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Articles

Investigating the Relationship between High School Technology Education and Test Scores for Algebra 1 and Geometry

Richard R. Dyer, Philip A. Reed, and Robert Q. Berry

The national report *A Nation at Risk* (National Commission on Excellence in Education, 1983) sparked the standards based education reform movement in the United States. As a result of *A Nation at Risk,* the focus of education policy has shifted from school inputs to student outcomes, and from minimum competency to high proficiency standards (Lee &Wong, 2004). Accountability has become the focal point of these policy shifts. Many states have developed academic standards for students and relied on high stakes testing to measure and improve the quality of public education. The focus on accountability can be seen in the reauthorization of the Elementary and Secondary Education Act 2001, also known as No Child Left Behind (NCLB). NCLB places major emphasis on improving students' achievement in the core academic areas of mathematics, science, language arts, and social studies, by demanding that all students make adequate yearly progress (AYP).

The emphasis on improving student achievement in the core academic areas has led technology educators to show linkages between their courses and the core academic areas. Technology education provides a contextual basis for reinforcing the content of the core academic areas (Berry & Ritz, 2004). One of the programmatic goals of technology education is applying other school subjects (ITEA, 1985). For example, the project method that is frequently used in technology education often requires reading, writing, research on the history of a technological area, scientific observation, and mathematical procedures.

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Background and Purpose

Contextual Learning

Students must be able to apply learning in novel situations, but "if students are expected to apply ideas in novel situations, then they must practice applying them in novel situations" (American Association for the Advancement of Science, 1990, p. 199). We can teach skills such as measuring but if students do not know when to use a certain type of measurement, then the learning is not meaningful (American Association for the Advancement of Science, 1993) An unintended consequence of the standards movement is that a great deal of instruction has moved away from situating learning in a contextual manner. Consequently, this leads to fragmentation in which students learn bits and pieces of knowledge with little or no connection to the "big picture" (Merrill, 2001).

The predominant view of learning today posits that "people construct new knowledge and understandings based on what they already know and believe" (Bransford, Brown, and Cocking, 1999, p. 10). This philosophy, known as constructivism, is based on the foundations laid by John Dewey, Jean Piaget, Lev Vygotsky, and other educators. Constructivist teachers actively engage the student in a variety of ways. In fact, national research on recognized mathematics and science teachers show that they utilize five strategies:

- Relating – learning in the context of one's life experiences or preexisting knowledge;
- Experiencing – learning by doing, or through exploration, discovery, and invention;
- Applying – learning by putting the concepts to use;
- Cooperating – learning in the context of sharing, responding, and communicating with other learners; and
- Transferring – using knowledge in a new context or novel situation—one that has not been covered in class (Crawford, 2001, p. iii).

The Center for Occupation Research and Development (CORD) has identified these five strategies as contextual learning strategies because they help teachers put teaching and learning into context. CORD has developed a series of resources on contextual learning that are research-based and include excellent classroom lessons (see Center for Occupation Research and Development, 1999a and 1999b). Transfer of learning is the central concept upon which these materials are based and the ultimate goal of contextual learning. Transfer of learning is the application of skills and knowledge learned in one context being applied in another context (Cormier & Hagman, 1987). If the skills to be transferred can be identified and the contexts can be established where learners see that the skills they have learned can be applied to solve problems in other contexts (situations), then student success should improve (Bjork & Richardson-Klavhen, 1989).

Effects of Integrated Curriculum

Curriculum integration of technology education with the core academic areas, particularly mathematics and science is not new to technology education (see LaPorte & Sanders, 1993; Childress, 1996). However, standards-based integration and the call for supporting research have been gaining attention in recent years (National Research Council, 2002; Harris and Wilson, 2003). Such integration can provide learning opportunities for students that are relevant and meaningful (Loepp, 1999). Beane (1996) listed four broad dimensions to curriculum integration: (1) the curriculum is organized around the real world; (2) pertinent knowledge is organized without regard to subject area lines; (3) learning is not based on an eventual test, but rather the content; and (4) real application and problem solving are used to connect the content to real world application. While the interest on curriculum integration has increased, there is a dearth of research on the impact that technology education has on student achievement in the core content areas.

Satchwell and Loepp (2002) designed and implemented a curriculum for technology education that integrated mathematics and science. They compared students involved in their curriculum project with students not involved and found a positive effect on mathematics and science achievement using a sub-test adopted from the Trends in International Mathematics and Science Study (TIMSS). Merrill (2001), however, found no differences between students taught using an integrative curriculum (technology education, mathematics, science) and those taught using traditional curricula.

Burghardt and Hacker (2002) focused on teachers using an integrated curriculum. They found that fourth grade students who had teachers trained with the integrated curriculum outperformed students who had teachers who were not trained on the New York State's Elementary School Science Program Evaluation Test. In addition, these students achieved significantly above the State average on the mathematics test.

Context for the Study

Almost every state has adopted academic standards in core academic areas. In addition, many states have developed assessment instruments aligned to their standards, to measure whether students have learned what was described in the standards. The Commonwealth of Virginia adopted the Standards of Learning (SOL) for the four core academic areas: English/Language Arts, Science, Mathematics, and Social Studies/History. The SOLs are important because they establish targets and expectations for what teachers need to teach and students need to learn. The SOL requirements provide greater accountability on the part of the public schools and give the local school boards the autonomy and flexibility they need to offer programs that best meet the educational needs of students (Virginia Department of Education, 1995).

In Virginia, the career and technical education (CTE) teachers have been utilizing competency based education (CBE) as a set of standards for teaching and learning. In 2000, the Virginia Department of Education's (VDOE)

Career and Technology Education Service developed crosswalks (correlations) to the SOLs in the four core content areas. These crosswalks provided integrative and contextual connections between CTE and the four core academic areas. These crosswalks became part of the competencies and an important tool to encourage communities to support the academic programs. After the development of the crosswalks, the VDOE developed a website, Virginia Linkages (http://www.valinkages.net/), to show explicit connection between the SOLs in the four core academic areas with courses in CTE areas (Virginia Department of Education, n.d.). A lesson plan template is provided as well as lesson bank. With this tool, teachers can plan learning opportunities that integrate CTE with the four core academic areas, apply a contextual basis to the SOLs, and plan meaningful opportunities that show application and relevancy to students.

Data on students taking CTE courses and performance in the four content areas indicate an increase in secondary students taking CTE courses and an increase in the pass rate percentage from the 2000-2001 academic year to the 2002-2003 academic year (Virginia Department of Education, 2000, 2001, 2002, & 2003). Table 1 shows the percentage of secondary students enrolled in CTE courses in Virginia who passed the SOL End-of-Course Tests in the four core areas from the 2000-2001 academic year to the 2002-2003 academic year. The data in Table 1 are not aggregated by CTE courses or courses within the four core academic areas. More detail is necessary to see relationships between

Table 1
Percentage of CTE students who passed the SOL End-of-Course Tests and total number of students enrolled in CTE courses (Virginia Department of Education, 2000, 2001, 2002, & 2003)

Core Academic Area	**Academic Year**			
	2000-2001	**2001-2002**	**2002-2003**	**2003-2004**
English				
%	75.2	78.0	86.3	81.5
n	71,182	74,666	73,011	79,860
Mathematics				
%	61.1	64.5	67.5	70.6
n	77,897	82,205	84,114	93,057
History				
%	54.7	69.7	71.7	73.8
n	87,708	92,938	91,987	103,505
Science				
%	69.8	69.8	70.4	70.3
n	82,823	85,922	84,329	95,19

students' performance on the SOL End-of-Course Tests and course taking patterns. If it were determined that technology education data are consistent with existing CTE data, then it is plausible that such data would show a significant positive relationship between enrollment in technology education and performance on SOL End-of Course Tests. While connections do not suggest cause and effect relationships, significant positive findings may suggest that an investigation into a cause and effect relationship between enrollment in technology education and performance on the SOLs may be informative.

Purpose

The purpose of this study was to compare the SOL End-of-Course mathematics performance of high school students who completed courses in illustration and design technology to students who have not completed an illustration and design technology course. This technology education course is an elective that fits under the CTE umbrella in Virginia. The following research questions were developed for this study:

1. Did students who had taken illustration and design technology courses perform better on their mathematics SOL tests than students who did not take illustration and design technology courses?
2. Did students who had not passed the mathematics SOL tests do better on their retake examinations after they took an illustration and design course?

Methodology

The population for this study was composed of students in the 10th, 11th and 12th grades who had taken the Algebra I and/or the Geometry end-of-course SOL examinations during the 2002-2003 school year. These students attended an urban high school in the southeastern region of the United States. There were 996 students matching the population criteria. They were separated into two groups for this study. The first group of students had taken one or more of the following Illustration and Design courses: Technical Drawing, Engineering Drawing, and Architectural Drawing. There were a total of 89 students in this group. All 89 students had taken Technical Drawing, with 39 having also taken Engineering Drawing, and 17 having taken Architectural Drawing during the time frame of the study. There were 907 students in the second group. These students had not taken any Illustration and Design Technology courses.

Data Collection

After obtaining necessary approval, data were collected from the high school's information database to generate a report of students who took the Algebra I and Geometry SOL tests during the 2002-2003 school year. In addition, technical illustration and design attendance data were collected for the same time period (Dyer, 2004). The following criteria guided the selection of students:

1. Students identified as special education were omitted from the study since test scores for these students are not listed within the database.
2. Students who took the Algebra I and Geometry End-of-Grade tests during the 2002-2003 academic year were divided into two groups to answer the first research question: one group of IDT students and one group of non-IDT students.
3. To test the second research question, students who retested in Algebra I and Geometry for the 2002-2003 academic year and who had taken Illustration and Design Technology courses between their first test and the retest were selected for the Illustration and Design Technology group. Students not taking an Illustration and Design Technology course between their first test and retest were selected for the non-Illustration and Design Technology group.

Students' names were used only during the database query and sorting process and compared to attendance records to identify the students for the Illustration and Design Technology group. After sorting was completed, names were removed and all retained data were placed in one of two categories: Non-Illustration and Design Technology or Illustration and Design Technology.

Statistical Analysis

A *t* test: was used to validate the first research question: Did students who had taken illustration and design technology courses perform better on their mathematics SOL tests than students who did not take illustration and design technology courses? The SOL scores of the Non-Illustration and Design Technology and Illustration and Design Technology groups were used to determine if there was a significant difference in the scores between the two groups. A Chi-square test was used to validate the second research question: Did students who had not passed the mathematics SOL tests do better on their retake examinations after they took an illustration and design course? The number of retests that the Non-Illustration and Design Technology and Illustration and Design Technology groups took was used to determine if there was a significant difference in the number of times the test was taken between the two groups. The means and standard deviations were used to show the quality of testing between the Non-Illustration and Design Technology and Illustration and Design Technology test groups.

Findings

Table 2 shows the composition of the two groups and their pass/fail ratio. The Illustration and Design Technology group had a 78% passing rate, while the Non-Illustration and Design Technology group had a passing rate of 73%. Table 2 also shows the means and standard deviations of test scores for the two groups. The Illustration and Design Technology group scoring on average 14 points higher than the Non-Illustration and Design Technology group.

Table 2
Composition of the Non-Illustration and Design Technology and Illustration and Design Technology Groups

Groups	Total	Pass	Failed	Mean	*SD*
Non-IDT	907	661 (73%)	246 (27%)	427	49.34
IDT	89	69 (78%)	20 (22%)	441	45.32

The *t* test analysis was used to test the first research question: Did students who had taken illustration and design technology courses perform better on their mathematics SOL tests than students who did not take illustration and design technology courses? The *t* test value for this study was 2.65 and the value was significant at the $p < .01$ level. This finding indicates a significant difference between the SOL end-of-course test scores of students who took Illustration and Design Technology courses and those that did not.

The Chi-square test was used to answer the second research question: Did students who had not passed the mathematics SOL tests do better on their retake examinations after they took an illustration and design course? Students who retested in Algebra I and Geometry for the 2002-2003 academic year but had taken Illustration and Design Technology courses between their first test and the retest were selected for the Illustration and Design Technology group. Likewise, students not taking an Illustration and Design Technology course between their first test and retest were selected for the non-Illustration and Design Technology group. There were 18 students within the Illustration and Design Technology study group requiring a retake examination from the previous school year(s). All 18 of the students took an Illustration and Design Technology course prior to passing the retake exam. The Non-Illustration and Design Technology group had 410 students requiring a retake examination from previous test cycles; 360 passed the retake exams. Table 3 shows the analysis of the retake examinations for each group. The calculated X^2 value was 2.492, the value from the table of significance at the $p <.05$ was 3.84. There was not a significant difference between students taking Illustration and Design Technology courses and a student's ability to pass retake examination.

Table 3
Number of Algebra 1 or Geometry test retakes for the Non-Illustration and Design Technology and Illustration and Design Technology students

		Number Passing After Retake		
Groups	**Total**	**One Retake**	**Two Retakes**	**Failed**
Non-IDT	410	251	109	50
IDT	18	18	0	0

Conclusions and Recommendations

The standards-based reform movement that began in the 1980's has evolved. In the 1990s, the focus was on producing subject-area content standards and modifying instruction. Today, the focus has shifted to assessment and, for technology education, demonstrating the impact on children and the efficacy of the discipline within general education. A compelling description of this need and a research agenda is outlined in the publication *Investigating the influence of standards: A framework for research in mathematics, science, and technology education* (National Research Council, 2002).

The results of this study help meet the call for meaningful research in several ways. This study outlined a method of data collection that can be easily replicated. Data were selected from test records in an existing school system database and from instructor attendance records. Both sources are readily available in most school systems, thus eliminating the need for researchers to create a research design and data collection method from scratch. Not only will this method of research save time, but also add credibility by using accepted data sources. Research problems can be eliminated such as the development and validation of instruments and human subject issues such as confidentiality.

Additionally, the types of courses offered in Virginia's Illustration and Design program (Technical Drawing & Design, Engineering Drawing & Design, and Architectural Drawing & Design) are widely offered in secondary schools within the United States. According to a national study of secondary technology education by Sanders (1999), Drafting/CAD was the second most often taught course and Architectural Drawing/Architectural Drafting was the fifth most popular course. Because these courses are offered so widely, this type of study could be used to collect data at the local, regional, and national levels. This form of large-scale data collection is especially important since the United States does not have a national education system.

Nevertheless, it must be noted that college-bound students tend to enroll in technology education drafting and CAD courses. They may be inherently higher achievers than the general school population. In order to determine whether or not there is a relationship between *instruction* in technology education and improved achievement in academic subjects, more studies must be conducted that are designed to determine if such relationships exist.

The conclusions of this study have several implications for practice. The fact that students in the sample that initially took IDT courses had a significantly higher pass rate on their mathematics tests is particularly noteworthy. It is plausible that the IDT courses helped this sample of students with their mathematics tests; however, IDT students who did not initially pass their examinations did not have a significant pass rate on their retake tests. However, all eighteen students did pass after one retake. There appears to be a trend showing that the IDT course may help students pass the test on re-takes, even though it did not reach statistical significance. The researchers recommend that this study be replicated with a larger sample in order to include more students.

In classroom practice, perhaps there is a need for technology instructors to help with the remediation of students who do not pass the test initially. For example, when students do not pass an SOL test in Virginia, tutors are often provided for the subject area (i.e. Algebra I). The argument could be made that mathematic instructors and tutors should work with technology teachers to help students understand the relevance and application of certain mathematic skills.

Finally, technology educators at the primary, secondary, administrative, and teacher education levels all need to insure that contextual learning is truly taking place. The profession has been working for five years to implement the *Standards for technological literacy: Content for the study of technology* (ITEA, 2000) and many states like Virginia have developed "crosswalks" to academic standards. As a profession we must insure our planning at all levels implements contextual practice *and* includes meaningful assessment. The profession's long tradition of contextual practice is meaningless if it cannot delineate the impact it is having on students.

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