which compared motion pictures to film slides; McCowen (1940), Murray (1960), and Vernon (1946), which compared the use of visuals to conventional methods of instruction (p. 10).

Visualization has been identified as one of the most important skills related to engineering and technical graphics (Gillespie, 1995). “Spatial visualization skills are an important component of engineering because of their direct relationship to the graphical communication associated with design” (Devon et al., 1994, p. 4). Strong spatial visualization skills have been shown to correlate to success, achievement, and retention in engineering programs and success in mathematics (McGee, 1979).

Vocational students have had difficulty translating 2-D schematics and blueprints into 3-D objects and converting 3-D objects into 2-D representations. This may be due to the lack of development of visualization skills (Rosenfeld, 1985). Visualization is particularly important to engineers because they must be able to solve problems involving abstract objects. They need to be able to communicate those solutions and understand the drawings or solutions of others (Mack, 1992).

The value of visualization and capabilities goes even beyond the ordinary. Using the solid modeling curriculum is also an effective way to close the gender gap in spatial visualization skills (Devon et al., 1994). Several studies found that differences exist in the spatial visualization abilities of males and females (Branoff, 1998; Devon et al., 1994; Gillespie, 1994; McGee, 1979). Studies of younger children showed little or no spatial
visualization differences between males and females prior to puberty. After puberty significantly different levels were evident, with males having a higher ability. In studies where differences were evident, males typically had stronger visualization skills (McGee, 1979). Devon et al. (1994) reported no significant gender differences when they examined the fall and spring semesters separately. The classes that received extensive solid modeling showed clear gender differences. However, other reasons, besides the effects of solid modeling, may be responsible for the noticeable differences. Reasons such as the larger number of females in the group and the fact that the lower pre-test scores of the females made for larger gains than many of the males may be responsible.

In Gillespie’s study (1994), gender differences were found to be significant at the .10 level, but this finding was not consistent with many previous studies. He found that the females had higher spatial visualization scores. Possible reasons for this were that the small number of females (5) might not have been a representative sample and one female had exceptional gains which skewed the results.

More differences between males and females such as the visual cues regarding the rotation of an object have been seen. Branoff (1998) examined the addition of coordinate axes on mental rotation tasks and found that males scored higher on the preliminary test that did not have coordinates. The three-dimensional coordinates system provides an extra dimension in space: depth perception. Depth perception is the result of identifying visual cues within the image which allow the observer to interpret the retinal image as three-dimensional (Marr, 1982). When coordinate axes were added to the object, the females showed no significant difference from the males. Branoff concluded that males tend to take a
more holistic approach to visualization and females more of an analytical approach. By adding a reference, the coordinated axes on the drawings, biases were eliminated (Branoff, 1998).

Unsolved Visualization Problems

Chaomei (2005), lists ten high-priority unsolved information visualization problems compiled by a panel of experts at the Institute of Electrical and Electronics Engineers, (IEEE) Visualization Conference in 2004. Chaomei’s 10 top unsolved problems of visualization are displayed in Table 3.

Table 3

<table>
<thead>
<tr>
<th>Chaomei’s 10 unsolved visualization problems (Chaomei, 2005)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problems</td>
</tr>
<tr>
<td>Problem 1</td>
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<td>Problem 2</td>
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<td>Problem 9</td>
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<td>Problem 10</td>
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</tbody>
</table>

Chaomei’s study is of great importance for this dissertation since it is a miniature of it. With the only differences being the number of participants and slightly different research methodology, Chaomei has identified the indicators of quality visualization representations.
Presented as unsolved visualization problems, those indicators form a category of quality indicators that every visualization must have in order to be more effective. Therefore, knowing these indicators and being familiar with Chaomei’s study is a necessity.

The complexity of the underlying analytic process involved in most information visualization systems is a major obstacle; end-users cannot see how their raw data is magically turned into colorful images (Chaomei, 2005, p. 12). In other words, designers and users need to find empirical evidence that is both generic and specific enough to inform their decision-making process. Chaomei also mentions that we need new evaluative methodologies and that the majority of existing usability studies heavily relied on methodologies that predated information visualization (Chaomei, 2005, p.12).

Understanding elementary and secondary perceptual–cognitive tasks is a fundamental step toward engineering information visualization systems. Tasks such as browsing and searching, and even judging the relevance of information, require a level of cognitive activities higher than that of identifying and decoding visual objects (Chaomei, 2005, p.13).

Prior knowledge can serve as a vehicle for communicating abstract information. The intended extraterrestrial audience is assumed to know modern physics and our solar system. The alien is also expected to figure out from the line drawings of a man and woman that the pioneer is coming in peace from a small planet. Information visualization and its users must have a common ground (Chaomei, 2005, p. 13). In conjunction with prior knowledge is the fourth problem that relates to education and training.

Education and training refers to the need for researchers and practitioners within the
field of information visualization to learn and share various principles and skills of visual communication and semiotics (Chaomei, 2005, p. 13). Workshops and publications are necessary to spread the new knowledge and educate other researchers so they don’t have to reinvent the wheel of already-known information.

Intrinsic quality measures appear as the fifth problem on the list. It is vital for the information visualization field to establish intrinsic quality measures (Chaomei, 2005, p. 14). Chaomei explains that the lack of quantifiable measures of quality and benchmarks will undermine information visualization advances, especially their evaluation and selection. The sixth problem on the list is scalability.

Parallel computing and other high-performance computing techniques have not been used in the field of information visualization as much as in the scientific visualization and a few other fields (Chaomei, 2005, p. 14). The reason that state-of-the-art technology is not being used for all different fields of information visualization is because there is not enough funding to allow it. More research and funded grants are needed to explore technology in more fields.

The purpose of information visualization is the insights into data that it provides, not just pretty pictures. What can we learn from making a pretty picture and enhancing the representation of insights? Aesthetics appears as the seventh problem into Chaomei’s list. It is important to understand how insights and aesthetics interact, and how these two goals could sustain insightful and visually appealing information visualization (Chaomei, 2005, p. 15).

The eighth problem on the list is a paradigm shift from structures to dynamics. An
emerging trend is to shift the structure – centric paradigm to the visualization of dynamic properties of underlying phenomena (Chaomei, 2005, p. 15). There are more profound challenges that visualizing changes over time. Even if a trend or a sharp change is recorded in a data set it might be impossible for the user to identify the change unless a second representation emphasizes the change. Therefore a collaboration of a visual that presents the change and one with a change detection mechanism are necessary for users to receive the correct results.

According to Chaomei (2005), because of the exploratory and decision-making nature of such tasks, users need to interact freely with raw data as well as its visualization to find causality. Techniques such as multiple coordinated views will enhance the discovery process. Having interactive visual representations that allow the users impact can be extremely valuable for the learning process as well a promoter of realistic results. It also serve as an error prevention mechanism.

According to Chaomei (2005), the greatest advantage of information visualization is its ability to show the amounts of information that are beyond the capacity of textual display. Therefore, we need more visual representations that are rich in detail, large in scale, extensive in duration, and widespread in scope. As Chaomei (2005), states in the conclusion of his article, the purpose of this study is to provoke some thinking, stimulate some debates, but most importantly, to inspire a constantly revised and updated list of top unsolved problems for the field (Chaomei, 2005, p. 16). Therefore, following Chaomei’s advice, I hope that by the end of this study I will be able to provide a new updated list and even solve some of the unsolved problems of visualization by providing more up-to-date information.
However, to better understand the unsolved problems of visualization it is essential that we study visualization and representations with in a greater detail. The next topic of this study will try to achieve this task by defining the different categories of visual representations.

**Descriptive and Depictive Representations**

Representations are objects or events that stand for something else (Peterson, 1996). Representations can differ from one another with respect to their informational content and their usability. The informational content of a representation refers to the set of information that one can extract from the representation with the help of available procedures (Schnotz, 2002, p. 103). Texts and visual displays belong to different classes of representations: descriptive and depictive representations.

Descriptive representations consist of symbols describing an object that have an arbitrary structure. Symbols are related to the content they represent by means of a convention (*ibid.*). Descriptive representations contain signs for relations. A depictive representation consists of iconic signs, such as pictures, sculptures, or physical models.

Descriptive representations and depictive representations have different uses for different purposes. Descriptive representations have a higher representational power than depictive representations although it is possible to mention only a few geometric indicators of a figure or to specify only the form of the object without providing information about its size or orientation in space (Imeokrapia, 2005, pp.46-47). For example, a picture of an object goes beyond information about its form to give information about its size. Accordingly, depictive representations have special value for gaining new information from already known information (Schnotz, *ibid.* pp. 103-104).
Instructional Materials

According to Reed (2000) despite the fact that many learning style researchers often promote the need for teacher flexibility (Ellis, 1979; Guild and Garger, 1985; Marshall, 1991; and Reiff, 1992), there are only a few researchers who have developed instructional models based on their learning style theories. Since the visual-based learning materials for technology education assessed in this study, were developed based on visual learning theories it is of great importance to familiarize our selves with the 4MAT system. With the 4MAT system, one should be able to see the connection of visual-based learning with the rest of the learning styles. Understanding the connection between different learning styles is beneficial when trying to assess instructional material since it gives the individual a holistic view of the knowledge to be transmitted and all available tactics to do so.

Bernice McCarthy’s (1980) 4MAT System is a very well known and widely used instructional model. McCarthy developed the 4MAT System in 1980 as a result of her classroom teaching experience, her dissertation (McCarthy, 1979) and a conference she held in Chicago in 1979 (McCarthy, 1987). According to McCarthy, a similarity exists in the learning style theories she researched. Two ways of perceiving information and two ways of processing information were defined; thereby, she was able to develop composites of four different types of learners (McCarthy, 1987).

**Imaginative learners.** These learners perceive information concretely and process it reflectively. They need to be involved personally and their favorite question is why? (McCarthy, 1987).

**Analytic learners.** These learners perceive information abstractly and process it reflectively. Analytic learners are interested in facts and their favorite question is what?
McCarthy recommends that teachers give them facts that will deepen their understanding (McCarthy, 1985).

Common sense learners. These learners perceive information abstractly and process it actively. Dynamic learners are problem solvers that commonly ask how? (McCarthy, 1987). Teachers should let this type of learners see how things works by letting them try things (McCarthy, 1985).

Dynamic learners: These learners are primarily interested in self-discovery and often ask the question if? (McCarthy, 1987). Teachers should let these learners teach themselves and others (McCarthy, 1985). Figure 4 shows the complete 4MAT system model.

Figure 4. The complete 4MAT System Model (McCarthy, 1980, p. 122)

According to Reed (2000), the 4MAT System has been widely used by learning style researchers from several disciplines. Some of those were: Blair and Judah (1990) for the
implementation of a tech prep program; Kelley (1990) developed a model for implementing
4MAT lessons in law school and Kearney and Thacker (1994) use 4MAT lessons to teach
photography in a youth correctional facility.

Scientific and Technical Visualization Curriculum

Based on visual learning, the Scientific and Technical Visualization Curriculum
was designed to increase interest and understanding of geometry and science concepts;
enhanced capabilities to visualize in both two (2-D) and three (3-D) dimensions; improved
presentation skills as applied to mathematical and scientific concepts; higher competency in
using the internet for accessing, processing, and sharing information (Clark and Mathews,
2000). According to Clark and Wiebe (2000) state that the scientific visualization courses,
with which the scientific and visualization curriculum is created, expose students to all of the
major and conceptual areas associated with visualization and give them experience in a broad
range of graphic techniques. Also through this curriculum, students use analytical and
communication tools to gain better understanding and appreciation and the advantage of
being able to apply the new acquired skill – visualization — to further study the sciences
enter the workforce or continue their study in multiple professions (Clark and Mathews,
2000).

The primary areas covered in the scientific and visualization curriculum courses
include: basic design process, graphing, image processing, animation, simulation,
presentation, and publication (Clark and Mathews, 2000). Although the Scientific and
Technical Visualization Curriculum is developed as a vocational track, it could be integrated
with other academic subjects. The concepts and information used throughout the curriculum
can be integrated easily into mathematics, science, and technology education classes (Clark & Wiebe, 2000).

Technology Education

Kaspryzk (1980) wrote that the word “technology” was originally derived from the ancient Greek words té chne (or techné) and logos and it has been synonymous with manual and oratory skill, rhetorical, “art ”productive science, wisdom and disciplined faculty (Kaspryzk, 1980, p.21). In 330 B.C. Aristotle combined techné and logos in order to derive the word “technologia.” This was eventually changed to “technology” by Johan Beckmann of Gottigen University in his book Introduction to Technology (Engstrom, 2000).

In 1981, Snyder and Hales defined technology in their monograph entitled Jackson’s Mills Curriculum For Industrial Arts. For definition see Table 4. Also many educators have viewed the term “technology education” differently (see Table 4).

Table 4

<table>
<thead>
<tr>
<th>Technology Education definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mills Curriculum, 1981</td>
</tr>
<tr>
<td>The knowledge and study of</td>
</tr>
<tr>
<td>human endeavors in creating and using tools, techniques and recourses, and systems to manage the man-made and natural environment for the purpose of extending human potential and the relationship of these to individuals, society and the civilization process (Snyder and Hales, 1981, p.2).</td>
</tr>
</tbody>
</table>

(Snyder and Hales, 1981, p.2).
Valesey (2003) states that one of the philosophical foundations for technology education was pragmatism. She describes John Dewey (1859-1952) as the best-known pragmatist who suggested that the “purpose of reflective thought is to turn obscurity into clarity, and that this is knowledge” (p.32). Dewey’s (1940) belief in practical hands-on education is reflected with this passage from *The Child and the Curriculum*:

> We cannot overlook the importance for educational purposes of the close and intimate acquaintance got with nature at first hand, with real things and materials, with the actual process of manipulation, and the knowledge of their social necessities and uses. The educative forces of the domestic spinning and weaving, of the sawmill, the gristmill, the cooper shop, and the blacksmith forge, were continuously operative (p.11).

In writing specifically about vocational education, Dewey (1944) remarked:

> Nothing is more tragic than failure to discover one’s true business in life, or to find that one has drifted or been forced by circumstances into an uncongenial calling. The right occupation means simply that the aptitudes of a person are in adequate play, working with a minimum of friction and a maximum of satisfaction (p.308).

Reed (2003) states the connection between earlier curricula and the ones used today:

> Technology education has historically incorporated inquiry into laboratory instruction. Early forms of this instructional strategy, however, focused more on tools, materials, and technical processes rather than structured cognitive process. The *Maryland Plan: Industrial Arts Program for the Junior High* (Maley, 1970) was one of the earliest programs that utilized an inquiry-based instructional approach in order to focus on the cognitive benefits of technology education (p.123).
One of the earlier curriculums, *The Maryland Plan* was developed by Donald Maley of the University of Maryland and focused on reviewing technological approaches involving tools and machines, power and energy, and transportation and communication (Stotter, 2004). The Maryland Plan supported the notion that technological problems could be incorporated in an anthropological study of modern industry, and Maley introduced the technological systems approach in the design of technology education programs. Maley’s design included communications, production, transportation, and their subsystems (Maley, 1969).

*In A Curriculum to Reflect Technology* (Warner, 1947), the major subject classifications were based upon six areas of industry; power, transportation, manufacture, construction, communication, and personnel management (Warner, 1947). A subsequent book by Delmar W. Olson (1963), *Industrial Arts and Technology*, proposed a design approach that put emphasis on the individual student searching for a unique solution instead of building teacher designed projects.

In 1966, Paul W. DeVore of the State University of New York-Oswego proposed that industrial arts should emphasize the study of man and technology as demonstrated in the areas of products, transportation and communication as well as the utilization of the properties of matter and energy. According to DeVore the rejection of the occupational and pre-vocational curriculum for the development of industrial arts favored long-term goals rather than short-term goals and it was necessary (1988).

In 1968, The Ohio State University (OSU) published the Industrial Arts Curriculum Project (IACP) to promote another philosophy about the industrial arts curriculums. *IACP* speaks of four domains of human knowledge: “formal, descriptive, prescriptive, and
praxiological.” This last term, praxiological knowledge, was described as the knowledge of practice and was roughly equivalent to the description of technology proposed by Warner (1947, p.255).

During the same period that the IACP project was being formulated at OSU, the American Industry Project (AIP) was developing curriculum at the University of Wisconsin-Stout (Stotter, 2004). The AIP endeavor suggested that the central focus of industrial arts should be the 13 basic concepts of industry: “communication, transportation, finance, property, research, procurement, relationships, marketing, management, production, materials, processes, and energy” (1947, p.255).

According to Stotter (2004), in 1981 the curriculum committee of the American Industrial Arts Association gathered 21 leaders representing all geographical areas of the nation. The purpose of this project, known as the Jackson’s Mill Industrial Arts Curriculum Symposium, was an effort to chart a unified direction for industrial arts. The project report was the culmination of three meetings over a two-year period. The Jackson’s Mill Industrial Arts Curriculum Theory (Snyder, 1981) was based on human productive activities.

The model determined that the focus of industrial arts should be on the study of industry and technology and their impact on society and culture. The model proposed that industrial arts should include the human productive activities of communication, construction, manufacturing, and transportation.

Based on the 1981 focus of industrial arts, multiple instructional materials were developed to achieve knowledge transmission. A plethora of such materials was created based on various learning styles and teaching strategies to promote the new academic goals. Instructional materials using technical and scientific visualizations were among those.
Technology Education and Visualization

By using simple and complex visualization tools, students can conduct research, analyze phenomena, solve problems and communicate major topics identified in the Standards for Technology Literacy (STL) as well as topics aligned with national science and mathematics standards (Wiebe, Clark, Petlick & Ferzli, 2004).

Ernst and Clark (2006), state that a technologically literate person understands and effectively communicates basic technological concepts, processes, and interrelationships with engineering, mathematics, science, and society. Communication technology is an integral component of technological literacy; therefore, modeling, visualizations, and presentations enforce communication technology concepts (Ernst & Clark, 2006). Having strong communication concepts strengthens individual’s technological and scientific knowledge and abilities while providing students with an opportunity to gain a firm grasp of engineering principles behind the technologies (Newhagen, 1996).

The study of engineering, mathematics, science, and technology-based content and the application of conceptual modeling, data-driven visualizations, physical modeling, and presentations promote visual literacy (Ernst & Clark, 2006). Visual and technical literacy maintains a significant role in successful knowledge and skill development in engineering and technology career paths (Wiebe, Clark, Ferzli & McBroom, 2003). A lead has to be to correlate technology education subjects and visualization through grants that promote the creation of supplemental visual-based learning material for technology education curricula.
Visual-based Material Grants

VisTE

According to Ernst and Clark (2006) in May 2002, the Department of Mathematics, Science and Technology Education in North Carolina State University’s College of Education received a three-year grant from the National Science Foundation to develop instructional units that utilize scientific and technical visualization. VisTE (Visualization in Technology Education) promotes technological literacy by attempting to link engineering, mathematics, science and technology concepts (Ernst & Clark, 2006).

Wiebe, Clark, Ferzli and McBroom (2003) stated that the VisTE project takes a different approach to determine how graphic communication and other subjects can be integrated into technology education. Its project goals aim to promote technological literacy through the use of scientific and technical visualization tools and techniques (Figure 5).
Three years after the starting date, the VisTE project has developed 12 units for technology education for grades 6 to 12. The VisTE units are based on benchmarks identified in the Standards for Technological Literacy developed by the Technology for All Americans Project through the International Technology Education Association (Ernst & Clark, 2006). The twelve units, otherwise known as topics, are shown below (Table. 5).
Table 5

*The Twelve VisTE Units*

<table>
<thead>
<tr>
<th>Unit</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Communications Technology: Introduction to Visualization</td>
</tr>
<tr>
<td>2</td>
<td>Medical Technology: Imaging</td>
</tr>
<tr>
<td>3</td>
<td>Biotechnology: The PCR</td>
</tr>
<tr>
<td>4</td>
<td>Transportation Technology: Visualizing Rocketry</td>
</tr>
<tr>
<td>5</td>
<td>Communications Technology: Introduction to 3D Modeling and Animation</td>
</tr>
<tr>
<td>6</td>
<td>Energy and Power Technology</td>
</tr>
<tr>
<td>7</td>
<td>Bioprocessing</td>
</tr>
<tr>
<td>8</td>
<td>Prosthetics</td>
</tr>
<tr>
<td>9</td>
<td>Weather</td>
</tr>
<tr>
<td>10</td>
<td>Nanotechnology</td>
</tr>
<tr>
<td>11</td>
<td>Biometrics</td>
</tr>
<tr>
<td>12</td>
<td>Careers and Technology</td>
</tr>
</tbody>
</table>

*Note.* From “Supporting technological literacy through the integration of engineering, mathematic, scientific, and technological concepts: The Twelve VisTE Units” by Ernst, V. E., Clark A. C. (2006)., *Published proceedings of the American Society for Engineering Education Annual Conference and Exposition*, Chicago, IL, Session 370.

VisTE research is based on five basic areas of investigation: 1) student test scores on knowledge of technology; 2) teachers’ ratings of the effectiveness of VisTE regarding enhancing students’ understanding of intended learning goals; 3) teachers’ ratings of effectiveness regarding enhancing students’ understanding of real-applications of technology; 4) students’ self-concept of ability in technology, mathematics and science; and 5) students’ attitudes toward general technology (Ernst & Clark, 2006).
To measure the students’ knowledge of the subject area pre and post, multiple-choice tests were used. Also, the instructional units were examined through a student survey used to indicate any influence of VisTE on students’ self-concept of ability in technology, mathematics or science (Ernst & Clark, 2006). The student survey was constructed with three main questions: 1) How hard or easy is it for you to learn technology? 2) How hard or easy is it for you to learn science? 3) How hard or easy is it for you to learn visualization? A 5-point Likert scale was used for the answers where 1 = very hard, 2 = hard, 3 = neither hard nor easy, 4 = easy, 5 = very easy. The data indicated that participation in VisTE was related to a slight increase in students’ self-concept of mathematical ability but was not related to changing students’ self-concepts of abilities in technology and science (Ernst & Clark, 2006). However, the examination of self-concept of ability was not the only factor assessed by VisTE. The relationship between participation in VisTE and students’ attitudes toward general technology were explored (Ernst & Clark, 2006).

TECH-Know

Science, mathematics, and technology (SMT) literacy is vital to US national interests, in particular to maintaining the economic health of the nation and the well-being of its citizenry, making the success of SMT education especially important. While science and mathematics education have been criticized in the past for being too theoretical and lacking in application, technology education (TED) has been criticized for emphasizing the making of things without sufficient grounding in theory (Peterson, 2000).

In August 2001, North Carolina State University received a four-year grant from the National Science Foundation to develop standards-based instructional materials for 20 Technology Student Association (TSA) activities. The TECH-Know Project represents a
significant collaboration between selected state departments, universities, businesses, and TSA. Having 144 technology education teachers involved, TSA curriculum resource committee members and business representatives from across the country, 20 units of instruction based on the Technology Student Association activities were created (Ernst, Taylor & Peterson, 2005). Table 6 shows all units.

Table 6

*The TECH-Know Units*

<table>
<thead>
<tr>
<th>Middle School Units</th>
<th>High School Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture and Biotechnology Challenge</td>
<td>Agriculture and Biotechnology Design</td>
</tr>
<tr>
<td>Cyberspace Pursuit</td>
<td>Desktop Publishing</td>
</tr>
<tr>
<td>Digital Photography</td>
<td>Film Technology</td>
</tr>
<tr>
<td>Dragster Design</td>
<td>Manufacturing Prototype</td>
</tr>
<tr>
<td>Environmental Challenge</td>
<td>Medical Technology Design</td>
</tr>
<tr>
<td>Flight Challenge</td>
<td>Radio-Controlled Transportation</td>
</tr>
<tr>
<td>Mechanical Challenge</td>
<td>Scientific Visualization</td>
</tr>
<tr>
<td>Medical Technology Challenge 1</td>
<td>Structural Engineering</td>
</tr>
<tr>
<td>Structural Challenge</td>
<td>System Control</td>
</tr>
<tr>
<td>Transportation Challenge</td>
<td>Technology Challenge</td>
</tr>
</tbody>
</table>


According to Ernst, Taylor & Peterson (2000) each TECH-Know unit consists of a student edition and teacher’s guide. The content in each instructional unit reflects Standards for Technological Literacy, Principles and Standards for School Mathematics, and National Science Education Standards. The TECH-Know units can be considered as visual-based since they all have combative projects focused on physical modeling, virtual modeling and
presentations. However, there are selected units that have more emphasis in visual learning, such as SciVis. The goal of Sci Vis is to learn about the role that scientific visualization plays in our modern world and to use the technology to present information (Tech-Know, 2005, p. 3). After studying SciVis and completing the activities, students, should be able to meet the following objectives (Table 7):

Table 7

SciVis Objectives

<table>
<thead>
<tr>
<th>Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demonstrate the role visualization has in scientific and technical communication.</td>
</tr>
<tr>
<td>Develop SciVis models for communicating scientific and technical information</td>
</tr>
<tr>
<td>Develop research skills for the collection of data needed for scientific visualization presentations.</td>
</tr>
<tr>
<td>Develop hardware and software computer skills needed to develop visualizations for a particular audience.</td>
</tr>
<tr>
<td>Learn to work in teams.</td>
</tr>
<tr>
<td>Produce a final visualization that requires the collection of data. Then use the development of a conceptual and a data-driven model for presentation to a given audience.</td>
</tr>
<tr>
<td>Have an enhanced ability to use graphics to communicate scientific and technical information better using 2-D, 3-D, static, or dynamic modeling techniques.</td>
</tr>
</tbody>
</table>

According to Ernst, Taylor & Peterson (2000), the framework established by the Standards for Technological Literacy defines the content for each unit. The Student Edition contains vignettes and the contextual information for real-world application. Four pilot states were selected based on interest in standards-based learning and the project. North Carolina, Virginia, Oklahoma, and Florida developed, piloted, and revised the units to reflect the TSA activities and Standards for Technological Literacy in technology education classrooms.
across the country (Ernst, Taylor & Peterson, 2005).

The TECH-Know units of instruction provide teachers the opportunity to be more successful by integrating cross-curricular, project-based, and problem-based learning in a real world context. According to Blue (2006) the TECH-Know Project developed co-curricular instructional materials that are closely aligned with foundational science, technology and mathematics concepts. Students are able to make connections to math, science, and technology while enhancing their understanding of the concepts embedded in these activities.

Materials such as the units from VisTE and TECH-Know constitute only a small percentage of visual-based instructional materials available to educators. However, being able to identify the ones that promote knowledge transmission and student learning requires further instructional tools such as quality indicators and teaching components. To be able to identify those indicators educators must first define the term quality itself.

Quality

What is the definition of quality? The Baldrige National Quality Programs core values supported the concept that the customer ultimately is responsible for defining quality. Quality is a function of learner expectations (Mustian, 1998). Quality refers to the amount of learning during trials. Learning trials that are qualitatively stronger require fewer trials to meet a standard. Likewise, the quantity of learning trials also can enhance learning. This can be done by increasing the time allowed for participating in learning trials (Skinner, Fletcher & Henington, 1996).

Therefore, we may all agree on the need for quality. Can we adequately identify the criteria for quality instructional materials? Each one of us has a different perception of quality instructional materials. So the real issue becomes not “what is quality”? but “how can
we reach consensus on the parameters of quality?” (Barbe, 1983). Senge (1990) defined quality as all the things that matter to a customer. Senge said that the things that matter are product quality, service quality, and delivery reliability.

Quality Indicators

Quality may be illusive or difficult to quantify. Quality indicators may be qualitative or quantitative. Taylor (1994) placed extension program indicators into three categories: process, client benefit, and consequence. Qualitative indicators such as those in human sciences are usually more difficult to assess behavioral impacts (Taylor, 2004). Many instruments that claim to measure quality are really focused on customer satisfaction surveys (Israel, 2004). This fact has not stopped education and business segments of our society from striving for high quality standards. American industries were challenged to address the serious problems associated with poor quality products in an international market. The education sector has subsequently followed in the search for quality.

Quality in Higher Education

Boyle and Bowden (1997) defined quality in higher education from an ethical perspective in very simple terms as “the value that is the right thing to do” (p.112). They state that highly effective institutes of higher education are concerned about quality for three primary reasons. The first is the moral obligation to all stakeholders to provide an educational environment of the highest possible quality. The second is competitiveness. In order to remain competitive in a market-driven environment, institutes of higher education must demonstrate they offer a “quality product.” The third is accountability. In an environment of limited resources, stakeholders are using quality indicators to allocate resources. Quality is comprised of the principles and values that are primary to the
organization and should be viewed as a dynamic concept that require continuous quality improvement (Boyle & Bowden). Adopting the same philosophy as in higher education the discipline of technology education has also consistently pursued quality.

Quality in Technology Education

Since its beginning, technology education has pursued quality outcomes consistently. Especially during the past 25 years, the process of establishing standards, or outcomes, has been a major area of focus at both the national and state levels (Dugger, 1988). However, what constitutes the elements of quality has not been adequately investigated. Henak (1992) declared that quality learning in a technology education program comes from the content, learning process, experiences, and growth opportunities offered to students.

The problem of educational quality and its assessment extends to the whole of education. According to the Education Commission of the States (1992), even though there have been many attempts to develop educational standards, new information on assessing the quality of education provided in schools, districts, and states is lacking. The Federal Coordinating Council of Science, Engineering, and Technology (1993) added that an evaluation process is needed in each state to analyze programs so that questions about the quality of a program can be answered. Further, if responsible change efforts are to be made to establish quality in a technology curriculum, they must include a structure for an objective and critical assessment of each program in order to establish benchmarks for the process (Dyrenfurth, Custer, Loepp, Barnes, Iley, & Boyt, 1993). Establishing quality programs also requires quality instructional material to transmit the content and knowledge of such curriculum.
Quality Instructional Material

An enduring question for educational research is the effect of individual differences on the efficacy of learning. Aspects of individual differences that have been much explored relate to differences in learning styles, strategies and concepts of learning. Such differences present a profound challenge for instructional designers, as research has shown that the quality of learning material is enhanced if the material is designed to take into account learners' individual learning styles (Rasmussen, 1998; Riding & Grimley, 1999).

Chapter Summary

This chapter reviewed three major areas of development of quality indicators for visual–based learning material. The first area, learning styles, traced different learning styles and gave detailed information about the development and usability of learning styles within the context of instructional material development and also the development of curricula. Theories such as Kolb’s learning styles were reviewed for a more holistic view and understanding of the different learning styles. The correlation between teaching technique and learning style also was studied to aid with instructional material development since most teaching theories are based upon one or more learning styles. More emphasis was given to the visual learning with theories of support and application models.

Part two of the review of literature began with a review of defining instructional material and it’s development. Greater emphasis was given towards visual-based instructional material. The components that construct visual-based instructional material such as visualizations and their efficiency were studied in greater detail. With the philosophy in mind that understanding the validity of key components of visual-based instructional material, will lead to the creation of more effective learning material other subcomponents
such as descriptive and depictive representations and realism in visualization were also a part of the research agenda. Finally, specific, technology education visual-based instructional materials and scientific and technical visualization curriculum were studied to help identify basic indicators that visual-based instructional materials need in order to be effective in the learning process. Quality indicators of similar materials also were identified during this process.

Part three of this chapter reviewed the philosophy of technology education, traced the profession’s history and gave detailed information about the development of the profession and how different early leaders’ philosophies helped establish and develop visual-based instructional materials for technology education programs. Technology education visual-based material grants also were researched and two major ones, VisTE and TECH-Know, were identified and studied in more detail. Identifying the quality indicators of the materials produced in the two grants played an important role in the development of the study.
Chapter Three: Methods and Procedures

Delphi Method

The Delphi method is based on a structured process for collecting and distilling knowledge from a group of experts by means of a series of questionnaires intersected with controlled consensus opinion feedback (Clayton, 1997). The technique was introduced in 1958 through Project DELPHI directed by the Rand Corporation to predict alternate national defense features. It is a procedure to “obtain the most reliable consensus of opinion of a group of experts...by a series of intensive questionnaires interspersed with controlled opinion feedback” (Dalkey & Helmer, 1963, p. 458). Studies comparing the Delphi’s results with other methods confirmed the effectiveness of the method related to generating ideas and the use of participants’ time (Ulschak, 1983). Lang (1998) described the Delphi method as the best known qualitative, structured, and indirect interaction research method to study current and future events.

The Delphi method has several advantages that make it useful. First, it is an efficient method to obtain information from experts and to reach consensus, for after each round, the panelists are confronted with their own ratings in comparison with the mean score and standard deviation on each item (Martino, 1993). Furthermore, the bias of dominant views within group discussions is avoided (Lang, 1998); members can consider individually which indicators for visual-based learning material they find important for this study.

In summary, the following statements highlight many of the advantages of using the Delphi method as a research tool: (1) it is a rapid and relatively efficient manner in which to acquire expert opinions (Dalkey, 1969); (2) if well designed, the procedure requires less effort of respondents than a conference (Dalkey, 1969); (3) the systematic procedures give
the appearance of objectivity to the outcomes (Dalkey, 1969); (4) there is a sense of shared responsibility due to anonymity, which decreases social inhibitions (Dalkey, 1969); (5) information can be obtained from a large group of experts that are geographically widely dispersed, and who may be of diverse backgrounds or live in remote locations (Strauss & Zeigler, 1975); (6) the researcher has an increased ability to focus the group’s attention on the topic of interest (Weatherman & Sevenson, 1974); (7) it increases rational input (Skutsch & Hall, 1973); and (8) it is a relatively inexpensive means of gathering group opinion.

Although many of the advantages of using the Delphi method were just described, a researcher also must be aware of its disadvantages, which follow. In summary, the following statements highlight many of the disadvantages of using the Delphi method as a research tool: (1) there is evidence for questioning the accuracy of Delphi forecasts and its utility (Weaver, 1971); (2) the inductive analysis of responses to the initial questionnaire may lead to problems in interpretation; (3) the improvable nature of a Delphi makes its utility subject to the influences of unforeseen events, such as scientific discoveries, politics, and events in nature (Linstone, 1978); (4) lack of assurance of consensual agreement by panel members; (5) motivating panel members to participate in the Delphi, and maintaining their interests in each subsequent round of questions.

Literature in general mixes both advantages and criticisms of using the Delphi method in making predictions. The common criticisms are uncertainty about the future, subjective judgment of experts, and required multidisciplinary perspectives (Stillwell, 1999). Sackman (1975) argued that the Delphi method neglects major areas of professional standards for questionnaire design, administration, application, and validation. Despite this imperfection, many researchers agree that the Delphi method is a valuable tool for
educational forecasting and planning (Lang, Martino, Ulschak & Welty, 1973). Linstone and Turoff (1975) established criteria to determine the appropriateness of using the Delphi method:

1. When the problem does not lend itself to precise analytical techniques but can benefit from subjective judgments on a collective basis.

2. When the individuals who need to contribute to the examination represent diverse backgrounds with respect to experience or expertise.

3. When more individuals are needed than can effectively interact in a face-to-face exchange.

4. When the time and cost make group meetings infeasible.

5. When disagreements are so severe or politically unpleasant that the communication process must be refereed and/or anonymity assured.

6. When the heterogeneity of the participants must be preserved to assure validity of the results and to avoid domination by the strength of certain personalities.

7. When a supplemental group communication process can help the efficiency of face-to-face meetings (p. 59).

This study meets these criteria except item number 5 where severe disagreements or politically unpleasant situations do not exist. Since all the other criteria were met and because of the need to have consensus on quality indicators for visual-based learning materials for 7-12 grade technology education programs in US the modified Delphi method was used to conduct this study.
Computer-based Delphi

According to Turoff and Hiltz (Turner & Turner, 1999), the computer-based Delphi method has a number of advantages over paper-and-pencil Delphi: (1) asynchronous interaction used in Delphi procedures is more easily accomplished; (2) contributors can have continuous access to the emerging database by contributors without prior summarization and possible introduction of bias by the investigators; (3) participants can update themselves frequently about the discussion before contributing, enabling a more informed contribution and less duplication of responses; (4) responses can be screened more easily prior to distribution; record keeping, data processing, and statistical analyses are facilitated; (5) communication among participants is faster and less costly; participants who are geographically distanced can be included; (6) A structure for the dynamic contribution of knowledge over time can be provided (p. 127).

Web-based Delphi

Traditional methods of survey distribution and collection that utilize the US postal system are slow and provide low rates of return. Internet technology provides a medium to decrease the amount of response time and provides easy follow-up using electronic mail (Turner & Turner 1999). Many existing research studies in the area of information technology are utilizing the Internet and the World Wide Web as media to collect consensus data (Nesbary, 2000).

The World Wide Web spans the globe, and geographical boundaries are becoming less of an issue in communication. Because of advanced online capability, the cost of survey administration for educational research is becoming cheaper and the amount of work required in survey distribution, collection and analysis is greatly reduced. Although studies remain to
be done, the validity of web-based survey research is likely to be strongest for researchers who target specific population samples (Watt, 1999). Early methods of Internet-based data collection typically embedded the instrument directly in the body of an e-mail message and requested the response to be replied to as an attachment or modification of the original message. However, researchers are increasingly directing participants to complete instruments that have been published as web pages (White & Dailey, 2001).

**Delphi Panel Selection**

Panel selection is critical in using the Delphi method (Lang, 1998). The success of a Delphi method rests upon selecting appropriate experts qualified in the subject area. The effective selection of the panel not only maximizes the quality of responses but also gives the results of the study credibility. The two primary advantages of e-mail panel selection over traditional recruitment approaches are time and cost (Andrews & Allen, 2002).

According to Lang, random selection of the participants is not acceptable. Instead, indicators and qualifications of desirable respondents should be identified in order to select participants. For this modified Delphi method, the panel members were selected purposefully. The selection of experts was done via e-mail communication (see Appendix A).

Simultaneous e-mail messages can be sent to all potential panelists, as opposed to sending individual mailings. Response time to e-mail inquiries is faster also than the time generally observed with mailed solicitations. Cost savings is a major plus since the cost of an individual e-mail message is negligible and the cost of postage is eliminated.

**Sources for Potential Panelists**

To create the necessary panel of experts for this study, two sources for experts in or related to the field or visual-based learning material was determined. The sources that the
researcher and reviewers agreed upon were (a) subject-specific grant participants and (b) subject-specific literature authors.

The size of the panel is one of the most important parts of a successful Delphi method. Therefore, a need for a sufficient number to ensure that the results of the study represent a true cross-section of experts and have a significant degree of reliability is necessary (Delbecq, Van ve Ven & Gustafson, 1975).

Delbecq, Van de Ven & Gustafson (1975) suggested using the minimized sufficient number of respondents, which is between 15 and 20, because large numbers of respondents generate many items and ideas, which makes the summarizing process difficult. Dalkey, Rourke, Lewis & Snyder (1972) reported that there was a definite and monolithic increase in the reliability of group responses with increasing group size. Linstone and Turoff (1975) suggested a panel size of anywhere from 10 to 50 participants and a reliability with a correlation coefficient approaching .9 was found with a group size of thirteen.

It has also been reported that the validity and reliability of the Delphi method does not improve significantly with more than 30 participants. According to Dalkey and Helmer (1963), although reliability increases as a panel gets larger, the increase is slight once 30 participants is surpassed. Delbecq, Van deVen, and Gustafson (1975) found that the error rate decreased rapidly as the group size increased from one to about thirteen; further small decreases in error rate continued to a size of about 25 people, at which point the error rate stabilized. Based on these findings, the researchers continued their experiments using groups of 15 to 20 people. The panel size of 21 for this study fits within the guidelines recommended for the modified Delphi method.

Selection of visual-based learning related grants was to seek appropriate
participants who are capable of identifying the quality indicators of visual-based learning material in technology education programs. A list of possible grants was selected to include visual-based learning material practitioners and theorists. The study needed panel experts who had ideas about what quality indicators would be required to exist in visual-based learning material in technology education programs to promote effective and efficient student achievement of designated learning objectives.

The first grant, VisTE (Visualization in Technology Education), was selected because of its relevance to the subject of visualization since its purpose was to create 12 units of instruction that incorporate visualizations into every day curriculum in technology education. The second grant, TECH-Know, was selected also because of its relevance to the subject. The TECH-Know units can be considered as visual-based since they all have combative projects focused on physical modeling, virtual modeling and presentations. However, there are selected units that have more emphasis in visual learning, such as SciVis. According to TECH-Know’s website description:

Participants in SciVis develop visualization focusing on a subject or topic from one or more of the following areas: technology, engineering, science, mathematics, social studies, or the arts (TECH-Know, 2004).

To identify potential participants for the study, an email was sent to the principal Investigator (PI) of each selected grant. The email described the purpose of the study was described and PI’s were asked to nominate up to 45 teachers as study participants. To be considered as a panelist in the study, participants must have met four out of five of the following criteria that were determined by the researcher and the reviewer panel of the study.
1. Current involvement in education with research and service as an education professional with a minimum of five years teaching experience with visual-based learning material in technology education.

2. Leadership in developing, implementing, and evaluating educational material for visual-based learning in technology education.

3. Record of publications or presentations in the field of visual-based learning material in technology education.

4. Model of professional teaching practices, which demonstrate knowledge, skills and attitudes for visual-based learning.

5. Regular collaboration with school, university, and state education department, professional associations, grants and community representatives to improve visual-based learning teaching and learning.

Group Nomination

During December 2006, the researcher contacted the PI’s of the two selected grants to receive the names of nominated grant participants that meet the selection criteria (see Appendix A for a copy of the letter). Dr. Clark, the PI of VisTE, has submitted 19 names and Dr. Richard Peterson, the PI of TECH-Know, 50 names. The names of two individuals were present on both lists however they were counted only once. Therefore, the overall number of referred participants became 67.

Potential Participant Identification

The potential participants to serve on the expert panel were identified (N=67). These individuals were nominated because they met the selection criteria. The expert panel selection was stratified according to middle school and high school technology education
instructors to ensure expert knowledge and experience with all different ages of students. From the 67 names, 53 were identified as being relevant with middle or high school. The randomization process used for this part of the study involved assigning a number starting from 1 to 53 to all 53 names. The random selection operation of a scientific calculator was used to identify twenty one names from the list.

During January 2007, all 21 individuals nominated for inclusion in the initial group of possible expert panel members were contacted first by email with 3 attachments: (a) Invitation Letter (see Appendix B); (b) Study Overview (See Appendix B); and (c) Study Participation (see Appendix B) to be a part of the study.

The next phase of panel selection was to identify candidates to be on the review panel for pilot-testing all instruments to be used in the Delphi method (Mayer & Booker, 1990, p. 141). Names of people that were a part of the initial stratifying process but not chosen to be on the expert panel were placed in a box for random selection to be on the review panel. Once three names were selected randomly these individuals were asked to participate on the review panel.

Final Panel Group

From the group nominated, 21 out of the 53 (39.6%) visual-based learning material experts agreed to participate in the study. The resultant 21-member panel of visual-based learning material in technology education consisted of 10 males and 11 females from two different grants. Panel experts identified for potential participation were technology educators that participate in one of the two grants as pilot or field testers, visual-based learning material authors, visual-based material in technology education practitioners.
Demographics Survey

In order to justify the expertise of the individuals selected to be a part of the expert panel, a demographics survey (see Appendix C) was created and hosted on the study’s web page (see Appendix A) for every participant to visit and complete. Prior to the survey completion, an email that included username and password—necessary to access the survey—was sent to all participants for data security reasons. In the demographics survey nine questions were asked:

1. Which title most accurately describes your current position? The purpose of this question was to justify that all participants have been involved with visual-based related material and have enough experience to be considered as experts;

2. Which of the following grade level(s) do you currently teach or oversee? One of the qualifying indicators of the participants is the teaching background;

3. What is the highest degree obtained as of January 1, 2007? All participants are required to hold at least a bachelor’s degree and have enough educational background to understand the questions of the study;

4. What is your gender? For demographic purposes and further research that correlates gender and visual expertise;

5. Year of graduation? To identify the participants’ age and do further research;

6. Current residence? To help with the stratifying process and create a more representative population of participants;

7. Have you been involved in VisTE and/or TECK-Know? To justify that all participants are familiar with the visual-based learning material;
8. Have you had any type of visual training within the last 5 years? To justify that all participants are aware of any changes that took place within the last five years and relate to visual-based learning material;

9. What courses have you taught in the last 2 years that require visual teaching/student capabilities? The purpose of this question is again to justify that the participant has been active with visual related material; therefore, the responses will be more valid.

The researcher and committee chairperson set those qualifications in accordance with guidelines for defining an expert to become a panel member as indicated by Meyers and Booker (1990). This diminished the possibility of researchers choosing someone only because of like beliefs or attitudes towards the subject matter (Mayer & Booker, 1990).

After receiving correspondence from the demographic survey participants a meeting with the review panel analyzed the results and modifications made to the data. The researcher examined the data using numerous methods of data presentation and statistical analysis. Analysis was conducted of data collected from middle school and high-school program respondents who served as the panel of experts for this study. To better understand the method of data analysis Figure 6 was created.
Figure 6. Method of Data Analysis

- Develop Instrument One: include letter, demographic survey, and instrument
  - Send to review panel for feedback
  - Send to panel experts
  - Combine answers given from panel experts
- Develop Instrument Two: include letter (Likert scale for rating)
  - Send to review panel for feedback
  - Send to panel of experts
- Analyze information collected from Round II: calculated mean, rank and median. Keep indicators above 3.01
- Conduct the Kruskal-Wallis, Whitney Mann U and Spearman’s rho Tests
- Develop Instrument Three: include letter and instrument (final form for consensus data)
  - Send to review panel for feedback
  - Send to panel of experts
  - Develop indicators into final form
  - Conduct the Whitney Mann U test
  - Email indicators in final form to all participants
Instrument Design and Implementation

Round I

The instrument for Round I (see Appendix C) of the modified Delphi method was developed from information found in the review of literature. Examples of quality indicators were established and placed in a survey instrument to indicate the actual format in which the indicators were written. The next step was to receive the approval from the review panel. Instruments were sent to the review panel for review and approval of the example indicators. Once the review panel approved the Round I instrument, it was accessible to the expert panel through the study’s web site. An email also was sent to the expert panel members after two weeks to remind them to reply (see Appendix C). The Round I instrument for this study consisted of examples of indicators provided to the expert panel to help them understand better the type of information and writing style the study was identifying. Those examples were derived from the literature review that the researcher conducted prior the instrument design. However, the main component of Round I was the collection of a new set of indicators suggested from the experts rather than the modification and acceptance or rejection of given indicators.

After completion of the Round I instrument by the panel of experts, all new suggested indicators were added to the instrument for Round II and changes were made to pre-existing given indicators. The newly created instrument for Round II then was sent to the review panel for approval. Once the review panel returned the instrument for Round II with their suggestions, all changes were made.
Round II

Round II of the modified Delphi method included the rating and ranking of those indicators from Round I. The instrument was developed and emailed to the review panel for verification (see Appendix D). The indicators were presented in random order. During this round, a rating process was established for evaluating the ideas expressed during the previous round. According to Linstone and Turoff (1975), a rating system must be established for such items as the relative importance, desirability, confidence and feasibility of various policies and issues. Furthermore, these scales must be carefully defined so that there is some reasonable degree of assurance that the individual respondents make compatible distinctions between concepts (p. 89).

Round II was used to rate the responses given in Round I on a Likert scale of one to five with one being strongly disagree and five being strongly agree. Electronic forms with radio buttons were used so the expert panel member could click a button representing the scale number selected upon receiving this information; the mean, median and standard deviation were developed for each item. Only the indicators with a mean of 3.01 or higher were represented on Round III. Those indicators with a statistical mean of less than three were eliminated as not being within the consensus, those indicators with a score of 3.01 or higher were kept for Round III (Rojewski & Meerrs, 1991; Mayer & Booker, 1990).

The second step in Round II was the ranking of the indicators received from Round I where participants reviewed the indicators kept after analyzing Round I and ranked each one in order of importance (Wicklein, 1993; Meyer & Booker, 1990). Each indicator kept from Round I was placed randomly in a list with a textbox provided underneath for ranking from most to least important. Also, the expert panel was given a final chance to add any new
indicators or edit any of the existing ones. To accomplish this, a text box was created at the end of the second round instrument that allowed experts to type the new or edited indicator. Within the textbox it was stated that any new indicators that were added had to be ranked and rated also.

Upon receiving the responses from Round II, the researcher met with Dr. Kim Weems, a professional statistician at North Carolina State University, to discuss the statistical analysis of the data collected. Among the statistical tests that were identified to be suitable for this study was the Kruskal-Wallis test.

The Kruskal-Wallis Test was conducted to rank the response elements from lowest to highest in the two designated samples (Hinkle, Wiersma, and Jurs, 1979). This test is an alternative to the One-Way Analysis of Variance, when the measurement scale assumption is not met. This, like many non-parametric tests, uses the ranks of the data rather than their raw values to calculate statistics. For this study the quality visual-based learning material indicator survey data is ranked. Hinkle, Wiersma, and Jurs (1979) also indicate that in the Kruskal-Wallis test the calculation of the p-value considers the central tendency of the responses and the total distribution of the responses for both groups. The sampling distribution for the p-value is used to test the null hypothesis against the alternative directional hypothesis. The calculated values for the p-value are evaluated in comparison to the critical values to determine if the null hypothesis is rejected or if there is evidence that fails to reject the claim. If the p-value is less than the critical value (\( \alpha = .05 \)) the null hypothesis is rejected; if the p-value is greater than the critical value the null hypothesis is not rejected. The null hypothesis for this test was:
The median of the middle school population for each quality indicator for visual-based learning material in technology education for grades 7-12 equals the median of the high school population for each quality indicator for visual-based learning material in technology education for grades 7-12.

\[ H_0: \Theta_1 = \Theta_2. \]

The alternative hypothesis for this test was:

\[ H_0: \Theta_1 \neq \Theta_2. \]

The Kruskal-Wallis test was used in this study to show a representation of consensus for each indicator. Most of indicators had a p-value higher than .05, which shows good representation of population consensus, and not enough evidence of a significant difference in-between the indicators. Also the researcher performed the Mann Whitney U test on each indicator as related to each of the two groups to analyze rate/ranking differences per individual for the responses of Round II. Because this was not a randomized sample, the researcher deemed it more appropriate to use non-parametric statistics. The Mann Whitney U test is one of the more popular nonparametric tests (Roscoe, 1975). The Mann-Whitney U test was used because of the concern about whether the t-test could detect significant differences due to the small sample size, and so not assume identical population sample distributions (Agresti et al., 1997). Significance was measured at an \( \alpha \) of .05.
The null hypothesis for this test was:

The median of the middle school population for each quality indicator for visual-based learning material in technology education for grades 7-12 equals the median of the high school population for each quality indicator for visual-based learning material in technology education for grades 7-12.

\[ H_0: \Theta_1 = \Theta_2. \]

The alternative hypothesis for this test was:

With respect to at least one of the inequalities, the median of the middle school population for each quality indicator for visual-based learning material in technology education for grades 7-12 is greater or less than the median of the high school population for each quality indicator for visual-based learning material in technology education for grades 7-12.

\[ H_0: \Theta_1 > \Theta_2 \text{ or } H_0: \Theta_1 < \Theta_2 \]

It is a suitable alternative to the t-test for two independent samples when the assumptions underlying the t-test cannot be met. This test is “almost as powerful as the t-test (about 95 percent relative power with typical research samples) and does not require homogeneity of variance nor normality of distribution” (Roscoe, 1975, p. 236). According to Popham and Sirotnik, (1992) the test can be employed with little loss in power. This test is based on the notion that if scores of two similar groups are ranked together, there will be considerable intermingling of rankings for the two groups. If the groups are different, however, most of the superior group’s rankings will be higher than those of the inferior group. Concentrating on the lower ranked group and counting the number of ranks of the high group that fall below the lower ranked group calculate the value of U. The Mann Whitney U test is equivalent to
the Wilcoxon 2-sample or Kruskal Wallis k-sample tests, and again, “is a suitable non-
parametric equivalent to the t-test” (Roscoe, 1975, p. 236). Since the assumptions described
above were being met with the indicators of this study, both the researcher and Dr. Kim
Weems, a statistician at North Carolina State University, agreed that the Mann-Whitney U
test was the appropriate one for this study.

In addition to Mann-Whitney U test, Spearman’s rank correlation coefficient
was used to indicate that consensus was transpiring between rounds. The Spearman’s
nonparametric test is suitable for the type of data found in this study, and the correlation
coefficient can be used for analysis of nonparametric data at both the ordinal and nominal
levels (Siegel, 1956). According to Gibbons (1976), it is noticeable that the use of these
nonparametric statistics as useful measures for data that has been ranked at the ordinal level.
He stated that, “if the distribution of such a variable is such that there is high correlation
between ranks and variate values, the nonparametric measures (Spearman, 1976) can be
interpreted as reasonable approximations to the association between the variables” (p. 295).
Gibbons also stated that the Spearman or Kendall Tau could be used to describe a style (such
as a learning style) as well as test a style or ranking of variables (1976). The only
requirements necessary to be used by these statistical measures were that the data be at least
at the ordinal measurement level and every subject be assigned a ranking order (Siegel, 1956,
p. 214-215). The null hypothesis for this test was:

**In the underlining population the sample represents, the correlation between the
ranks of subjects on middle school responses and high school responses equal
some value higher than 0,**

\[ H_0: \rho_s > 0 \]
The alternative hypothesis for this test was:

**In the underlining population the sample represents, the correlation between the ranks of subjects on middle school responses and high school responses equals some value lower or equal to 0,**

\[ H_0: \rho_s \leq 0 \]

The instrument for Round II was emailed to the review panel for member approval, who critiqued and reviewed the instrument.

*Round III*

The purpose of Round III was to develop consensus among expert panel members. This was accomplished by making the suggested modifications from the review panel to the upper 51 percent of indicators that were kept from Round II (Clark, 1997). Reviewers suggested changes including rewriting the instructions and rephrasing some of the indicators for better understanding and to eliminate ambiguity. In the third instrument (see Appendix E) panel members were asked to accept or reject only the final selections from Round II. In addition, participants were provided with the statistical analysis results from Round II: the median, mean and ranking of responses on each item. Experts were asked to check each characteristic and state whether it should be accepted or rejected.

To perform inferential statistics, the researcher performed the Mann Whitney U test on each indicator as related to each of the two groups in order to analyze rate/ranking differences.

As stated before, this test is based on the notion that if scores of two similar groups are ranked together, there will be considerable intermingling of rankings for the two groups. If the groups are different, however, most of the superior group’s rankings will be higher
than those of the inferior group. The value of U is calculated by concentrating the lower
ranked group and counting the number of ranks of the higher group that fall below the lower
ranked group. Significance was measured at an α of .05.

The null hypothesis for this test was:

The median of the middle school population for each quality indicator for visual-

based learning material in technology education for grades 7-12 equals the median

of the high school population for each quality indicator for visual-based learning

material in technology education for grades 7-12.

\[ H_0: \Theta_1 = \Theta_2. \]

The alternative hypothesis for this test was:

With respect to at least one of the inequalities, the median of the middle school

population for each quality indicator for visual-based learning material in

technology education for grades 7-12 is greater than or less than the median of the

high school population for each quality indicator for visual-based learning

material in technology education for grades 7-12.

\[ H_0: \Theta_1 > \Theta_2 \text{ or } H_0: \Theta_1 < \Theta_2 \]

Upon completion of the Mann Whitney U test a final form with the quality indicators of
visual-based materials was created; and a final copy was sent to members of both panels.

Chapter Summary

This chapter describes the procedures that the investigator undertook to conduct the
modified Delphi method. The purpose of the study was to reach consensus on identifying the
quality indicators of visual-based learning materials in technology education programs. The
study was directed by two main questions: (a) What indicators should quality visual-based
learning material in Technology Education have to be effective and efficient in transmitting information for grades 7-12? (b): What are the indicators of the learner’s characteristics that impact the selection of visual-based learning material in technology education for grades 7-12? A panel of experts and a review panel were selected through with random selection techniques and were identified as the main participants of the study. For those participants three instruments were created to be included in the modified Delphi method with a main target the identification of quality indicators of visual-based learning material in technology education programs through a consensus respond.
Chapter Four: Research Findings

The research problem that this study examined was the lack of adequate quality indicators to assess visual-based learning materials for grades 7-12 in technology education programs in the United States. The purpose of this research study was to identify those quality indicators that promote student learning and knowledge transmission through a modified Delphi method. To achieve the identification of the quality indicators three rounds were used as a part of the modified Delphi method. The data presented in this chapter includes results from the modified Delphi rounds conducted in the study, the demographic information about the expert and review panels, their combined experiences and backgrounds related to the subject of study.

Detailed information about the expert panel members is shown in this chapter through data collected during Round I using a demographic survey instrument. This data verifies the needed backgrounds and demographic information about panel members and their response rates to different questionnaires. Next, each modified Delphi round is reviewed to show information and knowledge gained from a given round. Consensus building is shown in this chapter for each round through the identification of modified Delphi procedures and processes, statistical analysis, and information-gathering techniques.

Two panels were selected for the study using the procedures described in Chapter III. The expert panel members were nominated by the PI’s of two material grants related to visual-based learning. The review panel members were selected with the same qualifications as the expert panel members but with the tasks of overseeing the formatting of questionnaires used in the research study and of reducing the bias of the researcher when combining and
modifying each indicator. A complete description of panel member selection is included in chapter 3. Both panels were polled using a demographics survey instrument to find information about each participant’s background and qualifications (see Appendix B and C for a copy of letters and instruments sent to the panel members). This survey was a part of Round I of the modified Delphi method. The return rate was 90.5 percent. The following information about the two panels was obtained from the demographic survey instrument.

Demographic Information about Participants

The review panel had three members: A high school technology education teacher, a middle school technology education teacher and a college-level technology teacher educator. The average years of teaching and/or overseeing a visual-based technology education program for the review panel was six years. Every member on the panel had at least a bachelor’s degree or higher and had taught at least one visual-based related subject during the last five years.

The expert panel consisted of 21 members from two visual-based material related NSF-funded grants. The expert panel members were representatives from across the United States in full-time positions as technology education teachers at the high school or middle school level. Table 8 shows summaries of demographic information on expert panel members in terms of: Positions held, grade levels taught/over seen, highest degree obtained, gender, involvement with visual-based material related grants and experience with visual training during the last five years.
Table 8

*Summary of Demographic Information on Expert Panel*

<table>
<thead>
<tr>
<th>Description</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology Teacher</td>
<td>19</td>
<td>100.0</td>
</tr>
<tr>
<td>Grant participant</td>
<td>19</td>
<td>100.0</td>
</tr>
<tr>
<td>Author</td>
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<td>10.5</td>
</tr>
<tr>
<td>High School Grades</td>
<td>8</td>
<td>42.1</td>
</tr>
<tr>
<td>Middle School Grades</td>
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<td>57.9</td>
</tr>
<tr>
<td>Male</td>
<td>11</td>
<td>57.9</td>
</tr>
<tr>
<td>Female</td>
<td>8</td>
<td>42.1</td>
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<tr>
<td>Bachelor’s Degree Holders</td>
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<td>47.4</td>
</tr>
<tr>
<td>Master’s Degree Holders</td>
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<td>52.6</td>
</tr>
</tbody>
</table>

*Note.* Total percent for all categories combined is 100 percent.

The demographic survey asked panel members: (1) Which title most accurately describes their current position? The three possible answers included: (a) Technology teacher using visual-based learning material, (b) visual-based learning grant related participant and (c) visual-based learning material author. Responses showed that all expert panel members, 100 percent, are technology teachers using visual-based learning material; all expert panel members, 100 percent, are a part of a visual-based learning grant; and few members, 10.5 percent, served as authors for visual-based learning material; (2) what grade level do they currently teach or oversee? Responses showed that almost half of the expert panel members, 42.1 percent, are teaching high school level grades and 57.9 percent at the middle school level grades; (3) what is the highest degree obtained as of January 1, 2007? Responses showed that almost half of the population, 47.4 percent, had a bachelor’s degree and more
than half, 52.6 percent, were masters degree holders; (4) what is the gender of the expert panel participants? Responses showed that 57.9 percent of the participants were males and 42.1 percent are females; (5) what was the year of graduation of the expert panel participants? This was also asked in order to determine the age of the participants. Results showed that the earliest graduation took place in 1972 and the latest in 1999. Assuming that the most common age for high-school graduation is 18 years old, the age of the participants ranges between 26 and 53 years old; (6) what is their current residence? Responses showed that all expert panel members, 100 percent, are residents of the United States; (7) has anyone had any type of visual training within the last 5 years? This was asked in the demographic survey to determine the expertise of the experts. Responses showed that all-expert panel members, 100 percent, have had some form of training; (8) what courses have they taught within the last years that require visual-based teaching/student capabilities? Responses showed that all expert panel members, 100 percent, have taught various courses, including solid modeling, CAD, Pro Desktop, VisTE materials, Tech Design, TECH-Know units, Dreamweaver and Technology Discovery.

Round I of the Modified Delphi Method

Round I of the modified Delphi method began with the development of a questionnaire (see Appendix A for letters and questionnaire sent to panel members) to identify the quality indicators of visual-based learning material in grades 7-12 for technology education programs. The questionnaire gave directions and definitions that were critical to the participant as well as to the study so that every panel member was using the correct format when completing the questionnaire. It also considered the same definitions of key
terms used in the instrument. Examples of related indicators from the review of literature were presented to aid the participants in format for typing a new indicator or modifying an existing one, as well as to start the brainstorming process. The panel members could keep or reject any example indicators given to them in this round or modify the example indicators. The majority of the panel members, 90.5 percent, completed and returned Questionnaire One. The majority of respondents, over 99.0 percent, suggested keeping most of the example indicators. Table 9 shows the example indicators sent in Round I and the total number of those experts who suggested that each indicator be kept for the study, rejected, or used if modified. The majority of the indicators that the expert panel members suggested were alike in meaning, but defined with different wording. The total number of new indicators suggested for by the expert panel members at the end of Round I was 12. Table 10 shows the example indicators modified by the researcher to meet the suggestions made by the expert panel. These modifications were approved by the review committee prior to being accessed by the panel of experts in Round II. Table 11 shows the new added indicators. Indicators used as examples could also be modified. Copies of all suggested modifications to indicators were emailed to the review panel to aid their understanding of modifications made to the indicators by the researcher. Review panel reviewed and suggested changes for next round.

In Round I each expert was allowed to indicate his or her preference to what would be quality indicators for visual-based learning materials for grades 7-12 in technology education programs. In the next two rounds, different processes and procedures were used in order to achieve consensus from the panel of experts as to which indicators the expert panel members felt were those of quality visual-based material.
Table 9

*Round-One Suggested Indicators to Keep, Reject or Modify*

<table>
<thead>
<tr>
<th>Suggested Indicator</th>
<th>Keep</th>
<th>Reject</th>
<th>Mod.</th>
<th>Indic.</th>
</tr>
</thead>
<tbody>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the amount of realistic detail contained in the Visualization used.</td>
<td>15</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the method by which the visualized instruction is presented to the students.</td>
<td>18</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon student’s interests and engagement.</td>
<td>17</td>
<td>0</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the type of educational objective to be achieved by the students.</td>
<td>15</td>
<td>3</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the technique used to focus student attention on the essential learning characteristics in the visualization materials, (e.g., cues such as questions, arrows, motion, verbal/visual feedback).</td>
<td>18</td>
<td>1</td>
<td>0</td>
<td>5</td>
</tr>
</tbody>
</table>

*Note:* Total number for each indicator is 19
Table 9 (Continued)

<table>
<thead>
<tr>
<th>Suggested Indicator</th>
<th>Keep</th>
<th>Reject</th>
<th>Mod.</th>
<th>Indic.</th>
</tr>
</thead>
<tbody>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for</td>
<td>17</td>
<td>0</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>grades 7-12 depends upon the type of test format employed to assess student</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>information acquisition, (e.g. for certain types of educational objectives visual</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>tests have been found to provide more valid assessments of the amount of information</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>students acquire by means of visualized instruction).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for</td>
<td>7</td>
<td>10</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>grades 7-12 depends upon the properties and quantity of the colors in the visualization used.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note: Total number for each indicator is 19*
Table 10

*Modifications made to Indicators from Round I to Round II*

<table>
<thead>
<tr>
<th>Indicator for Round I</th>
<th>Modifications to Indicator for Round II</th>
</tr>
</thead>
<tbody>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for</td>
<td>The effectiveness of visual-based learning material in Technology Education for</td>
</tr>
<tr>
<td>grades 7-12 depends upon the amount of realistic detail contained in the Visualization used.</td>
<td>grades 7-12 depends upon the amount of detail contained in the Visualization used.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for</td>
<td>The effectiveness of visual-based learning material in Technology Education for</td>
</tr>
<tr>
<td>grades 7-12 depends upon the method by which the visualized instruction is presented to the student</td>
<td>grades 7-12 depends upon the method by which the visualized instruction is presented since method varies on students.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for</td>
<td>The effectiveness of visual-based learning material in Technology Education for</td>
</tr>
<tr>
<td>grades 7-12 depends upon the type of educational objective to be achieved by the students.</td>
<td>grades 7-12 depends upon how the objectives are presented to the students.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for</td>
<td>The effectiveness of visual-based learning material in Technology Education for</td>
</tr>
<tr>
<td>grades 7-12 depends upon the technique used to focus student attention on the essential learning characteristics in the visualization materials, (e.g., cues such as questions, arrows, motion, verbal/visual feedback).</td>
<td>grades 7-12 depends upon the type of assessment employed to evaluate student learning, (e.g. for certain types of educational objectives visual tests have been found to provide more valid assessments of the amount of information students acquire of visualized instruction).</td>
</tr>
</tbody>
</table>
Table 11

*Suggested New Indicators for Round II*

<table>
<thead>
<tr>
<th>New Indicator</th>
<th>Ind. #</th>
</tr>
</thead>
<tbody>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the instructor’s ability to effectively and efficiently integrate visual-based learning material into the Technology Education classroom environment and curriculum.</td>
<td>7</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon time spent teaching background knowledge.</td>
<td>8</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the quality of the Visualization used.</td>
<td>9</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the student’s ability to effectively and efficiently understand integrated visual-based learning material into the Technology Education classroom environment and curriculum.</td>
<td>10</td>
</tr>
<tr>
<td>The effectiveness of Visual-based learning material in Technology Education for grades 7-12 depends upon the relevance of the materials.</td>
<td>11</td>
</tr>
<tr>
<td>The effectiveness of Visual-based learning material in Technology Education for grades 7-12 depends upon the direct correlation between the materials and the learning objective.</td>
<td>12</td>
</tr>
</tbody>
</table>
Table 11 (continued)

<table>
<thead>
<tr>
<th>New Indicator</th>
<th>Ind. #</th>
</tr>
</thead>
<tbody>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the level of the technology available to the student.</td>
<td>13</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the hardware being used.</td>
<td>14</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the teacher's confidence in the area of visual teaching.</td>
<td>15</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the amount of equipment i.e. computers available.</td>
<td>16</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the amount of training the instructor has with equipment i.e. software.</td>
<td>17</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon learning style of the students to which the visual material is presented.</td>
<td>18</td>
</tr>
</tbody>
</table>

Round II of the Modified Delphi Method

Round II of this study allowed the panel of experts to rate and rank all indicators from Round I (see Appendix D for the letters and questionnaires sent to panel members). The rating process used a Likert Scale of one to five with the following classifications for each rating number: (1) Represented a strong disagreement that the effectiveness of visual-based
learning material in technology education depends on the specific indicator; (2) represented disagreement that the effectiveness of visual-based learning material in technology education depends on the specific indicator and meets 49% or less of all quality characteristics; (3) represented a neutral position that the effectiveness of visual-based learning material in technology education depends upon the specific indicator and is appropriate for 51% or more of all quality indicators; (4) represented an agreement that the effectiveness of visual-based learning material in technology education depends on the specific indicator and is appropriate for 75% or more of all quality indicators; (5) represented a strong agreement that the effectiveness of visual-based learning material in technology education depends on the specific indicator and is appropriate for 100% of all quality indicators.

Once all data was collected, statistical means and standard deviations were calculated for each indicator. The indicators with a mean of 3.01 or higher were kept for the next round. The mean of 3.01 indicated that the modified Delphi process was starting to reach consensus by keeping only those indicators that had a rating at or above the statistical median of 3.01 for the rating scale of one to five. This assured the researcher that, overall, the indicators kept were appropriate for at least 51 percent of the visual-based learning materials in technology education for grades 7-12. Table 12 shows the indicators the expert panel members rated and the overall means and standard deviations for each category and indicators from round two of the modified Delphi method.
Table 12

*Overall Means and Standard Deviations for Round II Indicators*

<table>
<thead>
<tr>
<th>Indicators</th>
<th>M</th>
<th>SD</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>The effectiveness of Visual-based learning material in Technology Education for grades 7-12 depends upon the amount of detail contained in the Visualization used.</td>
<td>3.35</td>
<td>1.23</td>
<td>20</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the method by which the visualized instruction is presented since method varies on students.</td>
<td>4.15</td>
<td>.49</td>
<td>20</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon students’ interests and engagement.</td>
<td>4.7</td>
<td>.73</td>
<td>20</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon how the objectives are presented to the students.</td>
<td>4.05</td>
<td>.83</td>
<td>20</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the technique used to focus student attention on the essential learning characteristics in the visualization materials, (e.g., cues such as questions, arrows, motion, verbal/visual feedback).</td>
<td>3.90</td>
<td>.79</td>
<td>20</td>
</tr>
</tbody>
</table>
Table 12 (Continued)

<table>
<thead>
<tr>
<th>Indicators</th>
<th>M</th>
<th>SD</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>The effectiveness of visual-based learning material in Technology for grades 7-12 depends upon the type of assessment employed to evaluate student learning, (e.g. for certain types of educational objectives visual tests have been found to provide more valid assessments of the amount of information students acquire by means of visualized instruction).</td>
<td>3.55</td>
<td>.94</td>
<td>20</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology for grades 7-12 depends upon the instructor's ability to effectively and efficiently integrate visual-based learning material into the Technology Education classroom environment and curriculum.</td>
<td>4.15</td>
<td>.75</td>
<td>20</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology for grades 7-12 depends upon time spent teaching background knowledge.</td>
<td>3.5</td>
<td>1.15</td>
<td>20</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology for grades 7-12 depends upon the quality of the Visualization used.</td>
<td>4</td>
<td>56</td>
<td>20</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology for grades 7-12 depends upon the student’s ability to effectively and efficiently understand integrated visual-based learning material into the Technology Education classroom environment and curriculum.</td>
<td>4.35</td>
<td>.67</td>
<td>20</td>
</tr>
</tbody>
</table>
Table 12 (Continued)

<table>
<thead>
<tr>
<th>Indicators</th>
<th>M</th>
<th>SD</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>The effectiveness of Visual-based learning material in Technology Education for grades 7-12 depends upon the relevance of the materials.</td>
<td>4.25</td>
<td>.79</td>
<td>20</td>
</tr>
<tr>
<td>The effectiveness of Visual-based learning material in Technology Education for grades 7-12 depends upon the direct correlation between the materials and the learning objective.</td>
<td>3.6</td>
<td>.75</td>
<td>20</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the level of the technology available to the student.</td>
<td>3.6</td>
<td>1.05</td>
<td>20</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the hardware being used by the student.</td>
<td>3.85</td>
<td>1.18</td>
<td>20</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the teacher's confidence in the area of visual teaching.</td>
<td>4.05</td>
<td>.76</td>
<td>20</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the amount of equipment i.e. computers available.</td>
<td>3.4</td>
<td>1.10</td>
<td>20</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the amount of training the instructor has with equipment i.e. software.</td>
<td>3.85</td>
<td>.75</td>
<td>20</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon learning style of the students to which the visual material is presented.</td>
<td>4.4</td>
<td>.60</td>
<td>20</td>
</tr>
</tbody>
</table>
No new indicators were suggested or modified by the panel of experts and reviewers. Once Round II was completed, means for indicators were used to rank the indicators kept from this round in order from highest mean to lowest mean for each category. This was done to allow comparison of these statistically ranked means of indicators with the actual rankings of indicators conducted in round two by the experts to show that consensus was being achieved by the modified Delphi method.

The Kruskal-Wallis One-Way Analysis of Variance by Ranks was used in Questionnaire Two of the modified Delphi method to allow expert panel members to rank indicators kept from Round I (see Appendix D for letters and questionnaire sent to panel members). The ranking scale was from the most important indicator to the least important. This was done to ensure consensus by comparing ranked indicators’ medians to the statistical ranking (from the mean ratings) found in the same round.

Visual-based Learning Quality Indicators Identification

The major emphasis of the study involves determining the visual-based learning material quality indicators for technology education programs in grades 7-12. To help identifying the quality indicators medians were calculated to report differences in overall element utilization. Indicators that show experts’ opinions of “strongly disagree,” “disagree,” or “agree nor disagree” are considered indicators that are not quality indicators for visual-based learning material in technology education programs in grades 7-12.

Indicators that indicate experts’ opinion of “agree” or “strongly agree” are considered important indicators for visual-based learning material in technology education programs in grades 7-12.
Once the quality indicators were identified through experts’ consensus the Kruskal-Wallis Test, Table 13, was conducted for each of the 18 identified indicators to evaluate Hypothesis 1.

The Kruskal-Wallis Test was used to determine whether there was a significant difference between the middle school experts’ opinions and the high school experts’ opinions for the quality indicators for visual-based learning material in technology education programs in grades 7-12. Table 13 includes the sample population (n=10) for middle school and high school experts and the p-value that was used to determine whether the null hypothesis was accepted or rejected. In the Kruskal-Wallis Test, the p-value was used to test the null hypothesis against the alternative directional hypothesis. The calculated values for p-value were evaluated in comparison to the critical values for each indicator to determine if the null hypothesis was to be rejected or if there was evidence that fails to reject the claim. If the p-value was less than the critical value ($\alpha = .05$), the null hypothesis was rejected as illustrated in Table 13.
Table 13

Kruskal-Wallis and Mann-Whitney results for Visual-based learning material quality indicators

<table>
<thead>
<tr>
<th>Ind.</th>
<th>The effectiveness of Visual-based learning material in Technology Education for grades 7-12 depends upon:</th>
<th>Middle. (n)</th>
<th>High (n)</th>
<th>Mid. Mdn.</th>
<th>High Mdn.</th>
<th>Kruskal P-value</th>
<th>Mann P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The amount of detail contained in the Visualization used.</td>
<td>10</td>
<td>10</td>
<td>9</td>
<td>13</td>
<td>0.2083</td>
<td>0.1966</td>
</tr>
<tr>
<td>2</td>
<td>The method by which the visualized instruction is presented since method varies on students.</td>
<td>10</td>
<td>10</td>
<td>7</td>
<td>6.5</td>
<td>0.6147</td>
<td>0.9393</td>
</tr>
<tr>
<td>3</td>
<td>Students’ interests and engagement.</td>
<td>10</td>
<td>10</td>
<td>2.5</td>
<td>3</td>
<td>0.3986</td>
<td>0.3383</td>
</tr>
<tr>
<td>4</td>
<td>How the objectives are presented to the students.</td>
<td>10</td>
<td>10</td>
<td>6.5</td>
<td>7.5</td>
<td>0.3297</td>
<td>0.9093</td>
</tr>
<tr>
<td>5</td>
<td>The technique used to focus student attention on the essential learning characteristics in the visualization materials, (e.g., cues such as questions, arrows).</td>
<td>10</td>
<td>10</td>
<td>12</td>
<td>2.5</td>
<td>0.8018</td>
<td>0.0110*</td>
</tr>
<tr>
<td>6</td>
<td>The type of assessment employed to evaluate student learning.</td>
<td>10</td>
<td>10</td>
<td>13</td>
<td>8.5</td>
<td>0.6138</td>
<td>0.6749</td>
</tr>
<tr>
<td>7</td>
<td>The instructor's ability to effectively and efficiently integrate visual-based learning material</td>
<td>10</td>
<td>10</td>
<td>8.5</td>
<td>5.5</td>
<td>0.7199</td>
<td>0.6749</td>
</tr>
<tr>
<td>8</td>
<td>Time spent teaching background knowledge</td>
<td>10</td>
<td>10</td>
<td>13</td>
<td>10.5</td>
<td>0.2287</td>
<td>0.7329</td>
</tr>
</tbody>
</table>

Note. *p < .05
<table>
<thead>
<tr>
<th>Ind.</th>
<th>The effectiveness of Visual-based learning material in Technology Education for grades 7-12 depends upon:</th>
<th>Middle. (n)</th>
<th>High (n)</th>
<th>Mid. Mdn.</th>
<th>High Mdn.</th>
<th>Kruskal P-value</th>
<th>Mann P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>The quality of the Visualization used.</td>
<td>10</td>
<td>10</td>
<td>9.5</td>
<td>13.5</td>
<td>0.9627</td>
<td>0.1715</td>
</tr>
<tr>
<td>10</td>
<td>The student’s ability to effectively and efficiently understand integrated visual-based learning material into the Technology Education classroom environment and curriculum.</td>
<td>10</td>
<td>10</td>
<td>5</td>
<td>6.5</td>
<td>0.805</td>
<td>0.4009</td>
</tr>
<tr>
<td>11</td>
<td>The relevance of the materials</td>
<td>10</td>
<td>10</td>
<td>5.5</td>
<td>10.5</td>
<td>0.3921</td>
<td>0.0527</td>
</tr>
<tr>
<td>12</td>
<td>The direct correlation between materials and the learning objective.</td>
<td>10</td>
<td>10</td>
<td>11.5</td>
<td>10.5</td>
<td>0.5565</td>
<td>0.7004</td>
</tr>
<tr>
<td>13</td>
<td>The level of the technology available to the student,</td>
<td>10</td>
<td>10</td>
<td>6</td>
<td>15.5</td>
<td>0.1747</td>
<td>0.0436*</td>
</tr>
<tr>
<td>14</td>
<td>The hardware being used by the student.</td>
<td>10</td>
<td>10</td>
<td>11</td>
<td>16.5</td>
<td>0.379</td>
<td>0.1831</td>
</tr>
<tr>
<td>15</td>
<td>The teacher’s confidence in the area of visual teaching.</td>
<td>10</td>
<td>10</td>
<td>7.5</td>
<td>7.0</td>
<td>0.3297</td>
<td>0.6761</td>
</tr>
<tr>
<td>16</td>
<td>The amount of equipment i.e. computers available.</td>
<td>10</td>
<td>10</td>
<td>13</td>
<td>10.5</td>
<td>0.3158</td>
<td>0.6220</td>
</tr>
</tbody>
</table>

*Note. *p < .05
<table>
<thead>
<tr>
<th>Ind.</th>
<th>The effectiveness of Visual-based learning material in Technology Education for grades 7-12 depends upon:</th>
<th>Middle. (n)</th>
<th>High (n)</th>
<th>Mid. (Mdn)</th>
<th>High (Mdn)</th>
<th>Kruskal P-value</th>
<th>Mann P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>The amount of training the instructor has with equipment i.e. software.</td>
<td>10</td>
<td>10</td>
<td>8.5</td>
<td>7</td>
<td>0.8678</td>
<td>0.5956</td>
</tr>
<tr>
<td>18</td>
<td>Learning style of the students to which the visual material is presented.</td>
<td>10</td>
<td>10</td>
<td>9</td>
<td>5.5</td>
<td>0.0897</td>
<td>0.1836</td>
</tr>
</tbody>
</table>
The Mann-Whitney U Test was employed with ordinal (rank-order) data in a hypothesis-testing situation involving a design with two independent samples (middle school and high school experts) and testing for significant differences between the two medians. Significance was measured at an $\alpha$ of .05. Table 13 includes the sample population (n=10) for middle school and high school experts, the median from high and middle school experts, the rank from middle and high school experts and of course the p-value that was used to determine whether the null hypothesis was accepted or rejected. The calculated values for the p-value statistic were evaluated (see Table 13) in comparison to the critical values for each indicator to determine if the null hypothesis is to be rejected or if there is evidence that fails to reject the claim. If the value of the p-value was less than the critical value ($\alpha = .05$) the null hypothesis was rejected.

Next the Spearman’s nonparametric test was used to show the correlation between information found also in Round II. The test compared the ranking scores of the two sample populations (middle school and high school) from this round to each indicator’s median. This statistical process revealed the relationship between each indicator’s ranked score through the ranking process and ranked score through the rating process by comparing the two medians. The purpose of this statistical test was to show that no outliers (effects of one or more extreme scores) were influencing the consensus drawing process for the ranking of indicators in this round. Since the ranking of indicators would have a positive mean, the median would be positive for each indicator therefore, a high positive correlation was expected from this data used in the statistical test. Table 14 shows this assumption was held true for the data and a high positive correlation was achieved for all except 3 indicators. Indicator fourteen: The
effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the hardware being used by the student, which, it had a low correlation coefficient of -0.188. Indicator sixteen: The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the amount of equipment i.e. computers available, which, it had a low positive correlation coefficient of 0.164. These two indicators did not indicate consensus through a high positive correlation coefficient. However, the most significant factor is the overall correlation for the entire ranking of all indicators that had a negative coefficient correlation of 0.741 for the middle school experts and 0.873 for the high school experts.

Indicators Rating

Part of Round II included the rating process of the quality indicators. Both middle school and high school expert panel members rated the indicators from the most to the least important. The ten most important indicators according to the opinion of the high school experts were indicator two, three, four, five, seven, ten, seventeen, eighteen, and nineteen. The ten most important indicators according to the opinion of middle school experts were one, five, six, ten, eleven, twelve, thirteen, fourteen, sixteen and seventeen. To simplify readability of results Table 15 was created. The ten least important indicators according to the opinion of the high school experts were indicator one, six, nine, ten, eleven, twelve, thirteen, fourteen, sixteen, and seventeen. The ten least important indicators according to the opinion of middle school experts were indicator three, four, five, six, seven, eight, ten, fifteen, seventeen, and eighteen, Table 16 was created to simplify readability of results.
Table 14

*Spearman’s Rho Test for correlation in Round II*

<table>
<thead>
<tr>
<th>Ind #</th>
<th>The effectiveness of Visual-based learning material in Technology Education for grades 7-12 depends upon:</th>
<th>Middle r**</th>
<th>High r**</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The amount of detail contained in the Visualization used.</td>
<td>0.967</td>
<td>0.827</td>
</tr>
<tr>
<td>2</td>
<td>The method by which the visualized instruction is presented since method varies on students.</td>
<td>0.856</td>
<td>0.980</td>
</tr>
<tr>
<td>3</td>
<td>Students’ interests and engagement.</td>
<td>0.848</td>
<td>0.827</td>
</tr>
<tr>
<td>4</td>
<td>How the objectives are presented to the students.</td>
<td>0.976</td>
<td>0.980</td>
</tr>
<tr>
<td>5</td>
<td>The technique used to focus student attention on the essential learning characteristics in the visualization materials, (e.g., cues such as questions, arrows, motion, verbal/visual feedback).</td>
<td>0.127</td>
<td>0.169</td>
</tr>
<tr>
<td>6</td>
<td>The type of assessment employed to evaluate student learning, (e.g. for certain types of educational objectives visual tests have been found to provide more valid assessments of the amount of information students acquire by means of visualized instruction).</td>
<td>0.895</td>
<td>0.945</td>
</tr>
</tbody>
</table>

*Note* Assumption not held true, ** r represents the Spearman’s (Rho) for an indicator.
<table>
<thead>
<tr>
<th>Ind #</th>
<th>The effectiveness of Visual-based learning material in Technology Education for grades 7-12 depends upon:</th>
<th>Middle $r^{**}$</th>
<th>High $r^{**}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>The instructor's ability to effectively and efficiently integrate visual-based learning material into the Technology Education classroom environment and curriculum.</td>
<td>0.945</td>
<td>0.994</td>
</tr>
<tr>
<td>8</td>
<td>Upon time spent teaching background knowledge</td>
<td>0.812</td>
<td>0.848</td>
</tr>
<tr>
<td>9</td>
<td>Upon the quality of the Visualization used</td>
<td>0.867</td>
<td>0.909</td>
</tr>
<tr>
<td>10</td>
<td>The student’s ability to effectively and efficiently understand integrated visual-based learning material into the Technology Education classroom environment and curriculum.</td>
<td>0.945</td>
<td>1.000</td>
</tr>
<tr>
<td>11</td>
<td>The relevance of the materials.</td>
<td>1.000</td>
<td>0.782</td>
</tr>
<tr>
<td>12</td>
<td>The direct correlation between the materials and the learning objective.</td>
<td>0.837</td>
<td>0.803</td>
</tr>
<tr>
<td>13</td>
<td>The level of the technology available to the student.</td>
<td>0.976</td>
<td>0.909</td>
</tr>
<tr>
<td>14</td>
<td>Upon the hardware being used by the student.</td>
<td>-0.188*</td>
<td>0.894</td>
</tr>
<tr>
<td>15</td>
<td>The teacher’s confidence in the area of visual teaching.</td>
<td>0.809</td>
<td>0.945</td>
</tr>
</tbody>
</table>

*Note* Assumption not held true, $**r$ represents the Spearman’s (Rho) for an indicator.
Table 14 (Continued)

<table>
<thead>
<tr>
<th>Ind #</th>
<th>The effectiveness of Visual-based learning material in Technology Education for grades 7-12 depends upon:</th>
<th>Middle $r^{**}$</th>
<th>High $r^{**}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>The amount of equipment i.e. computers available.</td>
<td>0.164*</td>
<td>0.994</td>
</tr>
<tr>
<td>17</td>
<td>The amount of training the instructor has with equipment i.e. software.</td>
<td>0.848</td>
<td>0.976</td>
</tr>
<tr>
<td>18</td>
<td>Learning style of the students to which the visual material is presented.</td>
<td>0.903</td>
<td>0.926</td>
</tr>
<tr>
<td></td>
<td>Overall Total Scores for Combined Indicators</td>
<td>0.741</td>
<td>0.873</td>
</tr>
</tbody>
</table>

* Assumption not held true, ** $r$ represents the Spearman’s (Rho) for an indicator.
### Table 15

*Ten most important quality indicators from High and Middle School experts*

<table>
<thead>
<tr>
<th>Rank</th>
<th>High School</th>
<th>Middle School</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Learning style of the students to which the visual material is presented.</td>
<td>Upon the level of the technology available to the student.</td>
</tr>
<tr>
<td>2</td>
<td>Instructor's ability to effectively and efficiently integrate visual-based learning material.</td>
<td>Upon the amount of detail contained in the Visualization used.</td>
</tr>
<tr>
<td>3</td>
<td>How the objectives are presented to the students.</td>
<td>Upon the amount of equipment i.e. computers available.</td>
</tr>
<tr>
<td>4</td>
<td>Students’ interests and engagement.</td>
<td>Upon the hardware being used by the student.</td>
</tr>
<tr>
<td>5</td>
<td>Method by which the visualized instruction is presented since method varies among students</td>
<td>Upon the relevance of the materials.</td>
</tr>
<tr>
<td>6</td>
<td>Instructor's ability to effectively and efficiently integrate visual-based learning material into the Technology Education classroom environment and curriculum.</td>
<td>Upon the direct correlation between the materials and the learning objective.</td>
</tr>
<tr>
<td>7</td>
<td>Upon the technique used to focus student attention on the essential learning characteristics in the visualization materials.</td>
<td>Upon the type of assessment employed to evaluate student learning, (e.g. for certain types of educational objectives visual tests have been found to provide more valid assessments of the amount of information students acquire).</td>
</tr>
<tr>
<td>Rank</td>
<td>High School</td>
<td>Middle School</td>
</tr>
<tr>
<td>------</td>
<td>-----------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>8</td>
<td>Upon the quality of the Visualization used.</td>
<td>Upon the student’s ability to effectively and efficiently understand integrated visual-based learning material into the Technology Education classroom environment.</td>
</tr>
<tr>
<td>9</td>
<td>Upon the amount of training the instructor has with equipment, i.e., software.</td>
<td>Upon the amount of training the instructor has with equipment, i.e., software.</td>
</tr>
<tr>
<td>10</td>
<td>Student’s ability to effectively and efficiently understand integrated visual-based learning material into the Technology Education classroom environment.</td>
<td>Upon the technique used to focus student attention on the essential learning characteristics in the visualization materials.</td>
</tr>
</tbody>
</table>
Table 16

*Ten least important quality indicators from High and Middle School experts*

<table>
<thead>
<tr>
<th>Rank</th>
<th>High School</th>
<th>Middle School</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Upon the level of the technology available to the student.</td>
<td>Upon learning style of the students to which the visual material is presented.</td>
</tr>
<tr>
<td>2</td>
<td>Upon the amount of detail contained in the Visualization used.</td>
<td>Upon time spent teaching background knowledge.</td>
</tr>
<tr>
<td>3</td>
<td>Upon the amount of equipment i.e. computers available.</td>
<td>Upon how the objectives are presented to the students.</td>
</tr>
<tr>
<td>4</td>
<td>Upon the hardware being used by the student.</td>
<td>Upon the teacher's confidence in the area of visual teaching.</td>
</tr>
<tr>
<td>5</td>
<td>Upon the relevance of the materials.</td>
<td>Upon students’ interests and engagement.</td>
</tr>
<tr>
<td>6</td>
<td>Upon the direct correlation between the materials and the learning objective.</td>
<td>Upon the instructor's ability to effectively and efficiently integrate visual-based learning material into the Technology Education classroom.</td>
</tr>
</tbody>
</table>
Table 16 (Continued)

<table>
<thead>
<tr>
<th>Rank</th>
<th>High School</th>
<th>Middle School</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Upon the type of assessment employed to evaluate student learning (e.g. for certain types of educational objectives visual tests have been found to provide more valid assessments of the amount of information students acquire by means of visualized instruction).</td>
<td>Upon the technique used to focus student attention on the essential learning characteristics in the visualization materials (e.g., cues such as questions, arrows, motion, verbal/visual feedback).</td>
</tr>
<tr>
<td>8</td>
<td>Upon the student’s ability to effectively and efficiently understand integrated visual-based learning material into the Technology Education classroom environment.</td>
<td>Upon the amount of training the instructor has with equipment i.e. software.</td>
</tr>
<tr>
<td>9</td>
<td>Upon the amount of training the instructor has with equipment i.e. software.</td>
<td>Upon the student’s ability to effectively and efficiently understand integrated visual-based learning material into the Technology Education classroom environment.</td>
</tr>
<tr>
<td>10</td>
<td>Upon the quality of the Visualization used.</td>
<td>Type of assessment employed to evaluate student learning</td>
</tr>
</tbody>
</table>
Round III of the Modified Delphi Method

Round III, the last round in the modified Delphi method, was to determine final consensus of those indicators kept from Round II. Once modifications were made and approved by all members of the review panel, access was granted to the panel of experts to complete the last instrument for final verification of quality indicators (see Appendix E for letters and instrument sent to the panel members). The expert panel members could accept or reject each indicator as it was transcribed, but no modifications were permitted to any indicator. Twenty expert panel members, or 95.2 percent, returned the completed instrument.

The data from this instrument was analyzed using the Mann-Whitney U test that was employed with ordinal (rank-order) data in a hypothesis-testing situation involving a design with two independent samples and testing for significant difference between the two medians.

The Mann-Whitney U Test was employed with ordinal (rank-order) data in a hypothesis-testing situation involving a design with two independent samples (Middle school and high school experts) and testing for significant difference between the two medians. Significance was measured at an $\alpha$ of .05. The calculated values for the p-value statistic were evaluated (see Table 17) in comparison to the critical values for each indicator to determine if the null hypothesis is to be rejected or if there is evidence that fails to reject the claim. If the value of the p-value was less than the critical value ($\alpha = .05$) the null hypothesis was rejected. Table 17 includes the sample of each population (n=10) for middle and high school experts and the p-value for each indicator. Only one indicator, number 11 had a p-value s
Table 17

*Mann-Whitney Test results for Final round*

<table>
<thead>
<tr>
<th>Ind. #</th>
<th>The effectiveness of Visual-based learning material in Technology Education for grades 7-12 depends upon:</th>
<th>Middle (n)</th>
<th>High (n)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The amount of detail contained in the Visualization.</td>
<td>10</td>
<td>10</td>
<td>0.6506</td>
</tr>
<tr>
<td>2</td>
<td>The method by which the visualized instruction is presented since method varies on students.</td>
<td>10</td>
<td>10</td>
<td>0.5828</td>
</tr>
<tr>
<td>3</td>
<td>Students’ interests and engagement.</td>
<td>10</td>
<td>10</td>
<td>0.0767</td>
</tr>
<tr>
<td>4</td>
<td>How the objectives are presented to the students.</td>
<td>10</td>
<td>10</td>
<td>0.0767</td>
</tr>
<tr>
<td>5</td>
<td>The technique used to focus student attention on the essential learning characteristics in the visualization materials, (e.g., cues such as questions, arrows, motion, verbal/visual feedback).</td>
<td>10</td>
<td>10</td>
<td>0.5828</td>
</tr>
<tr>
<td>6</td>
<td>The type of assessment employed to evaluate student learning, (e.g. for certain types of educational objectives visual tests have been found to provide more valid assessments of the amount of information students acquire by means of visualized instruction).</td>
<td>10</td>
<td>1</td>
<td>0.1675</td>
</tr>
<tr>
<td>7</td>
<td>The instructor's ability to effectively and efficiently integrate visual-based learning material into the Technology Education classroom environment and curriculum.</td>
<td>10</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>Time spent teaching background knowledge.</td>
<td>10</td>
<td>10</td>
<td>1</td>
</tr>
</tbody>
</table>

*Note. *p < .05
Table 17 (Continued)

<table>
<thead>
<tr>
<th>Ind. #</th>
<th>The effectiveness of Visual-based learning material in Technology Education for grades 7-12 depends upon:</th>
<th>Middle (n)</th>
<th>High (n)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>The quality of the Visualization used.</td>
<td>10</td>
<td>10</td>
<td>0.3681</td>
</tr>
<tr>
<td>10</td>
<td>The student’s ability to effectively and efficiently understand integrated visual-based learning material into the Technology Education classroom environment and curriculum.</td>
<td>10</td>
<td>10</td>
<td>0.3681</td>
</tr>
<tr>
<td>11</td>
<td>The relevance of the materials.</td>
<td>10</td>
<td>10</td>
<td>0.0336*</td>
</tr>
<tr>
<td>12</td>
<td>The direct correlation between the materials and the learning objective.</td>
<td>10</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>13</td>
<td>The level of the technology available to student</td>
<td>10</td>
<td>10</td>
<td>0.1675</td>
</tr>
<tr>
<td>14</td>
<td>The hardware being used by the student.</td>
<td>10</td>
<td>10</td>
<td>0.5828</td>
</tr>
<tr>
<td>15</td>
<td>The teacher's confidence in the area of visual teaching.</td>
<td>10</td>
<td>10</td>
<td>0.1675</td>
</tr>
<tr>
<td>16</td>
<td>The amount of equipment i.e. computers available.</td>
<td>10</td>
<td>10</td>
<td>0.5828</td>
</tr>
<tr>
<td>17</td>
<td>The amount of training the instructor has with equipment i.e. software.</td>
<td>10</td>
<td>10</td>
<td>0.3006</td>
</tr>
<tr>
<td>18</td>
<td>Learning style of the students to which the visual material is presented.</td>
<td>10</td>
<td>10</td>
<td>0.6506</td>
</tr>
</tbody>
</table>

*Note. *p < .05
Chapter Summary

This chapter described the findings from the three rounds of the modified Delphi method used in this study to identify quality indicators for visual-based learning material in technology education programs for grades 7-12. The three rounds conducted in this study were explained, along with the statistical analysis applied. Round I explained the modifications to suggested indicators with a listing of suggested indicators from the expert panel members. Round II initiated a rating and ranking process for each indicator kept from Round I and a statistical comparison between the statistical ranking and rating to show consensus was being achieved. Round III allowed the expert panel members to accept or reject each indicator kept from Round II and reached final consensus. A series of statistical tests were used to show that final consensus was achieved for each indicator and to verify the indicators that were kept in the final list of quality indicators. The statistical tests included the non-parametric Kruskal-Wallis test used to determine whether there was a significant difference between the middle school experts’ opinions and the high school experts’ opinions. The Mann-Whitney U Test was employed with ordinal (rank-order) data in a hypothesis-testing situation involving a design with two independent samples testing for significant difference between the two medians, and the Spearman’s nonparametric test was used to show the positive coefficient correlation between the middle and high school populations responses found in Round II.
Chapter Five: Conclusions and Recommendations

Statement of the Problem

This study was designed to identify quality indicators for visual-based learning material in technology education programs for grades 7-12.

Conclusions for Research Questions

The major emphasis of the study involves determining the indicators that visual-based learning material used in Technology Education for grades 7-12 must have to effectively transmit information effectively and also the indicators of the learner’s characteristics to be exposed to such material. Two research questions have been proposed dealing with visual-based learning material:

RQ 1: What indicators must visual-based learning material in Technology Education for grades 7-12 have to be effective in transmitting information?

RQ 2: What are the indicators of the learner’s characteristics that impact the selection of visual-based learning materials in technology education for grades 7-12?

Both of these research questions were examined through the modified Delphi method conducted in this study. In the three modified Delphi rounds, a panel of experts in the field of technology education identified quality indicators through a consensus process. The modified Delphi method used in this study validated the quality indicators through the use of consensus-drawing processes using experts involved with visual-based learning material grants. Stratification measures used for locating expert panel members helped ensure that the indicators represented consensus from across the United States. The statistical tests applied
during the study validate that consensus was being achieved during the study and that consensus-gathering strategies used within the study were appropriate. Table 18 shows the validated indicators kept from the final modified Delphi round of this study:

Table 18

<table>
<thead>
<tr>
<th>Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>The effectiveness of Visual-based learning material in Technology Education for grades 7-12 depends upon the amount of detail contained in the Visualization used.</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the method by which the visualized instruction is presented since method varies with students.</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon students’ interests and engagement.</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon how the objectives are presented to the students.</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the technique used to focus student attention on the essential learning characteristics in the visualization materials, (e.g., cues such as questions, arrows, motion, verbal/visual feedback).</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the type of assessment employed to evaluate student learning, (e.g. for certain types of educational objectives visual tests have been found to provide more valid assessments of the amount of information students acquire by means of visualized instruction).</td>
</tr>
</tbody>
</table>
Table 18 (Continued)

<table>
<thead>
<tr>
<th>Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the instructor's ability to effectively and efficiently integrate visual-based learning material into the Technology Education classroom environment and curriculum.</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon time spent teaching background knowledge.</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the quality of the Visualization used.</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the student’s ability to effectively and efficiently understand integrated visual-based learning material into the Technology Education classroom environment and curriculum.</td>
</tr>
<tr>
<td>The effectiveness of Visual-based learning material in Technology Education for grades 7-12 depends upon the relevance of the materials.</td>
</tr>
<tr>
<td>The effectiveness of Visual-based learning material in Technology Education for grades 7-12 depends upon the direct correlation between the materials and the learning objective.</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the level of the technology available to the student.</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the hardware being used by the student.</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the teacher's confidence in the area of visual teaching.</td>
</tr>
</tbody>
</table>
Table 18 (Continued)

<table>
<thead>
<tr>
<th>Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the amount of equipment i.e. computers available.</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the amount of training the instructor has with equipment i.e. software.</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon learning style of the students to which the visual material is presented.</td>
</tr>
</tbody>
</table>

Conclusions for Hypotheses

Four null hypotheses were proposed concerning the identification of visual-based learning material indicators. The four hypotheses were:

Hypothesis 1: **The median of the middle school population for each quality indicator for visual-based learning material in technology education for grades 7-12 equals the median of the high school population for each quality indicator for visual-based learning material in technology education for grades 7-12.** The Kruskal-Wallis test was conducted to test the hypothesis above. The calculated values for p-value were evaluated in comparison to the critical values for each indicator to determine if the null hypothesis is to be rejected or if there is evidence that fails to reject the claim. If the p-value was less than the critical value ($\alpha = .05$) the null hypothesis was rejected. The p-value was less than the critical value in none of the indicators.

The Kruskal-Wallis test was used in this study to show representation of consensus.
for each indicator. All indicators had a p-value higher than .05, which shows good representation of population consensus, and not enough evidence for significant difference in-between the indicators.

Hypothesis 2: The median of the middle school population for each quality indicator for visual-based learning material in technology education for grades 7-12 represents equals the median of the high school population for each quality indicator for visual-based learning material in technology education for grades 7-12. The Mann Whitney U test was conducted to test the hypothesis above. Significance was measured at an $\alpha$ of .05. The calculated values for the p-value statistic were evaluated in comparison to the critical values for each indicator to determine if the null hypothesis is to be rejected or if there is evidence that fails to reject the claim. If the p-value was less than the critical value ($\alpha = .05$) the null hypothesis was rejected. The p-value statistic was less than the critical value in indicator numbers five: The effectiveness of visual-based learning material in technology education for grades 7-12 depends upon the technique used to focus student attention on the essential learning characteristics in the visualization materials, (e.g., cues such as questions, arrows, motion, verbal/visual feedback) and thirteen: The effectiveness of visual-based learning material in technology education for grades 7-12 depends upon the level of the technology available to the student.

Indicator number five concerns about the technique used to focus student attention on the essential learning characteristics in the visualization materials, such technique can be very hard to narrow down since a lot of different ones exist. Therefore, due to the large amount of information contained within this indicator, the researcher believes it was hard for
the experts to understand the exact meaning of this indicator and that is possibly why consensus was not represented and the null hypothesis was rejected.

Indicator number five concerns of the technology available to the student. Again, the term “technology” can include various systems, therefore it was hard for the experts to comprehend this term and that is why the null hypothesis was rejected for this indicator also.

The rest of the indicators tested in this test had a p-value larger than the critical value (.05), which it indicates that consensus was achieved through the study and indicators were well written and understood by the expert panel members.

Hypothesis 3: In the underlying population the sample represents, the correlation between the ranks of subjects on middle school responses and high school responses equal some value higher than 0. The test compared the ranking scores of the two sample populations (middle school and high school) to each indicator’s median. This statistical process revealed the relationship between each indicator’s ranked score and the median for that particular indicator to show that no outliers (effects of one or more extreme scores) were influencing the consensus drawing process for the ranking of indicators. Since the ranking of indicators would have a positive mean, the median would be positive for each indicator therefore, a high positive correlation was expected from this data used in the statistical test.

A high positive correlation was achieved for all indicators except indicator fourteen: The effectiveness of visual-based learning material in technology education for grades 7-12 depends upon the hardware being used by the student, which, it had a low correlation
coefficient of - 0.188 and indicator sixteen: The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the amount of equipment i.e. computers available, which, it had a low positive correlation coefficient of 0.164. These two indicators did not indicate consensus through a high positive correlation coefficient.

Both of these indicators support that the efficiency of a visual-based material depends upon the equipment and hardware used to deliver the information. Since some educators are not necessarily experts with teaching aid equipment and due to the rapid change of technological devices used in the classroom it was probably hard for the experts to agree upon a specific type of equipment and to make informed decisions; therefore consensus was not represented for those indicators. However, the most significant factor is the overall correlation for the entire ranking of all indicators that had a positive coefficient correlation of 0.741 for the middle school experts and 0.873 for the high school experts.

Hypothesis 4: The median of the middle school population for each quality indicator for visual-based learning material in technology education for grades 7-12 equals the median of the high school population for each quality indicator for visual-based learning material in technology education for grades 7-12. The Mann Whitney U test was conducted to test the hypothesis above. The calculated values for the p-value statistic were evaluated in comparison to the critical values for each indicator to determine if the null hypothesis is to be rejected or if there is evidence that fails to reject the claim. If the p-value was less than the critical value ($\alpha = .05$) the null hypothesis was rejected. The p-value statistic was less than the critical value in indicator number eleven: The effectiveness of
visual-based learning material in technology education for grades 7-12 depends upon the relevance of the materials.

The reason for this could be due to the nature of the indicator. This specific indicator is very broad, hard to understand and does not specify the kind of relevance within the materials.

Implications of the Research

Listed below are the implications of the findings and conclusions of this research study:

1. The study and the information gathered during the research process can help establish an assessment model for visual-based learning materials to be used in technology education programs in grades 7-12. Such an assessment tool can be very beneficial for the teachers teaching those grades and can help them make informed decisions during the visual-based material selection process.

2. The final list of the quality visual-based learning material indicators can serve as a guide for future visual-based learning material authors. For individuals involved with visual-based learning material grants, this list can serve as a part of the validation process since every indicator included in the list went through a statistical corroboration as a part of the study.

3. Another implication of the findings of this study is that a need exists within the profession to study the dimension of quality and assessment derived from the study; That way, when new visual-based learning programs are being created, a set of validated standards can be followed to promote knowledge endorsement and learning transmission. Quality outcomes from an educational program can occur only if the
program itself has been developed based on quality material and guidelines. This study began the process of quality indicators identification for the development of quality visual-based learning material for technology education programs.

Implications for Conducting Future Research

Implications from the research study also established how the researcher would do things differently in the future if this research study or a similar one were to be conducted again. No previous studies were found that identified the quality characteristics of visual-based learning material in technology education programs for grades 7-12. However, studies were found that evaluated the effectiveness of visuals for other academic disciplines. Previous studies, along with the findings from this study, raise questions that provide the basis for recommendations for future research.

1. First, the researcher suggests that larger, more diverse panels be established as a part of the panel selection procedures. Having a larger, more diverse population as members of the expert panel would give the researcher a better understanding of what those individuals who are responsible for initiating the findings of the research feel should be included in the quality assessment process.

2. If financial allocations were allowed, 30 to 50 members for this panel of experts, instead of 20, would better reflect what technology education professionals throughout the United States feel are the quality indicators for visual-based learning material in technology education programs in grades 7 to 12. Also the review panel could increase its membership to provide more feedback to the researcher.

3. A third way the research could be conducted differently includes the process of
developing unique passwords for each one of the experts’ panel members. This is recommended because having unique passwords would enable the researcher to identify each of the experts’ panel members to conduct further statistical analysis.

4. A fourth implication or factor to consider for conducting this type of research study differently would be to take the information found through this study to the next step. Since the quality indicators have been verified through a panel of experts, the next step would be to develop an assessment tool to be used in the creation of new visual-based learning material or the evaluation of pre-existed material during the selection process.

5. Another process that could have been done differently includes the comparison of nonparametric statistical analyses to parametric statistics. This would allow the comparison of outcomes through the different statistical methods and would give more credit to the research findings since parametric statistics could provide more powerful justifications than the nonparametric. This study used nonparametric statistical methods since the assumption of a non-normal distribution was adopted.

6. Another procedure that could improve this Delphi study includes the use of better communications between panel members and the researcher. Interest in the research from panel members seems to decrease over a long period of time during the Delphi study; therefore it is suggested by the researcher for this study that steps be taken to keep the interest of panel members at high levels. One procedure that could improve this problem is to send reminders on a biweekly basis, and appreciation letters at the end of each round.
Recommendations for Further Research

The experience of this research suggested many possible recommendations for further study in the areas of quality visual-based learning material in technology education programs for grades 7-12, and the use of the Delphi method as a research tool. The following recommendations are suggested for further study.

1. Additional research is needed on how to establish and assess quality indicators for visual-based learning material in technology education for all grades. This includes elementary, middle school, high school and college level visual-based learning material for technology education programs.

2. Additional studies should be conducted using other research methodologies to better understand the subject matter and aid in validating the information gathered.

3. This study should be replicated in 5 years to see if new quality indicators are identified for visual-based learning material in technology education programs for grades 7-12, and the information should be updated in the final quality indicators list for a more representative up-to-date assessment of visual-based learning materials.

4. Additional research is needed in developing an assessment strategy and model for assessing quality visual-based learning material in technology education programs for grades 7-12 at the national and international level.

5. Validate assessment tools to aid the selection process of quality visual-based learning material in technology education programs for grades 7-12 at both the national and international levels.

6. Additional research should be conducted to define the difference between a visual-
based learning material in technology education for grades 7-12 and a quality visual-based learning material in technology education for grades 7-12 using the guidelines identified in this study for a quality visual-based learning material.

Chapter Summary

Chapter five of the study presents the researcher’s explanations of the results and findings of this study. Starting with the conclusions for research questions, the final list of the validated quality indicators is presented with the researcher’s input. Continuing with the conclusions for the hypotheses, the researcher presented a series of statistical tests used to show that final consensus was achieved for each Round of the modified Delphi method and to verify which indicators were kept in the final list of quality indicators. The statistical tests included the non-parametric Kruskal-Wallis test to determine whether there was a significant difference between the middle school experts’ opinions and the high school experts’ opinions. The results showed no significant difference, which indicated well-written indicators, strong consensus and agreement among experts.

The Mann-Whitney U test was employed to test a hypothesis of a design with two independent samples to determine if significant difference occurred between the medians of expert populations. The results showed few significant differences, which indicated strong consensus among experts.

The Spearman’s rho nonparametric test was used to show a positive coefficient correlation between the middle and high school populations responses found in Round II. The results showed a strong positive correlation coefficient for the composite set of
indicators as well as positive coefficient for all except 2 of the individual indicators.

Implications of the research were noted and researcher identified strengths and weaknesses of the study. Finally, the implications for future studies, recommendations and suggestions were stated.
References


Federal Coordinating Council for Science, Engineering and Technology.


McCarthy, B. (1980). The 4MAT system: *Teaching to learning styles with right/left mode techniques*. Oak Brook, IL: Excel, Inc.


http://www.ncsu.edu/viste//aboutus.html


*Published proceedings of the American Society for Engineering Education Annual Conference and Exposition*, Salt Lake City, UT, Session 3138.


APPENDICES
Appendix A

Letter to Principal Investigators for Panel of Experts and Reviewers
Institutional Review Board Application
Institutional Review Board Approval
Study Webpage
November 30, 2006
Dr. Richard Peterson

Dear Principal Investigator:

As a leader in visual-based learning material in Technology Education, I need your help. Let me explain, I am currently doing research on quality characteristics for visual-based learning material in Technology Education as a part of my dissertation at North Carolina State University. I will be using a panel of experts, selected by leaders like you, from various grants, to identify these quality indicators. I would appreciate if you could recommend qualified participants from your grant (TECH-Know *) that you believe could best serve on this expert panel. You can submit the names of any grant participant for this expert panel as long as they meet the following qualifications:

a) has taught Technology Education subjects using visual-based learning material
b) he/she is the author of visual-based learning material in Technology Education
c) he/she is the author of visual-based learning material, literature or related grant proposal.

I thank you in advance for sending me your recommendation for this influential panel. Please reply back to this email with the name, school and email address for the individuals you suggest and send it to me by Friday November 12th. If you have any questions please contact me at the following phone numbers and addresses. Again thank you and I look forward hearing from you.

Sincerely,

Petros Katsioulidis

Phone Numbers: Cell (919)452 4561; H (919)596 3048

E-mail: gkatsiorg@ncsu.edu

Address: NCSU, Dept. of Math, Science, and Technology Education
Raleigh, NC 27695-7861
North Carolina State University
Institutional Review Board for the Use of Human Subjects in Research
Submission for New Studies

Title of Project: IDENTIFICATION OF QUALITY CHARACTERISTICS OF VISUAL-BASED LEARNING MATERIAL FOR TECHNOLOGY EDUCATION PROGRAMS
Principal Investigator: Petros Katsioloudis
Department: Math, Science & Technology

Source of Funding (required information):
(if externally funded include sponsor name and university account number)

Campus Address (Box Number)

Email: pjkatsio@ncsu.edu
Phone: 919 452 4591
Fax:

RANK: [ ] Faculty
[ ] Student: [ ] Undergraduate; [ ] Masters; or [ ] PhD
[ ] Other (specify):

As the principal investigator, my signature testifies that I have read and understood the University Policy and Procedures for the Use of Human Subjects in Research. I assure the Committee that all procedures performed under this project will be conducted exactly as outlined in the Proposal Narrative and that any modification to this protocol will be submitted to the Committee in the form of an amendment for its approval prior to implementation.

Principal Investigator:

Petros Katsioloudis
(typed/printed name) (signature)

As the faculty sponsor, my signature testifies that I have reviewed this application thoroughly and will oversee the research in its entirety. I hereby acknowledge my role as the principal investigator of record.
PLEASE COMPLETE IN DUPLICATE AND DELIVER, ALONG WITH A PROPOSAL NARRATIVE, TO:
Institutional Review Board, Box 7514, or email as an attachment to debra_paxton@ncsu.edu

************************************************************************
For SPARCS office use only
Reviewer Decision (Expedited or Exempt Review)

☐ Exempt  ☐ Approved  ☐ Approved pending modifications
☐ Table

Expedited Review Category:  ☐ 1  ☐ 2  ☐ 3  ☐ 4  ☐ 5  ☐ 6  ☑ 7  ☐ 8a  ☐ 8b  ☐ 8c  ☐ 9

________________________________________
Reviewer Name  Signature

DATE

North Carolina State University
Institutional Review Board for the Use of Human Subjects in Research
GUIDELINES FOR A PROPOSAL NARRATIVE

In your narrative, address each of the topics outlined below. Every application for IRB review must contain a proposal narrative, and failure to follow these directions will result in delays in reviewing/processing the protocol.
A. INTRODUCTION
1. Briefly describe in lay language the purpose of the proposed research and why it is important.

Since the early 1980s it has been a very little research for instructors to use when selecting specific types of visuals that will be most effective and efficient in facilitating student achievement of designated learning objectives. “What is urgently needed is systematic research efforts focused on three basic areas designed to provide data on: (a) what specific individual difference variables in learners actually make a difference in student achievement in the teaching learning process, (b) which of these individual difference variables interact significantly with different kinds of visualization used to complement oral/printed instruction, and (c) what is the extent of the range within specific individual difference variables that are accommodated by the use of specific types of visualization” (Dwyer, 1978, p. 5). Therefore, it is essential to identify characteristics of quality visual-based learning material for technology education curricula. Moreover, it is important to validate these characteristics through involvement of educational experts in the field of visual learning and technology education. Technology Education experts, who have knowledge related to visual learning and practical experience, involved in the creation of related materials, are a useful source of information to develop and validate the characteristics of visual-based learning materials for technology education.

The study data are essential to making informed decisions about choosing the specific characteristics of visual-based learning material for most effective and efficient student achievement of designated learning objectives. It is expected that the characteristics identified by this study would be beneficial to Technology Education educators developing visual-based learning materials. This study will also provide information to authors of visual-based learning materials and can serve as a guide for future materials.

2. If student research, indicate whether for a course, thesis, dissertation, or independent research.

Dissertation

B. SUBJECT POPULATION
1. How many subjects will be involved in the research? Twenty-five subjects
2. Describe how subjects will be recruited. Please provide the IRB with any recruitment materials that will be used.

Panel selection is critical in using the Delphi technique (Lang, 1998). The panel will be consisted of technology teachers that will be selected through two ongoing at this point grants funded by the National Science Foundation. The two grants are TECH-Know and VisTE. In both grants the teachers pilot and field-tested technology education visual learning educational materials. The PI's of the two grants; Dr. Aaron C. Clark and Dr. Richard Peterson will nominate the potential panel teachers. The reason the two Principal Investigators (PI's) have been selected to nominate the potential panel teachers is due to their expertise with visual-based learning material. Both Dr. Clark and Dr. Peterson have been authors of numerous articles related to visual-based learning material in Technology Education and have served as PI's of related to the subject grants. The experts’ panel will consist of 25 individuals. The PI’s will be asked for names of technology education teachers they would suggest for the panel from the grant participants that were pilot testing or field-testing visual learning materials. The names given by the two PI's will then be stratified by area codes so different regions within the US will be represented on the panel. Once the 25 expert panel members (N=25) are stratified by area codes, each member will be given a number and using the random number generation feature of a scientific calculator, 12 individuals will be selected for participating the study. Linestone and Turoff (1975) suggests a panel size of anywhere from 10 to 50 participants. It has also been reported that the validity and reliability of the Delphi technique does not significantly improve with more than 30 participants.

3. List specific eligibility requirements for subjects (or describe screening procedures), including those criteria that would exclude otherwise acceptable subjects.

- Current involvement in education with research and service as education professional with minimum of five years teaching experience with visual-based learning material in Technology Education.
- Provides leadership in developing, implementing, and evaluating educational material for visual-based learning in Technology Education.
- Record of publication or presentation in the field visual-based learning material in Technology Education.
- Models professional teaching practices, which demonstrate knowledge, skills and attitudes for visual-based learning.
• Collaborates regularly with school, university, state education department, professional associations, grants and community representatives to improve visual-based learning teaching and learning.

4. Explain any sampling procedure that might exclude specific populations.
   None

5. Disclose any relationship between researcher and subjects - such as, teacher/student; employer/employee.
   None

6. Check any vulnerable populations included in study:
   minors (under age 18) - if so, have you included a line on the consent form for the parent/guardian signature
   fetuses
   pregnant women
   persons with mental, psychiatric or emotional disabilities
   persons with physical disabilities
   economically or educationally disadvantaged
   prisoners
   elderly
   students from a class taught by principal investigator
   other vulnerable population.

   If any of the above are used, state the necessity for doing so. Please indicate the approximate age range of the minors to be involved.

C. PROCEDURES TO BE FOLLOWED
1. In lay language, describe completely all procedures to be followed during the course of the experimentation. Provide sufficient detail so that the Committee is able to assess potential risks to human subjects.

   The procedures for this research study will begin with a proposal for conducting the study and a review of literature to acquire information related to the subject and related subject matter. The study will use a modified Delphi technique for identifying the quality characteristics for supplemental technology education visual-based learning materials. The approach that will be used in this study to achieve its purposes will be the online modified Delphi methodology. This study will involve three rounds to achieve consensus among a group of experts in visual-based learning materials that are experienced technology teachers involved in pilot and field-testing
for visual-based learning material grant. All data will be gathered via a web site created to host the study and the World Wide Web as a primary mode of communication using Web-based instruments. Upon completion of the Delphi study, the components for visual-based learning material for technology education courses will be identified.

The Delphi study will start by having selected the experts’ panel. Selection criteria for expert panel members will be based on a review of the literature; therefore, potential panel members will be selected based on criteria. Panel selection is critical in using the Delphi technique (Lang, 1998). The panel will be comprised of technology teachers that will be selected through two ongoing at this point grants funded by the National Science Foundation. The two grants are TECH-Know and VisTE. In both grants the teachers pilot and field-tested technology education visual learning educational materials. The PI’s of the two grants; Dr. Aaron C. Clark and Dr. Richard Peterson will nominate the potential panel teachers. The reason the two Principal Investigators (PI’s) have been selected to nominate the potential panel teachers is due to their expertise with visual-based learning material. Both Dr. Clark and Dr. Peterson have been authors of numerous articles related to visual-based learning material in Technology Education and have served as PI’s of related to the subject grants. The experts’ panel will consist of 25 individuals. The PI’s will be asked for names of technology education teachers they would suggest for the panel from the grant participants that were pilot testing or field-testing visual learning materials. The names given by the two PI’s will then be stratified by area codes so different regions within the US will be represented on the panel. Once the 25 expert panel members (N=25) are stratified by area codes, each member will be given a number and using the random number generation feature of a scientific calculator, 12 individuals will be selected for participating the study. Linestone and Turoff (1975) suggests a panel size of anywhere from 10 to 50 participants. It has also been reported that the validity and reliability of the Delphi technique does not significantly improve with more than 30 participants (Ref).

All approvals from the Institutional Review Board will be obtained. After the experts’ panel are selected, a review panel of three members will be randomly selected from the list of names of all grant related individuals that were involved in the creation of the visual learning materials in VisTE and TECH-Know. Potential expert and review panel members will then be reached by telephone to seek their acceptance. Upon acceptance, a follow-up letter along with release forms will be faxed to the experts who accept the invitation to participate. Once the expert panel is established, a review panel of three members will be randomly selected from the list of the names not selected to be on the expert panel. The review panel will be consisted of one representative from the grant participants, one member from the list of technology education teachers, and one from the list of visual-based learning material authors. After the review panel members are selected, an email will be sent to each person selected to indicate whether or not they want to participate in the process to approve all modifications and materials prior to sending the materials to the panel of experts. The two primary advantages of e-mail panel selection over traditional recruitment approaches are time and cost (Andrews & Allen, 2002).
To be able to justify the expertise of the individuals selected to be a part of the expert panel, a demographics survey will be created and hosted in the study’s web page for every participant to visit and complete. In the demographics survey six questions will be asked:

1. Which title most accurately describes your current position?

2. Which of the following grade level(s) do you currently teach or oversee?

3. What is the highest degree obtained as of January 1, 2007?

4. What is your gender?

5. Year of graduation

6. Current residence

Upon receiving correspondence from the demographic survey participants a meeting with the review panel will be scheduled to analyze the results.

The instrument for round one of the Delphi process will be developed from information found in the review of literature. Examples of quality characteristics will be established and placed in a survey instrument to indicate the actual format in which the characteristics will be written. Once the review panel approves the Round I instrument, it will be accessible to the expert panel through the study’s web site. An email will also be sent to the panel members after two weeks to remind them to reply. Helmer (1983) suggests that it may be necessary to begin a Delphi study with an open-ended question designed to help define and identify potential subject matter to be included in subsequent instruments. The Round I instrument for this study will be consisted of an open-ended question asking the panelists to provide possible characteristics that a visual-based learning material in Technology Education should be consisted of. Example of characteristics will also be provided to the expert panel. Those examples will derive from the literature review.

The open-ended question will be:

Reflecting on a quality visual-based learning material in Technology Education such as the ones created from VisTE and TECH-Know what characteristics should be included in it? Please list all possible characteristics and give a specific description for each one of them.

The expert panel at North Carolina State University will review the instrument and necessary changes will be made.

Round II of the Delphi method will include the rating of those characteristics from round one. The instrument will be developed and emailed to the review panel for verification. The characteristics will be random order number under their corresponding categories. The round will be consisted of rating each characteristic from round one. Only the characteristics with a mean 3.1 or higher will be kept on
Round III. A one factor Repeated measures Analysis of Variance (ANOVA) statistical test will be conducted on the characteristics to see if any statistical significance could be seen in the rankings through the collected means for each characteristic in this round. Panel members will be asked to use a 5-point Likert scale to state their level of agreement on each characteristic (identified by round one), where 5 will be the highest agreement and 1 the lowest. Electronic forms with radio buttons will be used so the expert panel member can click a button representing the scale number selected. The expert panel will also have the ability to edit the given characteristics and submit feedback through a text-box. The second round instrument will be posted on the study’s web site hosted by the Web Services of North Carolina State University. The purpose of Round III will be to develop consensus among expert panel members. To measure consensus, interquartile range (IQR) and frequency will be used. The media will be used to determine the level of agreement and disagreement. Those characteristics that will receive high median and low IQR (Median ≥ 5; IQR ≤ 1.5) will be kept for the final list. In the third instrument panel members will be asked to accept or reject their original selections from Round II. In addition, participants will be provided with the statistical analysis results from Round II: (a) median, mode and the frequency of response on each item, (b) individual panel ratings for each item form Round II, and (c) comments made by each participant. Access of the instrument will be granted for each panel member. Participants will be asked to accept or reject each characteristic retained from the second round using a 5-point Likert scale. Also instructions for completing the instrument will be provided on the first page of the instrument.

2. How much time will be required of each subject?
   Three hours over a period of four weeks.

D. POTENTIAL RISKS
1. State the potential risks (physical, psychological, financial, social, legal or other) connected with the proposed procedures and explain the steps taken to minimize these risks.
   None

2. Will there be a request for information which subjects might consider to be personal or sensitive (e.g. private behavior, economic status, sexual issues, religious beliefs, or other matters that if made public might impair their self-esteem or reputation or could reasonably place the subjects at risk of criminal or civil liability)?
   No
   a. If yes, please describe and explain the steps taken to minimize these risks.
3. Could any of the study procedures produce stress or anxiety, or be considered offensive, threatening, or degrading? If yes, please describe why they are important and what arrangements have been made for handling an emotional reaction from the subject.
   No

6. How will data be recorded and stored?
   Data will be recorded and stored in a Web Page stored at the University’s server.
   
   a. How will identifiers be used in study notes and other materials?
      Each individual will be given a number and no names will be used.

   b. How will reports will be written, in aggregate terms, or will individual responses be described?
      Information will be described in a statistical form after it has been analyzed.

5. If audio or videotaping is done how will the tapes be stored and how/when will the tapes be destroyed at the conclusion of the study.
   Will not be used.

6. Is there any deception of the human subjects involved in this study? If yes, please describe why it is necessary and describe the debriefing procedures that have been arranged.
   No

E. POTENTIAL BENEFITS
   This does not include any form of compensation for participation.

1. What, if any, direct benefit is to be gained by the subject? If no direct benefit is expected, but indirect benefit may be expected (knowledge may be gained that could help others), please explain.

   The study data are essential to making informed decisions about choosing the specific characteristics (see definitions) of visual-based learning material for most effective and efficient student achievement of designated learning objectives. It is expected that the characteristics identified by this study would be beneficial to Technology Education educators developing visual-based learning materials. This study will also provide information to authors of visual-based learning materials and can serve as a guide for future materials.

F. COMPENSATION
1. Explain compensation provisions if the subject withdraws prior to completion of
   the study.

2. If class credit will be given, list the amount and alternative ways to earn the
   same amount of credit.

G. COLLABORATORS

1. If you anticipate that additional investigators (other than those named on Cover
   Page) may be involved in this research, list them here indicating their institution,
   department and phone number.

3. Will anyone besides the PI or the research team have access to the data
   (including completed surveys) from the moment they are collected until they are
   destroyed.
   NO

H. ADDITIONAL INFORMATION

1. If a questionnaire, survey or interview instrument is to be used, attach a copy
   to this proposal.

2. Attach a copy of the informed consent form to this proposal.

3. Please provide any additional materials that may aid the IRB in making its
   decision.
From: Debra A. Paxton, Regulatory Compliance Administrator
North Carolina State University
Institutional Review Board

Date: October 23, 2006

Project Title: Identification of Quality Characteristics of Visual Based Learning Material for Technology Education Programs

IRB#: 357-06-10

Dear Mr. Katsioloudis:

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.2). 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: M1263; the IRB Number is: 01XM.

2. Review de novo of this proposal is necessary if any significant alterations/additions are made.

Please provide a copy of this letter to your faculty sponsor. Thank you.

Sincerely,

Debra Paxton
NCSU IRB
Department of Mathematics, Science and Technology Education

A Dissertation Study conducted by Petros Katsioloudis

VisMATE: Modified Delphi Study

Modified Delphi Method: A modified Delphi method is a variation of the Delphi method developed by Delkey and Helmer at Rand. It utilizes rounds of a survey, with questions dropping off, new questions added, and participants being able to see anonymous responses from other participants. Unlike the original Delphi, a modified Delphi method provides panelists with opportunity to provide their comments between the rounds (Murray & Hammons, 1995). Panelists are able to view the comments anonymously and consider it while making their choices. The Modified Delphi method described here uses electronic mail to gather information, provide feedback, and report conclusions.

Purpose of the study

The purpose of the study is to determine consensus on characteristics that a “quality” Visual Based Learning Material in Technology Education should be imbedded with. In the presence of those characteristics the technology education visual based learning material will guarantee to certain extent effective transmission of certain types of information. Therefore, the study will identify those characteristics needed to be included in every visual based learning material needed by teachers and other professionals that will be most effective and efficient in facilitating student achievement and knowledge transmission.
Appendix B

Letter to Potential Panel of Experts
Letter to Potential Panel of Reviewers
Letter for Study Overview
Thank you Letter to Panel of Reviewers
Thank you Letter to Panel of Experts
Study Participation Letter
December 26, 2006

Dear Technology/Technical Professional,

I need your help. Let me explain, I am currently conducting a research on quality characteristics for visual-based learning material in Technology Education as a part of my dissertation at North Carolina State University. Yourself among others have been identified by Dr. Aaron Clark as a visual-based learning material expert because of your involvement with the VisITE "grant. Your expertise will help technology education programs across the globe assess the selection of visual-based learning material and strive to provide a better education for all students taking these programs, but in order to complete this task I need every member to respond to each of the three rounds of the Delphi process over the winter months.

Each round should take only a few minutes to complete and through an interactive website with the click of a button it can be submitted and sent to me with in a few seconds. The response time needed in order to continue the process in a timely fashion will be two weeks after access is granted for each round.

The first round will have two parts: (a) you will be asked to complete a simple one page demographic survey about yourself and (b) complete the first review of the Delphi process. This will involve you, the review panel member, to evaluate the questionnaire and give feedback about needed changes in format and overall structure before being emailed to the expert panel members. Instructions for each round will be included. If you agree to participate in this study please reply to this email by typing the words "reviewer agree" in the subject area of the email.

Sincerely,

Petros Katsioloudis

Etc.
January 9, 2007

Dear Technology/Technical Professional,

I need your help. Let me explain, I am currently conducting a research on quality characteristics for visual-based learning material in Technology Education as a part of my dissertation at North Carolina State University. Yourself among others have been identified by Dr. Aaron Clark as a visual-based learning material expert because of your involvement with the VistE "grant. Your expertise will help technology education programs across the globe assess the selection of visual-based learning material and strive to provide a better education for all students taking these programs, but in order to complete this task I need every member to respond to each of the three rounds of the Delphi process over the winter months.

Each round should take only a few minutes to complete and through an interactive website with the click of a button it can be submitted and sent to me with in a few seconds. The response time needed in order to continue the process in a timely fashion will be two weeks after access is granted for each round. Instructions for each round will be included. If you agree to participate in this study please reply to this email by typing the words “expert agree” in the subject area of the email.

Sincerely,

Petros Katsioulidis

Enc.
January 6, 2007

Dear Technology/Technical Professional,

I need your help. Let me explain, I am currently conducting a research on quality characteristics for visual-based learning material in Technology Education as a part of my dissertation at North Carolina State University. Yourself among others have been identified by Dr. Richard Peterson as a visual-based learning material expert because of your involvement with the TECH-Know grant. Your expertise will help technology education programs across the globe assess the selection of visual-based learning material and strive to provide a better education for all students taking these programs, but in order to complete this task I need every member to respond to each of the three rounds of the Delphi process over the winter months.

Each round should take only a few minutes to complete and through an interactive website with the click of a button it can be submitted and sent to me with in a few seconds. The response time needed in order to continue the process in a timely fashion will be two weeks after access is granted for each round. Instructions for each round will be included. If you agree to participate in this study please reply to this email by typing the words “expert agree” in the subject area of the email.

Sincerely,

Petros Katsioloudis

Enc.
January 10, 2007,

Dear Technology/Technical Professional,

I need your help. Let me explain, I am currently conducting a research on quality characteristics for visual-based learning material in Technology Education as a part of my dissertation at North Carolina State University. Yourself among others have been identified by Dr. Richard Peerson as a visual-based learning material expert because of your involvement with the TECH-Know " grant. Your expertise will help technology education programs across the globe assess the selection of visual-based learning material and strive to provide a better education for all students taking these programs, but in order to complete this task I need every member to respond to each of the three rounds of the Delphi process over the winter months.

Each round should take only a few minutes to complete and through an interactive website with the click of a button it can be submitted and sent to me in a few seconds. The response time needed in order to continue the process in a timely fashion will be two weeks after access is granted for each round.

The first round will have two parts: (a) you will be asked to complete a simple one page demographic survey about yourself and (b) complete the first review of the Delphi process. This will involve you, the review panel member, to evaluate the questionnaire and give feedback about needed changes in format and overall structure before being emailed to the expert panel members. Instructions for each round will be included. If you agree to participate in this study please reply to this email by typing the words "reviewer agree" in the subject area of the email.

Sincerely,

Petros Katsioloudis

Etc.
Study Overview

Title:
A Delphi Study to Identify the Quality Characteristics of Visual-based Learning Material in Technology Education Programs

Researcher: Petros Katsioulaoudis, Doctoral Candidate
School: North Carolina State University
Major: Technology Education

According to Clark and Matthews (2000) the use of visual technology enhances learning by providing a better understanding of the topic as well as motivating the students. Visualization methods are widely credited for simplifying presentation of difficult subjects as well as aiding cognition and their use in the power engineering industry and education is enjoying significant growth. (Idowu, Britton, Hartmann, Nehard, Abraham & Boyer, 2006).

Even though the success by which the visualization of content will facilitate learner acquisition of information is related to the individual’s level of perceptual and associative learning in the content area in which the learning is to occur, the individual has to have sufficient experience and maturity to realize that the use of visualization is merely an attempt to vicariously represent reality (Dwyer, 1978). In addition to the individual’s experience, the visualization itself plays an important role in the process of learning.

If all visual-based learning materials were equally effective in facilitating student achievement of all kinds of educational objectives, there will be virtually no problem associated with this type of instruction (Dwyer, 1978). However, this is not the case since there are many different types of visuals.

At the present time educators, when faced with a choice of selecting one type of visualization from an array of available materials, have no way of knowing whether one type of visual is any more effective than another in transmitting certain types of information (Dwyer, 1978). The lack of quantifiable measures of quality and benchmarks will undermine information visualization advances, especially their evaluation and selection (Chaonin, 2005). The importance of knowing how to select the best type of visual-based learning material is recognized throughout higher education; however, with the exception of some descriptive literature, few studies have been conducted to identify the essential characteristics of visual-based learning materials used in technology education. The purpose of this study will be to identify those characteristics needed to be included in visual-based learning material for effective knowledge transmission in technology education materials.

Method: Web-based Delphi method will be used to generate statements and reach consensus on visual-based learning material quality characteristics.
February 11, 2007

Dear Review Panel Member,

I would like to thank you for accepting a position on this vital panel for technology education in the United States. You have agreed to participate in our analysis using the Modified Delphi research technique to define quality indicators of visual-based learning material for grades 7th-12th in technology education programs. Your expertise will help technology education teachers across the United States identify and choose the best visual-based instructional material to provide more efficient knowledge transmission for all students using those materials. In order to complete this task, I need every member to respond to each of the three rounds of this research project over the winter/spring months. Each round should take only a few minutes to complete. The response time needed in order to continue the process will be two weeks after password access is granted to complete each round.

The first round will have two parts: (a) you will be asked to complete a simple one-page demographic survey about yourself and (b) complete the first review of the Modified Delphi process. This will involve you, the review panel member, to evaluate the questionnaire and give feedback about needed changes in format and overall structure before password access is granted to the expert panel members. Please consider the following two definitions when evaluating the questionnaire: Quality-a degree of excellence and relative worth; quality indicator-a trait or attribute.

If you see no problems with first Round you do not need to send anything about the first instrument just the demographics information. Instructions for each round will be included. As the review panel member, all you will need to provide is your time. Please remember that I need all responses back from each panel member in a timely manner so that each round is complete and all three rounds can progress so that the study will be a success. This first round is needed back in 48 hours after receiving it in order to set the process started.

Again thank you for agreeing to work with me on this important study. I know your time is valuable, but the resulting document will help determine the quality indicators of visual-based learning material for grades 7th-12th in technology education programs. If you have any questions or comments please feel free to contact me at any time.

Sincerely,

Petros Katsioloudis
February 9, 2007

Dear Expert Panel Member,

I would like to thank you for accepting a position on this vital panel for technology education in the United States. You have agreed to participate in our analysis using the Modified Delphi research technique to define quality indicators of visual-based learning material for grades 7th-12th in technology education programs. Your expertise will help technology education teachers across the United States identify and choose the best visual-based instructional material to provide more efficient knowledge transmission for all students using those materials. In order to complete this task I every member to respond to each of the three rounds of this research project over the winter months. Each round should take only a few minutes to complete. The response time needed in order to continue the process in a timely fashion will be two weeks after password access is granted to complete each round.

The first round will have two parts: (a) you will be asked to complete a simple one-page demographic survey about yourself and (b) complete the first review of the Modified Delphi process. This will involve you, the expert, to identify the quality indicators that you feel are important to have in a visual-based learning material for grades 7th-12th in technology education programs. Please consider the following two definitions when evaluating the questionnaire: Quality—a degree of excellence and relative worth; Quality indicator—a trait or attribute.

Instructions for each round will be included. As the expert panel member, all you will need to provide is your time. Please remember that I need all responses back from each panel member in a timely manner (2 weeks) so that each round is complete and all three rounds can progress so that the study will be a success.

Again thank you for agreeing to work with me on this important study. I know your time is valuable, but the resulting document will help determine the quality indicators of visual-based learning material for grades 7th-12th in technology education programs. If you have any questions or comments please feel free to contact me at any time.

Sincerely

Petros Katsioloudis
Study Participation Agreement

I, ___________________, have read the study overview provided by the researcher (Petros Kasioulidis). I pledge that I fully understand the nature of my commitment and intend to do my best to fulfill all of the obligations of participation. I also understand that I may withdraw my participation in said study at any time without any negative consequences.

Date: ___________________
Organization: ___________________
Title: ___________________
Name: ___________________
Signature: ___________________
E-mail: ___________________
Phone Number: Day Time: (___) ___________________
Appendix C

Letters and Instrument sent in Round I

Instructions to Expert Panel Members
Instructions to Review Panel Members
Demographics Survey
Disclaimer Letter
Instrument I
Reminder I
February 10, 2007

Instructions for **Round One** of the Study
Expert Panel Members

Listed below are the instructions for completing the first round of the study that is designed to define quality indicators of visual-based learning material for grades 7th-12th in technology education programs. Please complete the following two data collecting instruments for the Modified Delphi Study.

**Instructions:** To gain access to the instruments you need to visit the electronic link  
http://www4.ncsu.edu/~pjkassio/index.htm. Once the front page is loaded, at the left side you will see a list of links with the first one being *Demographic Survey*. Using the mouse cursor click on the link. A disclaimer page will now appear stating information related to the study and you the participant. Read carefully and if you accept the rules move the cursor where it states *Access the protected area*. Using the mouse click on the link. A new page that contains a Login box will now appear. Two empty text boxes are provided for you to type **Username** and **Password**. Inside the **Username** box type: john  
Inside the **Password** box type: orange  
After typing username and password move the cursor over the link **Login** and click. The desired instrument will now appear on a new page.

**Instrument one:** The first instrument to complete is a demographic questionnaire to find information about you and others that are participating in the study. The title of the instrument is *Demographic Survey for Delphi Study*. Using the Instructions described above complete each question to your best knowledge about what the questions are asking. Once you complete all questions of the survey, use the cursor to click the **Submit** button at the end of the demographic survey. All of your answers will be submitted.

**Instrument two:** The second instrument is the listing of quality indicators you feel are good characteristics of a visual-based learning material for grades 7th-12th in technology education programs. The title of the instrument is *Round One Questionnaire*. The first seven indicators are examples of the type of information and writing style the study is identifying. The examples can be used if you click **KEEP** underneath each indicator. If you do not wish to use the category please click on **REJECT** and write in a new indicator inside the text box provided underneath; to use the indicator but make changes in the wording, please click **MODIFY**. If you click **MODIFY**, please write your changes inside the provided text box underneath the indicator you wish to change. At the end of the page a provided text box (number 8) exists for you to **ADD** NEW indicators. Your main objective is to **ADD** more NEW indicators by typing inside the provided text box for new indicators. You may type as many **NEW** indicators as you need. **Note:** No set number of quality indicators is needed for each category.

Using the instructions described above complete each question to your best knowledge about what the questions is asking. Once you complete all questions of the survey, use the cursor to click the **Submit** button at the end of the demographic survey. All of your answers will be submitted. Please have your responds submitted with in the next 2 Weeks.

Again, thank you for taking your time to read these instructions and participate in the study. If you have any questions please contact me. (See contact info on the top of this page).
February 10, 2007

Instructions for Round One of the Study
Review Panel Members

Listed below are the instructions for completing the first round of the study that is designed to define quality indicators of visual-based learning material for grades 7th-12th in technology education programs. Please complete the following two data collecting instruments for the Modified Delphi Study.

Instructions: To gain access to the instruments you need to visit the electronic link http://www4.ncsu.edu/~pjktsio/index1.html. Once the front page is loaded, at the left side you will see a list of links with the first one being Demographic Survey. Using the mouse cursor click on the link. A disclaimer page will now appear stating information related to the study and you the participant. Read carefully and if you accept the rules move the cursor where it states Access the protected area. Using the mouse click on the link. A new page that contains a Login box will now appear. Two empty text boxes are provided for you to type Username and Password. Inside the Username box type: john
Inside the Password box type: orange
After typing username and password move the cursor over the link Login and click. The desired instrument will now appear on a new page.

Instrument one: The first instrument to complete is a demographic questionnaire to find information about you and others that are participating in the study. The title of the instrument is Demographic Survey for Delphi Study. Using the Instructions described above complete each question to your best knowledge about what the questions are asking. Once you complete all questions of the survey, use the cursor to click the Submit button at the end of the demographic survey. All of your answers will be submitted.

Instrument two: The second instrument is the listings of quality indicators you feel are good characteristics of a visual-based learning material for grades 7th-12th in technology education programs. The title of the instrument is Round One Questionnaire. The first seven indicators are examples of the type of information and writing style the study is identifying. The instrument has been approved through the North Carolina State University Institutional Review Board, however your appointment as a reviewer is to examine the Round one questionnaire for format, structure, accessibility. Please review the instrument and provide feedback by email to me at pjktsio@ncsu.edu within the next 48 hours.

Again, thank you for taking your time to read these instructions and participate in the study. If you have any questions please contact me (See contact info on the top of this page).
VisMATE Visual Material Assessment in Technology Education™

Demographic Survey for Delphi Study

Please choose by clicking on the button or type in textbox below each question.

1. Which title most accurately describes your current position? (choose all that apply)
   - Technology Teacher using visual-based learning material
   - Visual-based learning grant related participant
   - Visual-based learning material author
   (If other please write, edit, state in box below)

2. Which of the following grade level(s) do you currently teach or oversee?
   - middle school
   - high school
   - college/University
   - community/ technical school
   (If other please write, edit, state in box below)

3. What is the highest degree obtained as of January 1, 2007?
   - B.S/B.A
   - M.S/M.Ed
   - 6 year
   - Ed.D/Ph.D
   (Please indicate below the field/discipline and name of University your degree was earned)

4. GENDER
   - Male
   - Female

http://www.ncsu.edu/~pikat/lc/demosurvey.htm
5. CURRENT RESIDENCE:  ○ USA, State/Territory ☐ OR:  ○ non-USA, Country ☐

6. Year of Graduation from High School ☐

7. Have you been involved in VisTE and/or TechKNOW?
   Yes ☐ No ☐

8. Have you had any type of Visual training with in the last 5 years (i.e. CAD workshop)?

9. What courses have you taught with in the last 2 years that require Visual teaching/student capabilities?

Please submit survey.
Thank you
Welcome to the VisMATE survey. This survey is part of a research study about Visual based Learning material in Technology Education. We are asking to participate in this study by completing the following survey. The survey asks for information such as where you are from and your assigned username. Confidentiality will be kept between all participants and only the conductor of the research will know who you are for demographics purposes. No information will be released to anyone without the participant’s written approval. The survey should only take five minutes. Participation in this study is completely voluntary. You don’t have to complete the survey if you don’t want to.

There shouldn’t be any risks to you from the questions.

While there will be no direct benefit to you from the study, we hope to learn more about how to make education more fun and effective.

If you have any questions about the research, you can contact Mr. Petros Katsioloudis at 919-452-4591 or Dr. Aaron Clark at 919-515-1771.

If you have any questions about your rights as a research subject you can contact Mr. Mathew Romming, Assistant Vice Chancellor, Research Administration, Box 7514, NCSU Campus (919/513-2148)

If you agree to participate in the study, just click below on "Access the protected area" and when prompted enter the assigned username and password.

Access the protected area
VisMATE Visual Material Assessment in Technology Education™

Round 1 Questionnaire

Please review the following examples of quality indicators for Visual-based learning material for grades 7th-12th in Technology Education programs. You may keep, reject or modify the examples found in this data collection instrument. Please check KEEP to keep the indicator, REJECT if you do not think the indicator is appropriate, or MODIFY to reword the indicator, by typing in the text box provided underneath each stated indicator. Your main objective is to add more NEW indicators by typing inside the provided textbox for new indicators. You may type as many NEW indicators as you need. Note: No set number of quality indicators is needed for each category.

EXAMPLES

1. The effectiveness of Visual-based Learning Material in Technology Education for grades 7th-12th depends upon the amount of realistic detail contained in the Visualization used.

KEEP  ○ REJECT  ○ MODIFY  ○ (Write, edit, state in box below)

2. The effectiveness of Visual-based Learning Material in Technology Education for grades 7th-12th depends upon the method by which the visualized instruction is presented to the students.

KEEP  ○ REJECT  ○ MODIFY  ○ (Write, edit, state in box below)

3. The effectiveness of Visual-based Learning Material in Technology Education for grades 7th-12th depends upon students' interests and engagement.

KEEP  ○ REJECT  ○ MODIFY  ○ (Write, edit, state in box below)
4. The effectiveness of Visual-based Learning Material in Technology Education for grades 7th-12th depends upon the type of educational objective to be achieved by the students.

KEEP  ○  REJECT  ○  MODIFY  ○  (Write, edit, state in box below)

---

5. The effectiveness of Visual-based Learning Material in Technology Education for grades 7th-12th depends upon the technique used to focus student attention on the essential learning characteristics in the visualization materials, (e.g., cues such as questions, arrows, motion, verbal/visual feedback).

KEEP  ○  REJECT  ○  MODIFY  ○  (Write, edit, state in box below)

---

6. The effectiveness of Visual-based Learning Material in Technology Education for grades 7th-12th depends upon the type of test format employed to assess student information acquisition, (e.g. for certain types of educational objectives visual tests have been found to provide more valid assessments of the amount of information students acquire by means of visualized instruction.)

KEEP  ○  REJECT  ○  MODIFY  ○  (Write, edit, state in box below)

---

7. The effectiveness of Visual-based Learning Material in Technology Education for grades 7th-12th depends upon the properties and quantity of the colors in the Visualization used.

KEEP  ○  REJECT  ○  MODIFY  ○  (Write, edit, state in box below)
8. Please add new quality indicators in the text-box below. You can add as many as you need, just keep typing.

The effectiveness of Visual-based learning material in Technology Education for grades 7th-12th depends upon...

Please submit survey.

Thank you

Submit
February 19, 2007

JUST A REMINDER:
One week ago, you received information to help in the development of indicators of visual-based learning material for grades 7th-12th in technology education programs. As an expert panel member, it is vital for the success of the research that you return your responses by the due date. Many panelists have already emailed back their responses. If you haven’t emailed your responses, please do so by February 27th. I look forward to receiving your responses.

Thank you

Petros Katsioloudis
Appendix D

Letters and Instrument sent in Round II

Instructions to Expert Panel Members
Instructions to Review Panel Members
Instrument II
Reminder II
March 19, 2007,

Instructions for **Round Two** of the Study

**Expert Panel Members**

Dear Expert Panel Member,

Thank you for the timely response and quality information you gave in round one of the modified Delphi study on quality indicators of visual-based learning material for grades 7-12 in technology education programs. I received several new indicators as well as modifications were made to a few indicators. The next phase of the modified Delphi process is to sort through this information and begin to draw consensus. This round will allow you the expert to rate each indicator given in round one as well as make modifications or add new indicators if needed. The Likert scale to be used for rating the indicators is as follows:

1= Strongly Disagree that the effectiveness of visual-based learning material in Technology Education depends upon the specific indicator
2= Disagree that the effectiveness of visual-based learning material in Technology Education depends upon the specific indicator and meets 49% or less of all quality characteristics
3= Neutral position that the effectiveness of visual-based learning material in Technology Education depends upon the specific indicator and is appropriate for 51% or more of all quality characteristics
4= Agree that the effectiveness of visual-based learning material in Technology Education depends upon the specific indicator and is appropriate for 75% or more of all quality characteristics
5= Strongly Agree that the effectiveness of visual-based learning material in Technology Education depends upon the specific indicator and is appropriate for 100% of all quality characteristics.

Next **Rank** indicators on a scale. Starting with (1) being the most important indicator of quality (ex. 1 best, 2, 3, 4, 5, 6...) and continue to the final indicator that indicates the least value for quality, **Rank all available indicators**.

**Access Instructions**: To gain access to this instrument you need to visit the electronic link [http://www4.ncsu.edu/~pjkassis/Indext.html](http://www4.ncsu.edu/~pjkassis/Indext.html). Once the front page is loaded, at the left side you will see a list of links with the third one being **Round II**. Using the mouse cursor click on the link. A disclaimer page will now appear stating information related to the study and you the participant. Read carefully and if you accept the rules move the cursor where it states **Access the protected area**. Using the mouse click on the link. A new page that contains a **Login** box will now appear. Two empty text boxes are provided for you to type **Username** and **Password**.

Inside the **Username** box type: john
Inside the **Password** box type: orange

After typing username and password move the cursor over the link **Login** and click. The desired instrument will now appear on a new page. Instructions for this round will also be included on the instrument as well. Once you complete all questions of the survey, use the cursor to click the **Submit** button located at the end of the Round Two instrument. All of your answers will be submitted. Please have your responses submitted with in the next 2 Weeks. Again, thank you for taking your time to read these instructions and participate in the study. If you have any questions please contact me (See contact info on the top of this page).
March 12, 2007

Dear Review Panel Member,

Thank you for the quality review process each member conducted on instrument one. I know that after the modifications you suggested were made, the document read much better and the expert panel members were clear as to their tasks for the modified Delphi research process used in round one. I’ve collected all the information from these experts in round one, analyzed and condensed the data, and developed this new knowledge into a questionnaire for the expert panel members to rate each indicator. Your task is to review the enclosed questionnaire for round two, suggest improvements and modifications, as well as review those indicators condensed and/or modified for this round to make sure I’ve interpreted or made each modification correctly. Attachments with this new questionnaire are the copies of all original suggested modifications from round one suggested by an expert panel member.

If you see no problems with the Second Round Instrument you do not need to send anything about it. As the review panel member, you will need to provide feedback from each panel member in a timely manner so that each round is complete and all three rounds can progress so that the study will be a success. This first round is needed back in 48 hours after receiving it in order to set the process started.

Access Instructions: To gain access to this instrument you need to visit the electronic link http://www4.ncsu.edu/~pjkasios/index.htm. Once the front page is loaded, at the left side you will see a list of links with the third one being Round II. Using the mouse cursor click on the link. A disclaimer page will now appear stating information related to the study and you the participant. Read carefully and if you accept the rules move the cursor where it states Access the protected area. Using the mouse click on the link. A new page that contains a Login box will now appear. Two empty text boxes are provided for you to type Username and Password.
Inside the Username box type: john
Inside the Password box type: orange

After typing username and password move the cursor over the link Login and click. The desired instrument will now appear on a new page.

Again thank you for agreeing to work with me in this important study. I know your time is valuable, but the resulting document will help determine the quality indicators of visual-based learning material for grades 7th-12th in technology education programs. If you have any questions or comments please feel free to contact me at any time.

Sincerely,

Petros Katsioloudis
VisMATE Visual Material Assessment in Technology Education™

Round 2 Questionnaire

Please Rate (click the button) each of the following indicators found in round one using the following Likert scale:

1= Strongly Disagree that the effectiveness of visual-based Learning material in Technology Education depends upon the specific indicator

2= Disagree that the effectiveness of visual-based Learning material in Technology Education depends upon the specific indicator and meets 49% or less of all quality characteristics

3= Neutral position that the effectiveness of visual-based Learning material in Technology Education depends upon the specific indicator and is appropriate for 51% or more of all quality characteristics

4= Agree that the effectiveness of visual-based Learning material in Technology Education depends upon the specific indicator and is appropriate for 75% or more of all quality characteristics

5= Strongly agree that the effectiveness of visual-based Learning material in Technology Education depends upon the specific indicator and is inappropriate for 100% of all quality characteristics

Next Rank (by typing inside the textbox under each indicator) the indicators on a scale. Starting with one (1) being the most important indicator of quality (e.g., 1 best, 2, 3, 4, 5, 6, ...) and continue to the final indicator that indicates the least value for quality. Rank all available indicators.

Please identify whether you teach Middle School or High School

☐ Middle School  ☐ High School

1. The effectiveness of a visual-based learning material in Technology Education for grades 7-12 depends upon the amount of detail contained in the visualization used.

☒ Strongly Disagree, ☐ Disagree, ☐ Neutral, ☐ Agree, ☐ Strongly Agree

Rank:

2. The effectiveness of a visual-based learning material in Technology Education for grades 7-12 depends upon the method that the visualized instruction is presented.

☒ Strongly Disagree, ☐ Disagree, ☐ Neutral, ☐ Agree, ☐ Strongly Agree
3. The effectiveness of a visual-based learning material in Technology Education for grades 7-12 depends upon students' interests and engagement.

☐ Strongly Disagree, ☐ Disagree, ☐ Neutral, ☐ Agree, ☐ Strongly Agree

Rank:

4. The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon how the objectives are presented to the students.

☐ Strongly Disagree, ☐ Disagree, ☐ Neutral, ☐ Agree, ☐ Strongly Agree

Rank:

5. The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the technique used to focus student attention on the essential learning characteristics in the visualization materials, (e.g., cues such as questions, arrows, motion, verbal/visual feedback).

☐ Strongly Disagree, ☐ Disagree, ☐ Neutral, ☐ Agree, ☐ Strongly Agree

Rank:

6. The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the type of assessment employed to evaluate student learning, (e.g. for certain types of educational objectives visual tests have been found to provide more valid assessments of the amount of information students acquire by means of visualized instruction).

☐ Strongly Disagree, ☐ Disagree, ☐ Neutral, ☐ Agree, ☐ Strongly Agree

Rank:

7. The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the instructor's ability to effectively and efficiently integrate visual-based learning material into the Technology Education classroom environment and curriculum.

☐ Strongly Disagree, ☐ Disagree, ☐ Neutral, ☐ Agree, ☐ Strongly Agree

Rank:

8. The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends on
time spent teaching background knowledge.

- Strongly Disagree, - Disagree, - Neutral, - Agree, - Strongly Agree

Rank:

9. The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends on the quality of the visualization used.

- Strongly Disagree, - Disagree, - Neutral, - Agree, - Strongly Agree

Rank:

10. The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the student’s ability to effectively and efficiently understand integrated visual-based learning material into the Technology Education classroom environment and curriculum.

- Strongly Disagree, - Disagree, - Neutral, - Agree, - Strongly Agree

Rank:

11. The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends on the relevance of the materials.

- Strongly Disagree, - Disagree, - Neutral, - Agree, - Strongly Agree

Rank:

12. The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends on the direct association between the materials and the learning objectives.

- Strongly Disagree, - Disagree, - Neutral, - Agree, - Strongly Agree

Rank:

13. The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends on the level of the technology available to the student.

- Strongly Disagree, - Disagree, - Neutral, - Agree, - Strongly Agree

Rank:
14. The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends on the hardware being used by the student.

☐ Strongly Disagree, ☐ Disagree, ☐ Neutral, ☐ Agree, ☐ Strongly Agree

Rank: 

15. The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends on the teacher's confidence in the area of visual teaching.

☐ Strongly Disagree, ☐ Disagree, ☐ Neutral, ☐ Agree, ☐ Strongly Agree

Rank: 

16. The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends on the amount of equipment (i.e. computers available.)

☐ Strongly Disagree, ☐ Disagree, ☐ Neutral, ☐ Agree, ☐ Strongly Agree

Rank: 

17. The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends on the amount of training the instructor has with equipment (i.e. software.)

☐ Strongly Disagree, ☐ Disagree, ☐ Neutral, ☐ Agree, ☐ Strongly Agree

Rank: 

18. The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends on learning styles of the students that the visual material is presented to.

☐ Strongly Disagree, ☐ Disagree, ☐ Neutral, ☐ Agree, ☐ Strongly Agree

Rank: 

In case you need to add new quality indicators, please do so in the textbox below. Any new indicators must also be Rank and Rate as seen above. You can add as many as you need, just keep typing.
The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends on...
**Remember to Rank and Rate all new indicators using the Liker/Rank scale.

Please submit survey.

Thank you
March 29th, 2007

JUST A REMINDER:
One week ago, you received information to help in the development of indicators of visual-based learning material for grades 7-12 in technology education programs. As an expert panel member, it is vital for the success of the research that you return your responses by the due date. Many panelists have already emailed their responses. If you haven’t emailed your responses, please do so by March 31st. I look forward to receiving your responses.

Thank you

Petros Katsioulidis
Appendix E

Letters and Instrument sent in Round III

Instructions to Expert Panel Members
Instructions to Review Panel Members
Instrument III
Reminder III
April 10, 2007,

Instructions for Round Three of the Study
Expert Panel Members

Dear Expert Panel Member,

Thank you for the timely response and quality information you gave in round two of the modified Delphi study on quality indicators of visual-based learning material for grades 7-12 in technology education programs. I received several new indicators as well as modifications were made to a few indicators. The next phase of the modified Delphi process is to indicate whether or not you want to keep an indicator. This round will allow you, the expert, to give a final indication of KEEP or REJECT to each indicator. Remember you are to select yes (keep) or no (reject) to all indicators.

Listed below is an EXAMPLE of the process:

Indicator:
The effectiveness of a visual-based learning material in Technology Education for grades 7-12 depends upon the amount of detail contained in the visualization used.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Mean</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>3.35</td>
<td>4</td>
</tr>
</tbody>
</table>

KEEP  ○ REJECT ○ (Using the cursor click on bubble for the desired selection)

The rank, mean of rank, and median are given for the data obtained in round two of the study. Although this information identifies the mean scores from round two, it need not influence whether or not you decide to keep or reject indicators.

Access Instructions: To gain access to this instrument you need to visit the electronic link http://www4.ncsu.edu/~pjkasio/Indext.htm. Once the front page is loaded, at the left side you will see a list of links with the third one being Round II. Using the mouse cursor click on the link. A disclaimer page will now appear stating information related to the study and you the participant. Read carefully and if you accept the rules move the cursor where it states Access the protected area. Using the mouse click on the link. A new page that contains a Login box will now appear. Two empty text boxes are provided for you to type Username and Password.

Inside the Username box type: john
Inside the Password box type: orange

After typing username and password move the cursor over the link Login and click. The desired instrument will now appear on a new page. Instructions for this round will also be included on the instrument as well. Once you complete all questions of the survey, use the cursor to click the Submit button located at the end of the Round Three instrument. All of your answers will be submitted with in the next 2 Weeks. Again, thank you for taking your time to read these instructions and participate in the study. If you have any questions please contact me (See contact info on the top of this page).
April 16, 2007

Dear Review Panel Member,

Thank you for the quality review process each member conducted on instrument two. I know that after the modifications you suggested were made, the document read much better and the expert panel members were clearer as to their tasks for the modified Delphi research process used in round two. I've collected all the information from those experts in round two, analyzed and condensed the data, and developed this new knowledge into a questionnaire for the expert panel members to rate each indicator. Your task is to review the enclosed questionnaire for round three, suggest improvements and modifications, as well as review those indicators condensed and/or modified for this round to make sure I've interpreted or made each modification correctly.

If you see no problems with the Third Round Instrument, you do not need to send anything about it. As the review panel member, all you will need to provide is your time. Please remember that I need all responses back from each panel member in a timely manner so that each round is complete and all three rounds can progress so that the study will be a success. This third round is needed back in 48 hours after receiving it in order to set the process started.

Access Instructions: To gain access to this instrument you need to visit the electronic link http://www4.nccu.edu/~pkasiol/based.htm. Once the front page is loaded, at the left side you will see a list of links with the third one being Round III. Using the mouse cursor click on the link. A disclaimer page will now appear stating information related to the study and you the participant. Read carefully and if you accept the rules move the cursor where it states Access the protected area. Using the mouse click on the link. A new page that contains a Login box will now appear. Two empty text boxes are provided for you to type Username and Password. Inside the Username box type: john Inside the Password box type: orange

After typing username and password move the cursor over the link Login and click. The desired instrument will now appear on a new page.

Again thank you for agreeing to work with me on this important study. I know your time is valuable, but the resulting document will help determine the quality indicators of visual-based learning material for grades 7-12 in technology education programs. If you have any questions or comments please feel free to contact me at any time.

Sincerely,

Petros Kasioloudis
VisMATE Visual Material Assessment in Technology Education

Round 3 Questionnaire

For this final modified Delphi round, please indicate whether or not you want to keep or reject each indicator. Remember, you are to decide to keep or reject each indicator without any additional modifications made to that indicator. These indicators were kept from round two since they had a statistical mean of 3.01 or higher. The rank (value of each characteristic within the test), mean of rank (the average obtained by dividing the sum of all responses by the number of participants) and median (the midpoint in a series of numbers that derive from all responses) are given from the data obtained in round two of the study. Although this information identifies the mean scores from round two, it need not influence whether or not you decide to keep or reject indicators.

Thank you very much for participating in this study. A final copy of the results will be e-mailed to you.

Please identify whether you teach Middle School or High School

- Middle School
- High School

1. The effectiveness of a visual-based learning material in Technology Education for grades 7-12 depends upon the amount of detail contained in the visualization used.

   Rank: 8
   Mean: 3.55
   Median: 4

   KEEP □ REJECT □

2. The effectiveness of a visual-based learning material in Technology Education for grades 7-12 depends upon the method that the visualized instruction is presented.

   Rank: 16
   Mean: 4.15
   Median: 5

   KEEP □ REJECT □

3. The effectiveness of a visual-based learning material in Technology Education for grades 7-12 depends upon students' interests and engagement.

   Rank: 17
   Mean: 4.7
   Median: 5

   KEEP □ REJECT □

4. The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon how the objectives are presented to the students.

   Rank: 13
   Mean: 4.05
   Median: 4

   KEEP □ REJECT □

5. The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the technique used to focus student attention on the essential learning characteristics in the visualization materials, (e.g., cues such as questions, arrows, motion, verbal/visual feedback).

   Rank: 7
   Mean: 3.90
   Median: 5

   KEEP □ REJECT □

6. The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the type of assessment employed to evaluate student learning, (e.g. for certain types of educational objectives visuals tests have been found to provide more valid assessments of the amount of information students acquire by means of visualized instruction).

   Rank: 2
   Mean: 3.55
   Median: 4

   KEEP □ REJECT □

7. The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the instructor's ability to effectively and efficiently integrate visual-based learning material into the Technology Education classroom environment and curriculum.

   Rank: 12
   Mean: 4.15
   Median: 5

   KEEP □ REJECT □

http://www.ces.ncsu.edu/~pjkatico/round3.htm
8. The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends on time spent teaching background knowledge.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Mean</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>3.5</td>
<td>3</td>
</tr>
</tbody>
</table>

KEEP ○ REJECT ○

9. The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends on the quality of the visualization used.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Mean</th>
<th>Median</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>4.0</td>
<td>4</td>
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</tbody>
</table>

KEEP ○ REJECT ○

10. The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends on the instructor's ability to effectively and efficiently integrate the material into the Technology Education classroom environment and curriculum.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Mean</th>
<th>Median</th>
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</thead>
<tbody>
<tr>
<td>14</td>
<td>4.35</td>
<td>4</td>
</tr>
</tbody>
</table>

KEEP ○ REJECT ○

11. The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends on the relevance of the materials.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Mean</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>4.25</td>
<td>3</td>
</tr>
</tbody>
</table>

KEEP ○ REJECT ○

12. The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends on the direct association between the materials and the learning objectives.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Mean</th>
<th>Median</th>
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<tr>
<td>5</td>
<td>3.6</td>
<td>4</td>
</tr>
</tbody>
</table>

KEEP ○ REJECT ○

13. The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends on the level of the technology available to the student.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Mean</th>
<th>Median</th>
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</thead>
<tbody>
<tr>
<td>4</td>
<td>3.6</td>
<td>3</td>
</tr>
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</table>

KEEP ○ REJECT ○

14. The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends on the hardware being used by the student.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Mean</th>
<th>Median</th>
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</thead>
<tbody>
<tr>
<td>2</td>
<td>3.85</td>
<td>4</td>
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</table>

KEEP ○ REJECT ○

15. The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends on the teacher's confidence in the area of visual teaching.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Mean</th>
<th>Median</th>
</tr>
</thead>
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<tr>
<td>11</td>
<td>4.05</td>
<td>3</td>
</tr>
</tbody>
</table>

KEEP ○ REJECT ○

16. The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends on the amount of equipment (i.e. computers available.)

<table>
<thead>
<tr>
<th>Rank</th>
<th>Mean</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>3.40</td>
<td>3</td>
</tr>
</tbody>
</table>

KEEP ○ REJECT ○

17. The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends on the amount of training the instructor has with equipment (i.e. software.)

<table>
<thead>
<tr>
<th>Rank</th>
<th>Mean</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>1.85</td>
<td>4</td>
</tr>
</tbody>
</table>

http://www.nctuedu/~polkatie/round3.htm
18. The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends on learning styles of the students that the visual material is presented to.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Mean</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>4.40</td>
<td>3.00</td>
</tr>
</tbody>
</table>

Please fill out the following information if you are willing to have your name, school, and location printed with the final results of this research:

Name: 
School: 
City or Town: 

Please submit survey.
Thank you.
April 17, 2007

JUST A REMINDER:
As an expert panel member, it is vital for the success of the research that you return your responses by the due date. Many panelists have already emailed back their responses. If you haven’t emailed your responses, please do so by April 25th. PLEASE visit the front page and take instrument for Round III. To do that click on the link that spells Round III. In case you lost the link or forgot username and password see below:

http://www4.ncsu.edu/~pjkiotis/index1.htm
username: john
password: orange

**If you have already submitted your answers please ignore this reminder**

Thank you

Petros
Appendix F

Final letter and list of quality indicators

Letter to All Panel Members
Final List of Indicators
May 10, 2007

Dear Expert and Review Panel Members,

Thank you for your time, support, knowledge and resources that had allowed for the completion of this research study. Attached with this email is the final listings of quality indicators for which consensus was drawn upon by the panels. If you have any questions or concerns about these listings, please feel free to contact me at the email or address listed on the upper right corner of this page.

Sincerely

Petros Katsioloudis
Validated Indicators kept from Final Round

<table>
<thead>
<tr>
<th>Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>The effectiveness of Visual-based learning material in Technology Education for grades 7-12 depends upon the amount of detail contained in the Visualization used.</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the method by which the visualized instruction is presented since method varies on students.</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon students’ interests and engagement.</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon how the objectives are presented to the students.</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the technique used to focus student attention on the essential learning characteristics in the visualization materials, (e.g., cues such as questions, arrows, motion, verbal/visual feedback).</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the type of assessment employed to evaluate student learning, (e.g. for certain types of educational objectives visual tests have been found to provide more valid assessments of the amount of information students acquire by means of visualized instruction).</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the instructor's ability to effectively and efficiently integrate visual-based learning material into the Technology Education classroom environment and curriculum.</td>
</tr>
<tr>
<td>The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon time spent teaching background knowledge.</td>
</tr>
</tbody>
</table>
The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the quality of the Visualization used.

The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the student’s ability to effectively and efficiently understand integrated visual-based learning material into the Technology Education classroom environment and curriculum.

The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the relevance of the materials.

The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the direct correlation between the materials and the learning objective.

The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the level of the technology available to the student.

The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the hardware being used by the student.

The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the teacher's confidence in the area of visual teaching.

The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the amount of equipment i.e. computers available.

The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon the amount of training the instructor has with equipment i.e. software.

The effectiveness of visual-based learning material in Technology Education for grades 7-12 depends upon learning style of the students to which the visual material is presented.
Appendix G

List of panel members participating in study
<table>
<thead>
<tr>
<th>Name</th>
<th>Institution/Location</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jeremy Ernst</td>
<td>North Carolina State University, Raleigh, North Carolina</td>
<td>Review Panel Member</td>
</tr>
<tr>
<td>Phyllis Jones</td>
<td>Page High School, Greensboro, North Carolina</td>
<td>Expert Panel Member</td>
</tr>
<tr>
<td>Cindy Clay</td>
<td>Ridgeview Charter School, Atlanta, Georgia</td>
<td>Technology Teacher, Expert Panel Member</td>
</tr>
<tr>
<td>Todd Jessup</td>
<td>Mount Airy Middle School, Mount Airy, North Carolina</td>
<td>Expert Panel Member</td>
</tr>
<tr>
<td>Clay Payne</td>
<td>Northside Middle School, Anderson, Indiana</td>
<td>Technology Teacher, Expert Panel Member</td>
</tr>
<tr>
<td>Jill Parker</td>
<td>Elizabeth Middle School, Elizabeth, Colorado</td>
<td>Expert Panel Member</td>
</tr>
<tr>
<td>Dianne F. Summer</td>
<td>Bell Street Middle School, Clinton, South Carolina</td>
<td>Technology Teacher, Expert Panel Member</td>
</tr>
<tr>
<td>Bob Chandler</td>
<td>West Forsyth High School, Clemmons, North Carolina</td>
<td>Expert Panel Member</td>
</tr>
<tr>
<td>Steve Horsten</td>
<td>Lake Middle School, Rice Lake, Wisconsin</td>
<td>Technology Teacher, Expert Panel Member</td>
</tr>
<tr>
<td>Bill Glover</td>
<td>Prentiss County Vocational-Technical School, Booneville, Massachusetts</td>
<td>Expert Panel Member</td>
</tr>
<tr>
<td>James Payne</td>
<td>Stranahan High School, Fort Lauderdale, Florida</td>
<td>Technology Teacher, Expert Panel Member</td>
</tr>
<tr>
<td>Laura J. Hummell</td>
<td>Manteo Middle School/East Carolina University, Manteo, North Carolina</td>
<td>Expert Panel Member</td>
</tr>
</tbody>
</table>

*Note.* Remaining of Expert and/or Review panel members did not request their names and schools to be published at this point.