AC 2010-1920: TECHNOLOGICAL LITERACY: DESIGN AND TESTING AN INSTRUMENT TO MEASURE EIGHTH-GRADE ACHIEVEMENT IN THE TECHNOLOGY EDUCATION

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Abstract

This study was focused on the design and testing of an assessment instrument to measure eighth-grade student achievement in the study of technology. Through classroom experiences and refinement of instructional methods by trial and error, technology educators have witnessed some success (academic improvement) using hands-on, lab-based design and problem-solving instruction, but these advances have not been documented. In the year 2000, the International Technology Education Association (ITEA) introduced Standards for Technological Literacy (STL) (ITEA, 2000). To date, no clear methods for measuring and assessing student attainment in these standards has been instituted. It is the interaction of instruction in technology education and its influence on student learning that is the central problem addressed by this research. More importantly, it is the need within the technology education field to have a reliable and valid assessment tool to measure student learning in the study of technology. The study design was a two-group post-test only design that is grounded in the quasi-experimental quantitative research tradition. The study utilized a two-group post-test only design, a treatment group who had received instruction in technology education in the form a modular instructional delivery classroom and a control group who had not received any formal education in the study of technology. The results of study found that eighth-grade participants taking a technology class performed better \( M=15.42, SD=5.42 \) than those who had no previous technology class exposure \( M=14.07, SD=5.25 \). In comparing the means of the eighth-graders’ post-test, there was a significant difference \( F (1, 270) = 4.40, p=.037, p<.05 \) detected by the instrument designed and tested in this study. The results in this study suggest that standards-based modular instruction in technology education enhances student’s technological literacy.

Introduction

In the 21st century, the world will depend on individuals with higher levels of technology and science literacy (Standards for Technologica Literacy, 2000, p. v) \(^1\) than in the past. Importantly, Daggett (2005)\(^2\), Rose and Gallup (2005)\(^3\), and Feller and Whichard (2005)\(^4\) assert that more students than ever need to be educated to higher levels so that they can compete successfully in a job market that is increasingly dependent on technology. Students should be provided with focused coursework that will prepare them for college and/or provide them with the necessary technical preparation to acquire a job. These demands for higher education and for higher levels of technical skills derive from changes in business environments (Feller and Whichard, 2005)\(^4\). The Advancing for Excellence in Technological Literacy (AETL) states that Technological and scientific literacy is an imperative because of the technological world in which we live (ITEA, AETL, 2003)\(^5\). For instance, Hoachlander (2006)\(^6\) states that “we should use the world of work to engage and motivate students”. As a result, students will have more experience with rich and intricate problem solving that requires applying knowledge from diverse ranges of academic disciplines (p. 39).

Science literacy has to do with knowledge of the scientific world. According to Project 2061, sponsored by the American Association for the Advancement of Science (AAAS), science
literacy entails being familiar with the natural world and respecting its unity, as well as being aware of some of the important ways in which mathematics, technology, and science depend upon one another (1989, p. xvii). Technological literacy refers to the ability of a person to use, manage, and understand technology. The International Technology Education Association (ITEA) defines technological literacy as “the ability to use, manage, assess, and understand technology” (p. 9). In this study, technology refers to the modification of the natural environmental in order to satisfy perceived human needs and wants (Standards for Technological Literacy, 2000, p. 7). The definition of technology does not refer specifically to computers or the use of computers.

The literature suggests that when technology is integrated with other curriculums, there is a correlation to students’ performance and understanding, although not always positive. The literature has shown a positive, neutral, or even a negative impact on how the integration of technology affects teaching, learning style, and achievement (Childress, 1994, Hilton, 2003, Shumway, 1999). Studies conducted from 1994 to 2003 investigated how the integration of technology education has facilitated student learning styles and their ability to connect contextual applications in academic courses.

Grounding of the Research Perspective

A question arises, 1) what are the benefits to student learning (thinking or ways of knowing) when technology education is integrated? And 2) Do the standards for technological literacy and cognitive approaches to instruction improve student’s cognition or thinking and knowing about a subject? This paper will examine the interaction and the impact of student achievement in technology and traditional courses by studying both academic and technology subjects concurrently in a school curriculum in diverse schools.

One of the important areas that must be expanded on across the discipline of technology education is the creation of useful instruction and instructional materials that will benefit students’ attainment of technological literacy. By using research grounded in theories of cognitive science, educators will be able to relate their knowledge to demonstrated effective teaching and learning methods. However, as De Miranda (2004) asserts, technology education originated without any meaningful input from cognition science research (p. 1). Nonetheless, De Miranda suggests that technology education instructional methods are remarkably consonant with findings from cognitive science on the practices that define good instruction. De Miranda and Folkestad (2000) state the intent of instruction grounded in the cognitive sciences is to transfer “the self-regulation and monitoring of cognitive functions such as memory, process, control of thinking process, reflection, appropriate application, and the cognitive tools for thinking and learning from the teacher to the student” (p. 7).

The purposes of cognitive approaches are to integrate career, skills, and academic curriculum with technology to give students the opportunity to gain technological literacy and to compliment interact with other academic content. Once they learn about technology, the students will hopefully understand how English, math, and science, when properly integrated, relate to real life. Another way of thinking of technological literacy is the successful application of real people, real time, and real problems to real life (Feller & Whichard, 2005).
Recently, the study of technology has become necessary and more evident. Herschbach (1996)\textsuperscript{13} states that “rapid industrialization and technological change has placed new demands on schools to develop scientists, engineers, technicians, and skilled workers who will continue to propel the economy forward” (p. 24). As a result, many schools have adopted new science and technology programs that allow students to understand the connection between technology and academics (Hoachlander, 2006)\textsuperscript{13}. At the same time, students learn how technology relates to other general courses (p. 39). A question arises, what are the benefits to student learning (thinking or ways of knowing) when technology education is integrated? Do the standards for technological literacy and cognitive approaches to instruction improve student’s cognition or thinking and knowing about a subject?

Need for Assessing Technological Literacy

According to AETL, several groups, organizations, agencies, and institutions have made the case for technological literacy (p. 21). AETL asserts that the U.S. Commission on National Security/21\textsuperscript{st} Century reported in 2001:

“The health of the U.S. economy . . . will depend not only on [science, math, and engineering] professionals but also on a populace that can effectively assimilate a wide range of new tools and technologies” (p. 39).

AETL (ITEA, AETL, 2003)\textsuperscript{5} reports that no defined research exists on how widespread technological literacy is and that levels of technological literacy vary from person to person, and depend upon backgrounds, education, interests, attitudes, and abilities. AETL continues by mentioning that the field of technology education has not been accepted as a core subject and that a massive, coordinated effort is needed to achieve a technologically literate populace (p. 12).

Developing a Standards-based Achievement Test

According to Worthen, White, Fan, and Sudweeks (1999)\textsuperscript{14}, the origin of an assessment tool or test can be traced as early as 2000 B. C. Worthen, White, Fan, and Sudweeks (1999)\textsuperscript{14} state that in the United States, the first indication of a measurement technique was introduced in the mid-1850s by Horace Mann (p. 15). In the early 1900s through the mid-1950s, the development of assessment increased as it became the new standard for measuring individual performance. The 1970s witnessed the rise of an accountability movement that required each school district to set up educational goals, test them, and report them to state agencies (Worthen, White, Fan, Sudweeks, 1999)\textsuperscript{14}.

In 2000, the International Technology Education Association (ITEA) released Standards for Technological Literacy: Content for the Study of Technology (ITEA, 2000)\textsuperscript{1}. The purpose of these standards is for the student to achieve technological literacy by engaging in curriculum informed by the content standards and related benchmarks (ITEA, 2000)\textsuperscript{1}. Between 2000-2003, a companion document for the STL was introduced entitlee, Advancing Excellence in Technological Literacy: Student Assessment, Professional Development, and Program Standards (AETL). It was created to define how assessment of technological literacy should be designed and implemented (p. 3).
The AETL (ITEA, AETL, 2003)\textsuperscript{5} asserts that assessment goals define who and when to assess and what type of assessment tool or method to use (p. 18). The assessment standards in AETL are to be utilized in conjunction with STL (p. 17). AETL (ITEA, AETL, 2003)\textsuperscript{5} asserted that students who can recite factual information are not necessarily progressing toward technological literacy. To achieve technological literacy, the AETL provides educators with guidelines for meeting or developing assessments (p. 20). It is important to highlight that this document does not provide a test, quiz or any other assessment tool and it should be the technology teacher who creates or develops these assessment tools to assess whether students have achieved the desired educational outcomes according to STL.

Assessing Validity and Reliability of a Technology Literacy Instrument

Hopkins and Antes (1985)\textsuperscript{17} and Gronlund (1998)\textsuperscript{18} classified three types of validity: content, criterion related (includes concurrent and predictive), and construct. Content validity for an achievement test is establishing and demonstrating how closely the content being assessed fits the objectives. According to Gronlund (1998)\textsuperscript{18}, validity is concerned with the interpretation and use of assessment results (p. 200). Criterion is concerned with test scores or performance and how they are related to an external criterion. There are two types of criterion studies: concurrent and predictive. Concurrent is associated with performance at present time while predictive is associated with performance at a future time. Construct validity is concerned with evidence of what qualities the assessment is measuring. In other words, the measurement should predict how the individual is going to perform in different specific situations. These elements measured include defining what is to be measured as well as a description of the development of the test, the pattern of relationship between test score and other significant variables, and other types of evidence that contribute to the meaning of the test score.

Reliability of Achievement Tests

The AETL (ITEA, AETL, 2003)\textsuperscript{5} suggests that validity and reliability should be established in technology education consistent with classroom experience. AETL asserts that validity and reliability will be consistent for both formative and summative assessment (p. 23). This implies that teachers will reflect upon the definitions of validity and reliability from the data and several sources (p. 23).

Assessment Methods

AETL (ITEA, AETL, 2003)\textsuperscript{5} mentions that no single tool or method can “do it all.” Assessment of technological literacy should utilize multiple approaches to assess both student cognition and performance (p. 19). The following are 14 sample methods that may be used as assessment approaches. (1) In computerized assessment—the use of a computer is key to measure performance on some attribute, such as visual, problem solving and may not be related to computers and technology. (2) Demonstrations /Presentations/ Multimedia requires students to demonstrate and present the result of their design, invention, or created artifact. (3) Individual and group activities require each student to be accountable for their own work and piece of a project in socially distributed expertise networks, organized work, or research by one, two, or more individuals. (4) Informal Observations/Discussions allows students to observe and/or discuss individually or as a group the work and interactions that occur during a problem-solving
design process, as well as the interactions with other students. (5) Open-Ended Questioning poses questions to students that permit students to identify their understanding of the information being taught and attempts to identify student misconceptions and uses that information to adjust instruction. (6) Paper-and-Pencil Testing is an assessment method that allows students to demonstrate their understanding via a multiple-choice test, essay, or other test using paper and pencil. (7) Peer assessment allows students to be evaluated and receive feedback from other classmate(s). (8) Performance Assessment demonstrates how students perform and apply knowledge and assesses what the students know and can do. (9) Portfolios and Work Samples of student work are collected and organized that include results of research, successful and less successful ideas, notes on procedures, and data collected. A portfolio may be in many forms, from photographs depicting student growth and understanding to a socialized electronic journal showing work completed over a period of time. (10) Projects/Products/Media and/or videos/ slide shows/ posters allow students to demonstrate and apply their knowledge and abilities in electronic, poster and/or video format. These may take many forms and are limited by time, resources, and imagination. (11) Reports/Research method demonstrates students’ ability to work on a project or topic that will end in a document study. (12) Rubrics/Checklists is an assessment given to the student with criteria taken from the content standards. Points or words are assigned to each phrase or level of accomplishment. This method provides feedback to the students about their work in key categories, and it can be used to communicate student performance to parents and administrators. (13) Student Interviews (Written and Oral) allow students to demonstrate their skills and knowledge in an oral form with a planned sequence of questions. (14) Student Self-Reflection encourages individuals to evaluate themselves in their knowledge, performance, and results of their work.

Guidelines for Developing Assessments in Technology Education

The following are guidelines established by AETL and STL that will allow the teacher not only to assess but also to advance technological literacy (ITEA, AETL, 2003)\(^5\).

Standard A-1: Assessment of student learning, will be consistent with Standards for Technological Literacy: Content for the Study of Technology (STL). STL articulates what every student should know and be able to do in technology—content that enables students to use, manage, assess, and understand (p. 21).

Standard A-2: Assessment of student learning, will be explicitly matched to the intended purpose. Effective assessment incorporates a variety of formative and summative practices and provides all students with the opportunity to demonstrate their understanding and abilities (p. 22).

Standard A-3: Assessment of student learning, will be systematic and derived from research-based assessment principles. Like curricula, assessment should be designed to accommodate a variety of levels of developmental and intelligence as well as provide pre-assessment activities to familiarize all students with the content (p. 24).

Standard A-4: Assessment of student learning, will reflect practical contexts consistent with the nature of technology. Students assessment must reflect the active, dynamic nature of the study of technology and the manner in which people draw upon and exercise knowledge and abilities acquires through experience (p. 30).
Standard A-5: Assessment of student learning, will incorporate data collection for accountability, professional development, and program enhancement. Assessment involves the process of collecting data, interpreting the results, and reporting the results. The result can be used to make decisions that directly affect the understanding and development of technological literacy (ITEA, AETL, 2003, p. 36)\(^5\).

Procedure

The study was accomplished in four successive phases:

1) Develop a content matrix to identify STL standards with benchmarks and create an item test bank.
2) Establish content validity through expert review of item test bank. All 15 item content reviewers were considered experts in the field of technology education.
3) Pilot test items for reliability and internal consistency and select items for three parallel forms of the test.
4) Select and recruit schools and student sample selection to administer the final instrument.

Instrument Development

The process of selecting the test bank items began by looking at the five major categories of STL. Each category lays out what each student should learn at four levels, grades K-2, 3-5, 6-8, and 9-12. Each standard and benchmark is related to previous standards and benchmarks that prescribe what a student should know and be able to do to be technologically literate (Standards for Technological Literacy, 2000, p. 12)\(^1\). In addition to the STL categories, 20 benchmarks are organized into grades K-2, 3-5, 6-8, and 9-12, as shown in Figure 2 (Standards for Technological Literacy, 2000)\(^1\).

<table>
<thead>
<tr>
<th>Technology Categories/Factors</th>
<th>Standards</th>
<th>Benchmarks</th>
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<tbody>
<tr>
<td>The Nature of Technology</td>
<td>K-2 3-5 6-8 9-12</td>
<td></td>
</tr>
<tr>
<td>Technology and Society</td>
<td>K-2 3-5 6-8 9-12</td>
<td></td>
</tr>
<tr>
<td>Design</td>
<td>K-2 3-5 6-8 9-12</td>
<td></td>
</tr>
<tr>
<td>Abilities for a Technological World Society</td>
<td>K-2 3-5 6-8 9-12</td>
<td></td>
</tr>
<tr>
<td>The Design World</td>
<td>K-2 3-5 6-8 9-12</td>
<td></td>
</tr>
</tbody>
</table>

1. The characteristics and scope of technology  
2. The core concepts of technology  
3. The relationships among technologies and the connections between technology and other fields of the study

4. The cultural, social, economic, and political effects of technology  
5. The effects of technology on the environment  
6. The role of society in the development and use of technology  
7. The influence of technology on history

8. The attributes of design  
9. Engineering design  
10. The role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving

11. Apply the design process  
12. Use and maintain technological products and systems  
13. Assess the impact of products and systems

14. Medical technologies  
15. Agricultural and related biotechnologies  
16. Energy and power technologies  
17. Information and communication technologies  
18. Transportation technologies  
19. Manufacturing technologies  
20. Construction technologies
A set of two questions were developed for each benchmark to assess the goal for this category. To maintain content validity, the items selected were matched by the standard and benchmarks at their level of interest. It is important to note that the benchmarks used in the study only included those for grades 6-8.

Standard and Benchmarks Example

For example, in the first category, the Nature of Technology, the first standard states that the students will develop an understanding of the characteristics and scope of technology. The researcher then identified the benchmarks (in this case, there are four) and two questions were created for each benchmark to form a test bank for this standard category. The following benchmarks are what the questions targeted and what students should be learning in this benchmark, according to the Standards for Technological Literacy:

(F) New products and systems can be developed to solve problems or to help do things that could not be done without the help of technology,
(G) The development of technology is a human activity and is the result of individual and collective needs and the ability to be creative,
(H) Technology is closely linked to creativity, which has resulted in innovation, and,
(I) Corporations can often create demand for a product by bringing it onto the market and advertising it.

Form of Assessment

For this particular study, the researcher elected to use the selecting-type items approach, in particular, multiple-choice items were chosen because they are assumed to measure knowledge, comprehension, and application outcomes (Gronlund, 1998, Hopkins & Antes, 1985, Oosterhof, 2003). The Standards for Technological Literacy (2000) was used to develop the test items and the benchmarks served as item specifications.

Guiding Principles for Item Construction

According to Hopkins and Antes (1985), Gronlund (1998), Osterlind (1998), and Oosterhof (2003), multiple-choice test format items have strengths and weaknesses. The strengths have to do with their ability to assess mental attributes. The advantages are that multiple-choice items can be designed to measure students’ ability to interpret, discriminate, select, and make applications. Some of the guiding principles when creating multiple-choice test items relate to the creation of the stems. The stems are the statements or questions of the items and should contain a central problem. The items should be practical and realistic, not academic and artificial, and should have four and preferably five independent choices. Items with responses that are obviously wrong should not be included and the inclusion of clues should be avoided. When writing the list of choices, the choices should be on separate lines and when choices include a series of numbers, these choices in should be put in either ascending or descending order. The correct answers should be scattered and when a negative response is wanted, it should be made clear.
Additional strengths of the multiple-choice items are that students need less time to record responses, and the test provides more flexibility for assessing a diversity of content as well as different levels of behavior. Another strength of multiple-choice items is that they are designed to identify an example of a particular concept. Finally, multiple-choice items provide greater test reliability because each question allows for a precise objective interpretation. Some limitations for multiple-choice items are that constructing good items are difficult and time consuming (Gronlund, 1998, Hopkins & Antes, 1985, Osterlind, 1998, Oosterhof, 2003). Furthermore, multiple-choice items are ineffective in measuring certain types of problem-solving items. They also fall short in capturing items that allow for one and only one answer for every problem.

Instrument Validity

To achieve validity of the research instrument and ultimately the research study, the researcher has relied on establishing content validity. According to Cohen, Manion, and Morrison (2000), content validity shows adequate and representative coverage to which the sample of items on a test are representative of some defined field or domain of content.

The researcher developed a content matrix that focused on the five categories of the STL and the 20 benchmarks. The next step was to develop a test bank of items according to the categories and benchmarks in the standards for technological literacy.

Instrumentation Specification

In selecting the bank items, the researcher used the following guiding principles to develop the item. First, the age of the student being tested was taken into consideration. According to Gronlund (1998), the recommended testing time for middle-school students is about 30 to 45 minutes, so the instrument was designed for that timeframe. Second, the time available for testing was taken into account. Gronlund (1998) asserts that typically students at this age answer one multiple-choice question item per minute. In determining the appropriate number of items to be used, Gronlund (1998) suggests that we should use at least 10 items per outcome. Finally, Gronlund (1998) assert that when using fewer than 10 items, only tentative judgment should be made and these judgments should be verified by other means.

Test Bank Item Development and Content Matrix across the Standards Benchmarks

The researcher first identified the five standard categories and extracted the 20 benchmarks at the 6-8 grade level. Then the researcher created a matrix to determinate the target. Second, the researcher developed a test item bank that correlated or addressed those targets. Once the test item bank was developed with questions matching the standards and benchmarks requirements, the researcher randomly selected two questions for each benchmark and submitted the test to experts for content validity review.

Content Validity Procedure
The procedure began by sending an email requesting expert participation. The content experts were identified and selected from nationally recognized technology teacher education programs and were identified using the national directory published by the Council on Technology Teacher Education. The experts selected to serve as content validation experts also had participated in the review of the national STL and were university professors and middle school teacher experts. These criteria ensured a deep knowledge of STL and the benchmarks for each standard. Once the 15 experts (ten university professors and five middle school teachers), agreed to participate, a second letter, the test bank items, and instructions with an evaluation instrument for the test bank items developed by the researcher was included in a package. The researcher asked the expert panel to return the evaluation package within two weeks. When the evaluation packages were returned, the researcher looked for commonalities in the review responses and vetting of undesirable items. The researcher examined comments and suggestions and made corrections suggested by the content review experts. Based on the evaluative feedback, a pilot test item bank was established.

Pilot test and Item Analysis Phase

The researcher next performed a pilot study to develop, adapt, and check the feasibility of techniques, determine the reliability of measures, and to calculate how big the final sample needed to be. The pilot test consisted of three parallel forms, A, B and C, with 35 questions each derived from the item test bank. The item test bank consisted of 172 items covering the grade 6-8 standards and benchmarks. The parallel forms tests were constructed to reduce test fatigue and keep the assessment completion time appropriate for the grade level in which it was administered. The purpose of the pilot testing was to see how the items performed, whether high correlation existed, if question unstable, and if students understood the test. The three parallel forms pilot test was administered to 86 middle school students who had not taken technology education classes. Each test form was taken by at least 26 students in the pilot test sample.

Schools: Control and Experimental

This quantitative study examined the relationship and effect of two types of instruction on student technological literacy. The four schools selected for this study were middle schools that have an eighth-grade level. Two schools deliver technology education instruction and the control schools do not deliver technology education courses. Both control and experimental schools are part of the XXX XXXXXXXX Unified School District (XXXXX) in California. Moreover, the schools are demographically similar. For example, the school district enrolls a large multicultural and diverse ethnic student population. The average student population in the schools range from 1,044 students to 2,807 students, where the average number of English-language learners per school ranged from 267 students to 1,524 students. The most important criterion in finding an appropriate population was whether the comprehensive public middle school offered technology education classes.

Technology Education Programs

Schools offering technology education programs in this study needed to be implementing curriculum aligned with the Standard for Technological Literacy (STL). The curriculum should be directed toward delivering the Standards for Technological Literacy as opposed to a
vocational curriculum. The courses must have modular curriculum delivery methods and a class rotation schedule of instruction that ensures all students were exposed to the curriculum equally.

Students

The student population eligible for the study comprised middle-school students who are currently in the eighth grade, who have had at least one semester of technology education, either in the seventh grade or early eighth grade. The rationale for this selection was that in the majority of middle schools, technology education is a required elective in the seventh grade. The racial/ethnic background of the students includes Hispanics, White, Asian, and African-American; in most of the schools selected, Hispanic students comprise the majority of the school population. Convenience sampling was used in this study. Students are assigned to classes by the registration office when they enter middle school. Students assigned to a technology class formed the experimental group. The non-treatment control group was students who did not take a technology education class but possess a similar educational and demographic background.

Teachers and Curriculum

The teachers selected for this study have a teaching background in the field of technology education. They must have earned a credential/license in technology education or industrial arts to participate in this study. In addition, to be eligible for participation, needed to have three years of teaching experience at the middle grade level. The rational for this teacher selection criterion was to avoid the interjection of teacher effects into the results. Teacher effects if found could seriously violate the assumptions under the general linear model.

The teaching curriculum needed to be in a modular classroom/lab. In a modular classroom/lab, students are provided with a learning module that explores physical science, technology, and design concepts. Also in a modular lab, the students work in teams of two or three in a learning unit or center (module), where they master the material through a combination of hands-on exercises and multimedia computer instructions.

The learning unit may include multimedia instruction, video, guidebook/workbooks that guide students through the activity. Students work an average of seven to ten instructional days in the module, which includes seatwork, worksheets, interacting web-based instruction, Digital Video Discs, and hands-on experiments. Students have periodic tests or assessments about the unit and complete a final project—a design brief. The design brief represents the final or culminating activity designed to engage the student in problem solving and to demonstrate their application and knowledge learned in the module. At the end of the instructional module, the students present the result of their final design brief project, and then the students rotate to the next learning module. When the students rotate to a new curriculum module, students may retain their partner or assume a new student partner. Topics/areas of study in a modular environment investigate several areas of technology, ranging from transportation, construction, manufacturing, communication, and environmental, each aligned to STL.

Group Selection
The participants for this study included those students who took a technology education class (n = 135) by the end of the fall semester of 2006 and a comparison control group of students who did not take a technology education class (n = 137) at a different school. The middle schools were purposefully chosen for this research because of access and geographical location (see Table 1, control and experimental group schools). The selected schools were located in two geographically diverse locations in the XXXX that represent the experimental group, and two in the control group. The goal of the group selection was to administer the technology literacy instrument to 50 students per school, which is the equivalent of two classes.

<table>
<thead>
<tr>
<th>School</th>
<th>Address</th>
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<tbody>
<tr>
<td>Experimental</td>
<td></td>
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<tr>
<td>MS # 1</td>
<td>XXXXX</td>
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<tr>
<td>MS # 2</td>
<td>XXXXX</td>
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<tr>
<td>Control</td>
<td></td>
</tr>
<tr>
<td>MS # 3</td>
<td>XXXXX</td>
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<tr>
<td>MS # 4</td>
<td>XXXXX</td>
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</tbody>
</table>

Table 1 shows the two groups of experimental and control schools selected. The experimental group contains two middle schools and the control contains two middle schools. The sample was drawn from 68 students from each school, which is the equivalent of having N=135 in each group.

School Selection

The Human Subject Committee’s approval was obtained before the research began. Once the schools were selected, the researcher contacted the administrator and teachers in charge of the school and classroom and asked permission for their school and class participation. A permission letter was sent for approval to the school principal and teachers for participation. The schools and teachers were selected based on the criteria in the sample discussion. The researcher also created the necessary forms to request permission from parents, students, and schools to participate in this study (informed consent). Assurance that names of respondents and school would remain anonymous was made clear to the participants. Finally, a cover letter was provided with information regarding the technological literacy test.

Teacher Selection

Once the schools were selected and approval from the school administrator granted, a permission letter was disseminated to qualifying teachers requesting permission to use his/her class and students for the study. This letter also explained to them what the research entails and how their participation is very important for the field of education, especially technology education. The researcher also provided the teacher with instructions on how to administer the test and the necessary forms, such as consent forms and information that the student needed to take home and share with their parents since they are under 18 years old. The forms needed to be signed and
turned in to the teacher before the study begun. Once the consent forms and information form were collected, the researcher scheduled a time to administer the test.

Student Selection

The students selected to participate in the study were selected based on three criteria. First, each student was required to have a technology course for one semester. Second, each student was required to be at the eighth-grade level at the beginning of this study. The third and last criterion for selecting the students was demographics to ensure a diverse student population. Participants were informed about the purpose of the study and what was required of their participation. Participants were asked to take home a consent form, review it with their parents, and have them sign and return it to their teacher in order to participate in the study. The consent form described the study, the benefits of their participation and their rights as research participants. If participants agreed to participate in the study, the researcher provided the participants with two consent forms. The first consent form was for the participant and their parents or guardians to sign and return to the researcher and the second was for the participants to keep.

Test Administration and Data Organization

The final technology literacy test was administered between the dates of December 4, 2006 and December 8, 2006. In total 137 students were administered the test in the control group and 135 were administered the test in the experimental group. All tests were administered by the qualified teachers after confirmation of receipt of the student assent form and parent consent form that was then matched to the official class role to ensure compliance to human subjects research protocol. The final test packets were collected by the researcher from each teacher and placed in individual envelopes to ensure each was accompanied by student and parent consent forms along with teacher and school administration consent forms.

Following the collection of the test forms from the participating teachers, the data was coded and entered into a Statistical Program for the Social Sciences (SPSS 15.0) data files for cleaning and screening. No identifiable coding was used to trace individual test scores to individual students. This was not necessary since the focus of the research was on instrument performance and the ability of a valid instrument to detect differences in student achievement in the study of technology. The raw data test forms were then locked in a secure storage in the possession of the Principal Investigator for the required time.

Final Test Data Analysis: Sample Descriptive Statistics

The subjects were selected from four middle schools who took a technology literacy test created by the researcher. The total number of participants in this study was 272 eighth grade students. The study sample size of 272 represents a sample sufficient for attaining results with a 95% confidence level with a confidence interval of +2.59%. The total number of students who took the test with technology education classes was 135. The total number of students who took the test with no technology education classes was 137. All participants were tested by the same post-test instrument and with an equal amount of allotted test time. The scores were then compared with frequency count of percentages using mean, median and standard deviation measurement for the total group of participants. The participant’s genders were evenly
distributed 50% (N=135) females and 50% (N=137) males. Table 8 shows the sample descriptive data across gender between the experimental and control group.

Table 8. Gender of Participants in the Study

<table>
<thead>
<tr>
<th>Gender of Participants</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>135</td>
<td>50</td>
</tr>
<tr>
<td>Male</td>
<td>137</td>
<td>50</td>
</tr>
<tr>
<td>N</td>
<td>272</td>
<td>100</td>
</tr>
</tbody>
</table>

The purpose of this study was to measure the impact of instruction in technology education and if instruction of technology education instruction is enhancing students’ technological literacy in the eighth grade level guided by the Standards for Technological Literacy (STL). The total possible score on the test was 35. Table 9 shows that the mean score of students who took a technology class was higher than those who did not took a technology class.

Table 9. Test Score Statistics

<table>
<thead>
<tr>
<th>Post-test</th>
<th>Technology Education</th>
<th>No Technology Education</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>135</td>
<td>137</td>
</tr>
<tr>
<td>Mean</td>
<td>15.42</td>
<td>14.07</td>
</tr>
<tr>
<td>SD</td>
<td>5.42</td>
<td>5.25</td>
</tr>
</tbody>
</table>

Analysis of Variance

To analyze the variation in student scores collected on the technological literacy measure an ANOVA test was used to determine if there were significant mean differences between group scores. A two-tailed test was applied to the data and scores were analyzed for significance of difference. The purpose of this test was to determine if there was a significant difference between the mean score in the post-test between the two groups. A significant difference between the mean score using an alpha level .05 was detected. A one-way analysis of variance using the post-test between groups and within groups of the eighth-grade participants was performed. The results of this analysis are shown in Table 11. The results indicated that there was significant difference between the experimental and control group in this study.

Table 11. ANOVA

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tech</td>
<td>135</td>
<td>15.42</td>
<td>5.42</td>
<td>.47</td>
</tr>
</tbody>
</table>
A one-way between-groups analysis of variance (ANOVA) was performed using post-test between groups and within groups of the eighth-grade participants. Comparing the means of the eighth-graders post-test scores, there was found to be significant difference $F(1, 270)=4.40, p=.037$ as shown in Table 12.

Table 12. Analysis of Variance between Groups

<table>
<thead>
<tr>
<th>Variance</th>
<th>Sum of Squares</th>
<th>Df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>125.13</td>
<td>1</td>
<td>125.12</td>
<td>4.40</td>
<td>.037</td>
<td>.253</td>
</tr>
<tr>
<td>Within Groups</td>
<td>7679.34</td>
<td>270</td>
<td>28.44</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>7804.47</td>
<td>271</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The Cohen $d$ statistic of .253 in Table 12 above is derived from the group mean differences and standard deviation to calculate the effect size (Gliner & Morgan, 2000). The results of this analysis indicate that the technology education instruction or treatment had a small to medium effect on the overall performance of the students in this sample.

Gender

A one-way between groups ANOVA was performed to determine if male and female scores differed on the technology literacy test. The results indicated that there was no significant difference in gender scores on the standardized technology literacy test from the males ($N=134, M=14.79, SD=5.55$) compared with the females ($N=138, M=14.69, SD=5.20$), as illustrated in Table 13.

Table 13. Comparative Scores between Males and Females

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>134</td>
<td>14.79</td>
<td>5.55</td>
<td>.48</td>
</tr>
<tr>
<td>Females</td>
<td>138</td>
<td>14.69</td>
<td>5.20</td>
<td>.44</td>
</tr>
<tr>
<td>Total</td>
<td>272</td>
<td>14.74</td>
<td>5.37</td>
<td>.36</td>
</tr>
</tbody>
</table>

The univariate results were within acceptable limits. A Levene's test for equality of variances achieved no statistical significance, $F(1, 270)=0.3, p=.17$, as shown in Table 14.
Univariate normality was tested and skewness and kurtosis statistics were well within acceptable limits; a visual inspection of the univariate frequency distribution and Q-Q plots showed no exceptions to this judgment of univariate normality. However, none of the skewness and kurtosis statistics was unreasonably high and given the relatively large sample sizes, it was concluded that no transformations were necessary.

Finally, a one-way between-groups analysis of variance (ANOVA) was performed using post-test between and within the two test groups of the eighth-grade participants—those who had technology education instruction and those who did not (see Table 15). A close examination of the means of the eighth-graders’ post-tests shows there was not a significant difference between and within groups across gender, $F(1, 270)=4.40, p=.88$.

Table 15. One-way Analysis of Variance between Test Groups across Gender

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>Df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Group</td>
<td>.72</td>
<td>1</td>
<td>.72</td>
<td>.03</td>
<td>.875</td>
</tr>
<tr>
<td>Within Groups</td>
<td>7803.75</td>
<td>270</td>
<td>28.90</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>7804.47</td>
<td>271</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Summary

The study was designed to assess the level of technological literacy achieved by eighth-grade students as measured by a self-designed/developed technology literacy instrument correlated with the Standards of Technology Literacy. Students took the test derived from randomly selected items from the test bank during the first week in December of 2006, which was the end of their fall semester. The sample was drawn from a modular technology education program that implemented a program with a common set of modular provided by a commercial vendor. The teachers selected for this study have a teaching background in the field of technology education. They must have earned a credential/license in technology education or industrial arts to participate in this study. In addition, eligible participants, needed to have three years of teaching experience at the middle grade level. All 272 sample participant data was compiled and statistically analyzed by the researcher. The goals of the analysis were to detect if there was a difference between students who took a technology class compared with those who did not take a technology class.
The results of this study indicate that there is promise in demonstrating that instruction in technology education can influence a student’s level of knowledge/literacy in the subject. The problem is that the effect size is small and the lack of gain in detection is not going to be done effectively unless multiple assessment methods are used, such as test, performance, portfolios, and projects in a holistic assessment model. While the field of technology education is not quite there yet, an important step that this study provided in its attempt was the creation of a reliable and valid instrument. Hoepfl (2007) stated that a balanced and comprehensive assessment plan will likely include both traditional and alternative measures of student capability (p. 65). While the results of this study can only be considered exploratory, much work remains in optimizing the instruments and grade-level target desired to be measured. This study selected only the eighth-grade content standards and benchmarks to serve as a test bed or proof-of-concept that a reliable and valid psychometric instrument can be designed and tested. This study was not intended to be a sole measurement instrument for technological literacy, but one piece of an important segment or approach.

Recommendations for Future Research

The researcher makes the following recommendations for further research based on the results and experiences in this study and to further measure the impact of instruction in technology education to determine if technology education instruction guided by the Standards for Technological Literacy (STL) is enhancing students’ technological literacy at all grade levels. First, it is important to acknowledge that there were significant limitations to this study in that it was exploratory in nature and was limited to the eighth-grade-level standards and benchmarks. In future studies, expanded assessment should be designed and tested at the middle school level and/or high school. Second, the psychometric instrument must be tested more thoroughly. It is the recommendation from this researcher that item response theory guide further expansion and development of grade level appropriate instruments. It will be a challenge for the field of technology education to measure the depth and breadth of student attainment in each of the content categories and benchmarks because of the challenge of instrument design under classroom and ecological constraints of student testing. Simply put too much content to test in one sitting. Assessment in technology education should look towards a blend of classical testing and authentic assessment that measures not only student knowledge, but also performance. Therefore, if technology educators are going to infer further from this work, we need to expand the scope of the study and to perform more large-scale testing, coupled with more rigorous correlation between instruction and assessment, to determine if in fact the treatment (i.e., technology instruction) is creating the assessed results.

The development of an instrument that measures the level of technological literacy guided by the Standards for Technological Literacy (STL) is needed in order to provide evidence that the Standard for Technological Literacy, when applied properly, can enhance student technological literacy. As mentioned in the addendum to STL Advancing Excellence in Technology Literacy: Student Assessment, Professional Development, and Program Standards document (AETL), the instrument should be used as a multi-step process to collect data on how students learn, understand, and the achieve ability to apply what they learn in their daily lives.

The results of this study should not be used as the only instrument to measure technology literacy; on the contrary, it should help the field to understand more clearly what is entailed in
developing a psychometric assessment instrument and what additional components need to be addressed to make this instrument more effective. As an additional step, if we can demonstrate that by taking technology education courses, students will perform better in math and science courses, then this will demonstrate the importance of technology education to overall student academic achievement. This indeed should be the next step in enhancing the research advanced by this study.

In addition, the psychometric assessment instrument designed and tested focused on what students should know, not on what students should be able to do, which it is another important area to explore. Technology literacy is not only about being knowledgeable about technology but also about being able to use, manage, and apply technology properly. The use, management, and application of technology open a vast void in current research that must be explored in the future. Specifically, having more open-ended questions, projects, scenario-based, and problem-solving types of questions can help the instrument assess the students’ daily learning activities in this technological world. In conclusion, several more assessment instruments must be developed to more accurately and reliably measure technological literacy, furthermore these instruments and assessment protocols must be guided by the principles of the STL and the AETL. In reality, this study served to begin the conversation in the technology education field regarding assessing student attainment in the study of technology as outlined in the content standards and benchmarks for the study of technology (ITEA, 2000).¹

Bibliography


