ABSTRACT

FAHRER, NOLAN EDWARD. An Investigation of Performance and Cognitive Assessments in the 3D-Modeling unit (Competency B) of the North Carolina State High School Drafting II-Engineering Curriculum in the Wake County Public School System. (Under the direction of Jeremy V. Ernst.)

The purpose of this research was to investigate identifiable differences between performance and cognitive assessment scores in the 3D-Modeling unit of the North Carolina high school Drafting II-Engineering course curriculum in Wake County. The study aimed to provide further investigation of the need of skill-based assessments in engineering/technical graphics courses to possibly increase accuracy in evaluating student’s factual and conceptual knowledge to be successfully prepared for the workplace. Additionally, both cognitive and performance assessments should be held as equally important measures of student outcome when considering curricular revisions and additions as well as assessment procedures.

The study consisted of 92 high school students in North Carolina enrolled in Drafting II-Engineering in the Wake County Public School System during the 2009 spring semester. Students were administered existing assessment items provided in the 3D-Modeling unit of the Drafting II-Engineering curriculum. The results provided evidence that there were no significant differences between performance and cognitive assessment in the particular unit. However, it is necessary to further develop and implement performance-based assessments in Career & Technical Education that require students to exhibit both skills and knowledge.
An Investigation of Performance and Cognitive Assessment in the 3D-Modeling unit (Competency B) of the North Carolina State High School Drafting II-Engineering Curriculum in the Wake County Public School System

by

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CHAPTER 1

INTRODUCTION

Over the years, state and national education organizations have set standards and used initiatives such as the No Child Left Behind Act of 2001 (2002), Carl D. Perkins Career and Technical Education Act of 2006 (2006), and the amended Elementary and Secondary Education Act of 1965 (2002) to help improve state curricula and instruction. Improvement in such areas often includes updating or introducing new curricula and utilizing standardized assessments to gauge school quality and teacher effectiveness. While these transformations in educational practice and instruction are somewhat effective, changes in assessment practices are also required (Firestone & Schorr, 2004).

The primary role assessment plays in education is to enhance student learning through classroom instruction while keeping in mind that it is secondarily used to hold teachers and institutions accountable and stimulate educational reform (Herman & Aschbacher, 1992, NCTM, 1993, and Linn, 2000). Too frequently standardized assessments are used encouraging a narrow, instrumental approach to learning that emphasizes the reproduction of what is presented at the expense of critical thinking, deep understanding, and independent activity (Boud, 1990). A common form of standardized assessment is curricular tests. Standardized curricular tests are generally used at the state level for school accountability and to better assess students’ mastery of approved skills and knowledge. However, educational researchers have observed that most items on standardized curricular tests often require little more than students to be able to recall facts to arrive at a correct answer (Masters & Mislevy, 1993). Kiker (2007) notes that business and industry leaders, as well as school reform advocates, generally agree that in order for students to be successfully
prepared for further education and the workplace requires more than traditional core academic skills. In order to gauge successful development of performance skill, assessments must accurately measure what knowledge students have learned and can demonstrate, whether academic or career oriented.

Using performance assessment is an alternative means to standardized assessment when evaluating student effectiveness and competence. Performance assessment may allow students the opportunity to learn through a more active process involving a students’ construction rather than a selection of responses.

Although engineering/technical graphics instructors use cognitive assessments for end of course testing, students are often evaluated using performance assessment. This performance assessment can take many forms, each focusing on skills in context rather than in isolation. These constructions often resemble those commonly required for functioning in industry, and illuminate students’ learning and thinking processes (OTA, 1992). By utilizing both cognitive and performance assessments in courses in engineering/technical graphics, student learning can be enhanced and true competence and ability can be more accurately gauged. Gordan (1998) stated: “It is important to understand, however, that no single assessment method can completely measure a student’s range of skills and knowledge in a content area. Thus, it is necessary to use several types of assessment methods to help students learn about their skills in even a single content area”.

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The relevant research presented covers current assessment practices in North Carolina state high school engineering/technical graphics courses, topics in assessment, and the constructivist learning theory. Review of the previous research will provide the foundation for utilization of performance assessment as a viable form of assessment in courses in engineering/technical graphics areas.

**Purpose of the Study**

Engineering/technical graphics courses in North Carolina public high schools possess performance components that are fundamental in the measurement of skill-based technical proficiencies; however our current school accountability measurement system leans heavily in favor of standardized cognitive assessment. By utilizing both cognitive and performance assessments, student learning can be enhanced and true competence and ability can be more accurately gauged.

This study investigated identifiable differences between performance assessment and cognitive (VoCATS) assessment scores in the 3D-Modeling unit (Competency B) of the North Carolina state high school Drafting II-Engineering course curriculum in the Wake County Public School System. The purpose of this study was to provide further investigation of the need of skill-based assessments in engineering/technical graphics courses to possibly increase accuracy in evaluating student’s factual and conceptual knowledge to be successfully prepared for the workplace. Additionally, both cognitive and performance assessments should be held as equally important measures of student outcome when considering curricular revisions and additions as well as assessment procedures (Ernst,
2008). Industry and education must work together to adjust curricula and assessment to meet the needs of students to move on to further education and secure future employment.

**Research Question and Hypotheses**

The researcher cast the following question examined in this study as: Is there an identifiable difference between performance assessment scores and cognitive (VoCATS) assessment scores in the 3D-Modeling unit (Competency B) of the North Carolina state high school Drafting II-Engineering curriculum in Wake County Public School System?

To further investigate that question, the following research hypotheses were proposed:

1. There is no significant difference in means of the student participants’ performance and cognitive (VoCATS) assessment scores in the 3D-modeling unit (Competency B) of the North Carolina state high school Drafting II-Engineering curriculum in the Wake County Public School System.

2. There are no significant differences in means of the student participants’ performance and cognitive (VoCATS) assessment scores in the 3D-modeling unit (Competency B) of the North Carolina state high school Drafting II-Engineering curriculum in the Wake County Public School System between grade levels.

**Assumptions**

1. Since the population of interest was individuals enrolled in Wake County Public School System, all students have taken Drafting I or a comparable course as a pre-requisite to
enrolling in Drafting II-Engineering, therefore competent in basic engineering/technical graphics concepts.

2. Students may or may not be enrolled at the same school in Wake County.

3. Since the sample was taken from students enrolled in the Drafting II-Engineering course, it was assumed that all students would have relatively little or no prior experience in 3D Modeling.

4. It was assumed that all students had the required knowledge of computers to learn new software.

5. It was assumed that the conditions for completing the study were the same for all individuals.

6. It was assumed that all classrooms were equipped with the proper technology and computer software.

Limitations

1. The student participants’ in the sample ranged from 14-19 years of age. Cognitive abilities of the students could differ with age.

2. Since the study used the Drafting II-Engineering course curriculum and is a high school elective, student participants’ may or may not have completed a geometry course. Completing a geometry course could further aid students in understanding of terminology used in the Drafting II-Engineering curriculum.

3. Some students may have prior knowledge and experience regarding 3D-Modeling software and concepts.
4. It is possible, but not likely, that some students may not have completed the assessments to the best of their abilities.

5. Teachers could have variation in their instruction.

**Definition of Terms**

The purpose of this section is to provide definition and/or background information for terms used in this study.

**Carl D. Perkins Career and Technical Education Act of 2006** – Carl D. Perkins Career and Technical Education Act aims to provide an increased focus on the academic achievement of career and technical education students, strengthen the connections between secondary and postsecondary education, and improve state and local accountability (U.S. Department of Education, 2007).

**CAD** – This term has come to represent many different things. The most common are computer-aided design, computer-aided drafting, and computer aided design/drafting. The usage of the term really depends on the context. If one is producing mainly 2D documents, computer-aided drafting is probably appropriate. Computer-aided design generally reflects design utilizing a 3D modeling database (NCDPI, 2003).

**Constraint-based modeling software** – constraint-based modeling software is a type of computer aided drafting & design (see definition) software that uses feature definitions (extrude, revolve, fillet, etc.), dimensional and geometric constraints (equal, parallel, concentric, etc.), and
a feature tree (how the features are arranged) to define 3D solid models (see definition) (NCDPI, 2005).

**Constructivist Learning Theory** – The constructivist learning theory is described as a learning process that involves actively and individually constructing knowledge through experience (Garlfield, 1995).

**Course weight** – the degree of importance given to each objective in relation to the entire course of study (NCDPI, 2006).

**Elementary and Secondary Education Act of 1965** – This program is designed to support the development of the additional state assessments and standards required by Sec. 1111(b) of the Elementary and Secondary Education Act (ESEA), as amended. If a state has developed the assessments and standards required by Sec. 1111(b), funds support the administration of those assessments or other activities related to ensuring that the state’s schools and local education agencies (LEAs) are held accountable for results (U.S. Department of Education, 2004).

**Engineering/Technical Graphics** – A method of communication used by engineers and other technical professionals during the process of solving technical problems. Engineering/technical graphics follow standards and conventional practices agreed upon by the profession, so that the information can be accurately read and interpreted by the individuals who have learned the standards and conventions (Bertoline, Wiebe, Miller & Mohler, 1997).
**No Child Left Behind Act of 2001 (NCLB)** – NCLB is the latest federal legislation that enacts the theories of standards-based education reform, which is based on the belief that setting high standards and establishing measurable goals can improve individual outcomes in education. The Act requires states to develop assessments in basic skills to be given to all students in certain grades, if those states are to receive federal funding for schools. The Act does not assert a national achievement standard; standards are set by each individual state (U.S. Department of Education, 2003).

**VoCATS** – the Vocational Competency Achievement Tracking System (VoCATS) is a statewide computerized instructional management system used primarily in North Carolina secondary career and technical education (CTE) to serve as an umbrella under which CTE curriculum is developed, disseminated and implemented, and student achievement is evaluated (NCDPI, 2005).

**Standardized Assessment** – A type assessment that is administered, scored, and interpreted in a consistent, pre-determined manner and is generally used at the state level for school accountability and to better assess students’ mastery of approved skills and knowledge (Popham, 2002).

**3D-Solid Model** – Objects that are defined as a solid mass, and may contain information about the density, mass, moment of inertia, volume, and center of gravity of the object typically created using a constraint-based modeling software (see definition) (NCDPI, 2003).
Summary

This chapter summarized relevant research concerning changes in assessment practice that are needed to accurately measure 21st century skills and accurately represent what knowledge students have learned and can demonstrate. Performance assessment was discussed as being a viable form of assessment used to more accurately gauge true student competence and ability. More importantly this type of assessment may aid in successfully preparing students for the workplace. The theoretical construct was that assessment can be improved in courses in engineering/technical graphics areas by investigating identifiable differences between performance assessment and cognitive (VoCATS) assessment in the 3D Modeling unit (Competency B) of the North Carolina state high school Drafting II-Engineering Curriculum.
CHAPTER 2

REVIEW OF LITERATURE

Introduction

Curriculum and instruction are areas in education that are commonly improved or updated by government initiatives such as the No Child Left Behind Act of 2001 (2002). Improvement of such areas often includes updating or introducing new curricula and utilizing standardized assessments to gauge school quality and teacher effectiveness. While these transformations in educational practice and instruction are somewhat effective, changes in assessment practice are also required (Firestone & Schorr, 2004). Development of assessments must measure 21st century skills and accurately represent what knowledge students have learned and can demonstrate, whether academic or career oriented (Gordan, 1998). In addition, these skills are commonly required for functioning in industry, and illuminate students’ learning and thinking processes (OTA, 1992).

Due to their nature, skills found in engineering/technical graphics and other courses in Career and Technical Education (CTE) may require multiple types of assessment. However, the current school accountability measurement system leans heavily in favor of using only standardized cognitive assessment. Too frequently, standardized assessments are used and commonly encourage a narrow, instrumental approach to learning that emphasizes the reproduction of what is presented at the expense of critical thinking, deep understanding, and independent activity (Boud, 1990).
Performance assessment is discussed by educational practitioners as being a worthy alternative assessment to be utilized in conjunction to existing standardized cognitive assessments (Flexer & Gerstner, 1993). However, further research is needed in the field to identify how performance assessment can be utilized as a viable form of assessment in courses in engineering/technical graphics areas. The following review of literature summarizes current CTE assessment, the role of assessment in education, and the constructivist learning theory.

**Career and Technical Education**

Career and Technical Education (CTE) is composed of instrumental based courses that provide meaningful contexts in which students can apply the concepts they learn in academic classrooms to a setting designed to show real world relevance (Martinez, 2007). CTE courses are structured in a way that promotes the performance based learning component, which can enhance student learning and more accurately gauge true student competence. This requirement allows students to directly demonstrate their abilities in order to measure their skill-based technical proficiencies. If students are required to demonstrate their abilities in this fashion, opportunities are provided for instructors to effectively assess course content competency.

The nature of educational assessment is to assist learning, measure individual achievement, and evaluate program effectiveness (National Academy of Sciences, 2003). Although the primary function is to determine whether learners have achieved the goals and
objectives of courses, assessment is used for a variety of purposes by a variety of persons or organizations (Reeves & Okey, 1996).

Educational assessment is used by the Carl D. Perkins Act for school accountability purposes. Accountability is required of all states that accept federal funds to support vocational programs (Association for Career and Technical Education, 2006). To measure accountability, CTE courses use established performance measures to determine academic and technical skills progress and proficiency. These established measures come in the form of standardized cognitive assessments and provides uniform measurement across student populations.

North Carolina secondary schools use the Vocational Competency Achievement Tracking System (VoCATS), which is composed of a 100 item multiple choice standardized cognitive assessment aligned with each particular course objective. This system was developed by the North Carolina Department of Public Instruction for all high school CTE courses offered in the state of North Carolina. All students enrolled in CTE courses are required to complete this standardized assessment at the culmination of each course. However, there is no performance component currently included. According to Ernst (2008) if skill-based performance and cognitive knowledge are both of equal importance in CTE, it should be reflected in assessment practice. Investigations have been proposed to add to the current research on whether or not a possible performance assessment could be incorporated into the state accountability system.
The CTE Course Design is provided in a framework and referred to as the VoCATS Course Blueprint. The VoCATS Course Blueprint framework includes the recommended sequence of units, core competencies, and the specific objectives of each competency. The VoCATS Course Blueprint is exclusively aligned to the learning question, which is part of the four fundamental questions that are addressed in A Taxonomy for Learning, Teaching, and Assessing (Anderson & Krathwohl, 2001). The generic learning question referred to is as follows:

The Learning Question – What is important for students to learn in the limited school and classroom time available?

The stated competencies and objectives found in the Course Blueprint are NCDPI’s response to “The Learning Question”. Each unit of instruction includes a core competency which Parry (1996) defines as a cluster of related knowledge, attitudes, and skills that affects a major part of one’s job; correlates with performance; can be measured; and can be improved. Within each core competency specific objectives are included and both are worded in the format of a statement. Competency and objective statements begin with an action verb and make a complete sentence when combined with a noun (i.e. - Demonstrate communication, problem solving, and team building skills.) a format modeled on the work of Ralph Tyler (1949). The specific objectives written for each competency are aligned with a cognitive and performance course weight. This in turn will determine the number of test-items per objective on any test developed by the state department. For example, on the VoCATS 100 item cognitive assessment, an objective having a value of 10% will have 10
test-items representing that objective. Each unit’s percentage of course weight is roughly 50% cognitive and 50% performance (see Figure 2.1).

The Engineering curriculum is one of the many course offerings under the Engineering Technologies pathway of the Trade and Industrial (T&I) Education in the state of North Carolina. It includes a three course series of Drafting I, Drafting II-Engineering, and Drafting III-Engineering. The focus of the current study is the Drafting II-Engineering course which includes the following topics: Leadership, 3D Modeling, Manufacturing Processes, Dimensioning and Conventional Tolerancing, Sectional Views, Auxiliary Views, and Pattern Development. These topics reflect the unit breakdown that exists within the course blueprint.

The Drafting II-Engineering curriculum includes cognitive and performance assessments that align with the specific objectives found in the VoCATS Course Blueprint. Cognitive test items are provided in a computer supported secure test item bank in the form of multiple choice questions and are a component of the VoCATS post assessment. A performance test item is also provided and is composed of a prescribed activity accompanied by a rubric that reinforces and complements the cognitive test items. Currently, there is no standardized performance assessment included within the VoCATS. Reeves, Laffey, and Marlino (1996) suggest that standardized cognitive assessments may lack the face validity that alternative performance assessments could provide and demonstrates the inadequacy of cognitive assessments. Further research is needed to order to include this component.
The Drafting II-Engineering curriculum emphasizes the use of 3D CAD concepts introduced in the Drafting I curriculum. According to Ault (1999) there must be an increased emphasis on 3D solid modeling within the engineering graphics curriculum. Respectively the second unit within the Drafting II-Engineering sequence is titled 3D Modeling and makes up 20% of the total Drafting II-Engineering course weight. To achieve mastery in this competency, students must demonstrate 3D solid modeling techniques. NCDPI highly recommends that constraint-based modeling software be used to build on these concepts. The cognitive portion of the specific objectives requires students to explain techniques for creating, modifying, and duplicating 3D geometry. The performance objective requires students to construct a 3D solid model (see Figure 2.1). The cognitive and performance assessments provided by the state make up the course weight for the 3D-Modeling unit of the Drafting II-Engineering curriculum (NCDPI, 2005).

<table>
<thead>
<tr>
<th>Comp#</th>
<th>Obj#</th>
<th>Unit Titles/Competency and Objective Statements (The Student will be able to :)</th>
<th>Time</th>
<th>Course Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td></td>
<td>3D MODELING</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D402.00</td>
<td>Demonstrate 3D solid modeling techniques.</td>
<td>10%</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>D402.01</td>
<td>Explain techniques for creating 3D geometry.</td>
<td>7%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D402.02</td>
<td>Explain techniques for modifying and duplicating 3D geometry.</td>
<td>3%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D402.03</td>
<td>Construct a 3D solid model.</td>
<td></td>
<td>10%</td>
<td></td>
</tr>
</tbody>
</table>

Figure 2.1 Drafting II-Engineering – 3D Modeling Competency and Objectives (NCDPI, 2005)
Assessment in Education

The role of assessment and evaluation in education has been prominent since the earliest approaches of formal education. The term “assessment” is often used by different people in different contexts (Garfield, 1994). The purpose of assessment is to accredit knowledge and performance of students using course test grades or scores (Barrow, 2006). However, it seems that the role of assessment in education is evolving. Emerging visions of assessment are currently topics of educational research. The current reform movement in educational assessment encourages teachers to think about assessment more broadly than "testing" and using test results to assign grades and rank students (Romberg, 1992; Lesh & Lamon, 1992).

The primary role of assessment is to enhance student learning by improving classroom instruction (NCTM, 1993). The secondary roles are to communicate the progress of students and provide measures for accountability (Herman, 1992, and Linn, 2000). Assessment serves the needs of all levels of educational hierarchy.

Enhancing the quality of learning is a potential benefit of assessment that affects all stages of the learning process (Dochy & McDowell, 1997). According to Ridgway & Schoenfeld (1994) assessment culture can be used to change instruction from a system that transfers knowledge into student’s heads to one that tries to develop students who are capable of learning how to learn. Current assessment practice tends to encourage rote learning and the ability to recall factual knowledge. Summative assessments have been too dominant and more emphasis should be given to the potential of assessments to enhance learning (Crooks,
Meaningful learning will not take place in the long term unless teachers are efficient in monitoring pupil strengths and needs in order to track and assist with their progress (Harris, 2007). This can be accomplished using formative assessments.

Formative assessment is concerned with gathering information about learning as it is taking place so that instructional modifications may be made to improve the quality or amount of learning (Anderson & Krathwohl, 2001). Black & Wiliam (1998) conducted a review of literature of over 250 articles by researchers from several different countries to survey the evidence about the effects of improving formative assessment on pupil performance. Several of these studies show firm evidence that innovations designed to strengthen the frequent feedback that students receive about their learning yield substantial learning gains. This review showed that there is a strong body of evidence to support a claim that formative assessment practices can raise standards.

At the same time, the published evidence also showed that such practices were only weakly developed in most classrooms. According to Black & Wiliam (1998), formative assessment is not well understood by teachers and is weak in practice. They also note that its implementation calls for rather deep changes both in teachers’ perceptions of their own role relation to their students and in their classroom practice.

In an experiment conducted by Bergan, Sladeczek, Schwarz, & Smith (1991), the outcomes of 5 year old children being taught in kindergarten using formative assessment were analyzed. The belief was that close attention to the early acquisition of basic skills using
a pre-test is essential to student learning outcomes. It involved 838 children drawn mainly from disadvantaged backgrounds in six different regions in the United States. Students were required to participate in a pre-test to assess their level of basic skills, and then consulted about their progress after two weeks. New assessments were then given after four weeks giving teachers a further diagnostic view and the ability to make new decisions about student needs. The whole course lasted eight weeks. Outcome tests were compared with prior tests of the same skills taken by students who were not required to participate in a pre-test. The data was analyzed using structural equation modeling which showed the pre-test measures were a strong determinant of all outcomes. This example successfully illustrates the embedding of a formative assessment routine within an innovative educational program to improve student learning. However, only if the feedback provided to the learner actually improved their performance was the feedback functioning formatively (Black, 2003).

Accountability is the application of consequences to assessment results and can occur at the federal, state, district, school, classroom, teacher, or student level (Council of Chief State School Officers, 2000). Accountability uses assessments to gauge school quality, teacher effectiveness, and set guidelines for funding appropriation.

The current federal accountability system is the No Child Left Behind Act of 2001 (NCLB, 2002). A major component of this act is to gauge school quality which mandates that all students reach a specified proficiency level in reading, writing, and mathematics and demonstrate adequate yearly progress (AYP). Any school that does not achieve AYP for all students two years in a row faces serious consequences from state and federal authorities.
(Gordan, Yocke, Maldonado, & Sadler, 2007). The NCLB Act brings enormous pressures from within the test driven education system to raise the proficiency standards of all students (Daggett, 2003). According to a study conducted by Kim & Sunderman (2005), the accountability requirements of the NCLB place high-poverty schools and racially diverse schools at a disadvantage because they rely on mean proficiency scores and require all subgroups to meet the same goals for accountability. In the study the researchers conclude that there are flaws in NCLB, and that these issues require further research in order to reach equality.

Teacher quality and effectiveness is another component of NCLB. It requires that all teachers of core academic subjects be “highly qualified”. To be considered highly qualified, a teacher must be fully certified in the subject(s) taught, have a bachelor’s degree, and demonstrate subject area competence in a manner to be determined by the state (Harris & Ray, 2003). States are required to ensure all schools and districts meet these teacher requirements and if sufficient progress is not made towards achieving 100% compliance, state intervention will be required. In addition, districts are required to only hire highly qualified teachers for programs that receive federal Title 1 funds, or they risk losing that funding (NCLB, 2002).

In addition to gauging school quality and requiring teacher effectiveness, assessment is used to hold states which seek funds to support vocational education programs accountable. The Carl D. Perkins Career and Technical Education Act of 2006 (2006) mandates that all states that seek funds for these programs implement standardized
assessment measures to provide uniform measurement across student populations. This legislation places greater accountability on the integration of academic standards, and is aligned directly with the NCLB (2002) movement.

Assessment and accountability have had prominent roles in many educational reforms during the past (Linn, 1993). They also have been the center for political controversy (Madaus, 1985). The explicit objective is to interweave assessment and instruction in order to improve education (Dochy & McDowell, 1997). It also aims at improving our school system in hopes to restructure parts of it to function more efficiently.

There has been considerable debate about how useful state assessment is as instruments for reforming educational practice. Firestone, Mayrowetz, & Fairman (1998) discuss two studies that evaluate assessments for shaping instruction. The first study concludes that high stakes assessments dumb down the curriculum, de-skill teachers, push students out of school, and generally sew fear and anxiety among both student and educators (Corbett & Wilson, 1991; Smith, 1991). The second study argues for measurement-driven reform, argues that “if you test it, they will teach and learn it”, and that assessment can guide the educational system to be more productive and effective (Popham, 1987). While both positions disagree about the different consequences of state assessments, they do agree that assessment is useful in shaping instruction.
Types of Assessment

As previously reviewed, assessment is used to enhance learning, communicate progress, and aid in school accountability. Several categories of assessment are necessary to accomplish these tasks. Six general categories of classroom assessment are identified. The categories identified are objective paper and pencil items, standardized cognitive assessment, performance assessment, informal observation, essay type items, and portfolios (Gordan, 1998).

Cognitive assessment generally come in the form of objective paper and pencil classroom test items and standardized tests used for external assessment. Traditional objective classroom assessments are frequently summative and are used for final exams and other forms that require the teacher to assign a grade (Cross & Angelo, 1988). According to Linn (1993) these types of assessments focus on basic skills and drill and practice on factual knowledge. However, multiple choice objectivity types of tests are convenient for teachers because they can be automatically scored, and their markings will not be biased for or against any particular group of students (Baker, 1997).

A standardized test is generally defined as any test that is administered, scored, and interpreted in a consistent, predetermined manner. Popham (2002) indicates that standardized assessments can be found in two forms, one form being national achievement tests and the other standardized curricular tests. National achievement tests are standardized assessments that are commonly designed to make predictions about how a test taker will perform in a subsequent setting. In 2001 there were five nationally standardized achievement tests that
were used in the United States public schools such as Iowa Tests of Basic Skills (Popham, 2002). Popham (2002) states that there is a high likelihood that the specific content included in this and similar tests may be seriously inconsistent with local curricular aspirations. Many education policy makers assume that national achievement tests content will mesh well with what is supposed to be taught locally, but test takers must cope with considerable national curricular diversity. A study at Michigan State University conducted almost two decades ago suggests that as many as 50% of the items included in a nationally standardized achievement test may cover content that is not even taught in a given locality (Popham, 2002).

Standardized curricular tests are a widely used type of cognitive assessment and are generally used at the state level for school accountability and to better assess students’ mastery of approved skills and knowledge. However, Masters & Mislevy (1993) have observed that most items on standardized curricular tests often require little more than students to be able to recall facts to arrive at a correct answer. According to Boud (1990), in many cases these tests encourage a narrow, instrumental approach to learning that emphasizes the reproduction of what is presented at the expense of critical thinking, deep understanding, and independent activity. As a result, schools and teachers tend to narrow their curricula and courses with the aim of helping students pass tests from external agencies (Baker, 1997). In a study conducted by Tan (1992), he concludes that too frequent usage of formal standardized curricular testing causes negative effects on our education system even with tests well linked to instruction. Many argue that using alternative types of assessment is the answer to these negative effects. If alternative assessments are implemented properly,
motivation and learning progress will increase and school instruction can be correctly evaluated for effectiveness (Dochy & McDowell, 1997).

Alternative assessment is becoming increasingly of interest to educational researchers and reflects the frustration with traditional approaches as well as the sincere desire to assess the attainment of higher order educational goals that involve deep understanding and active use of knowledge in complex, realistic contexts (Herman, Aschbacher, & Winters, 1992). There is no single definition of alternative assessment but it has been described as an alternative to standardized testing and all of the problems found with such testing (Huerta-Macías 1995). Garcia & Pearson (1994) include the following in their review of these labels: performance assessment, portfolio assessment, informal assessment, situated (or contextualized) assessment, and assessment by exhibition. They state that alternative assessment consists of all efforts that do not adhere to the criteria of standardization, efficiency, cost effectiveness, objectivity and machine scoring. Most importantly this type of assessment provides alternatives to traditional testing in that it does not intrude on regular classroom activities, reflects the curriculum that is actually being implemented in the classroom, provides information on the strength and weaknesses of each individual student, provides multiple pathways to gauge student progress, and is more multi-culturally sensitive and free of norm, linguistic, and cultural biases found in traditional testing (Garcia & Pearson, 1994).

Many researchers inquire if alternative assessments can be aligned to many of the state’s general or functional curricula. Browder and Flowers (2004) conducted a study in
three states where experts in mathematics and language arts, along with a group of stakeholders (teachers and administrators), examined the performance indicators relative to their alignment to national standards and curricula. On the surveys, 86% of math experts and 70% of stakeholders indicated that performance indicators were clearly linked to national math standards. Eighty-six percent of language arts experts and 100% of stakeholders that responded to the survey indicated that performance indicators were clearly aligned to language arts standards. The results suggest that alternative assessments have a strong focus on academic and functional skills.

A widely used form of alternative assessment is performance assessment. Performance assessment is defined as “testing methods that require students to create an answer or product that demonstrates their knowledge or skills” (U.S. Office of Technology Assessment [OTA], 1992). According to Elliot (1997) performance assessments are best understood as a continuum of assessment formats that range from the simplest student constructed responses to comprehensive demonstrations of work over time. These might involve a construction rather than a selection of responses, direct or indirect observation of student behavior on tasks resembling those commonly required for functioning in the world outside of school, and illuminating students’ learning and thinking processes (OTA, 1992).

Performance assessment of students’ achievement is not new to many educators but is usually only apparent in the areas of physical education, art, music, and vocational and technological arts. To a large extent, students’ products or performances are used to determine whether learning objectives of a class been met (Elliot, 1997). However,
performance assessment is becoming more prevalent in core classes in areas such as mathematics, science, language arts, and social studies. In a study conducted by Flexor and Gerstner (1993), issues involving the construction of alternative forms of assessment by mathematics teachers were studied through the case study of assessment development in three elementary schools. Three schools with 14 third-grade teachers were selected and matched with three comparison schools where data would also be collected. The three schools continued to use the end-of-chapter tests, but they supplemented those with other assessments that involved more conceptual understanding and higher order thinking. The researcher concluded that even though there were dilemmas among teachers, positive effects were observed in their students using performance assessment.

Many educators use weak forms of performance assessment to ask students to apply knowledge and skills by producing a product and provide students feedback in the form of grades. Besides these two traditional elements, new, pedagogically stronger forms of performance assessment take steps to influence students’ performances. Assessment tasks are selected that are clearly aligned or connected to what has been taught, sharing scoring criteria for the assessment task with students prior to their working on the task, providing students clear statements of standards or several models of acceptable and exemplary performances prior to their attempting a task, encouraging students to complete self-assessments of their performances, and interpreting students’ performances by comparing them to consensus standards that are developmentally appropriate, as well as comparing them to other students’ performances (Elliott, 1991, 1994). As conceptualized here, these stronger forms of
performance assessments interact in visible ways with instruction that precedes and follows an assessment task.

Since a performance assessment is a type of educational assessment in which judgments are made about student knowledge and skills based on observation of student behavior or inspection of student products, educational reformers have hailed policy that pushes performance assessment (Lam, 1995). They claim that by replacing selective response tests such as multiple-choice tests, schools will improve. Many others argue that cognitive and performance assessments should complement each other and that there is a need for varied assessment. A study conducted by Ernst (2008) indicated that there are variations, differences, and correlations between North Carolina Engineering/Technical Graphics I cognitive and performance assessment. In the study 157 engineering/technical graphics student participants from six different North Carolina counties were assessed using existing Engineering/Technical Graphics I curriculum. The students were evaluated using the state end-of-course assessment developed and administered by North Carolina for the cognitive assessment and four performance projects each representing 25 points (of 100 of the overall student performance score) for the performance assessment. The purpose of these paired evaluations was to identify relationships when comparing cognitive and performance scores in Engineering/Technical Graphics I. Ernst (2008) concluded that there was a significant difference between the two assessments. However, after further examination of the data, evidence provided concludes that the cognitive and performance assessments results tended to increase or decrease together. Future findings like these could open the possibility for
assimilation of assessment practices given the need for varied assessment for individual and school accountability.

Performance assessment can also be helpful in assisting with instructional decisions. In a descriptive study conducted by Gordan (1998), six general categories of classroom assessment were examined to identify how assessment information was used to address ten different instructional decisions. Gordan’s target population was all teachers in West Virginia who taught full time secondary vocational technical education with a sample of 240 teachers. The categories of assessment examined were objective paper and pencil items, standardized cognitive assessment, performance assessment, informal observations, essay type items, and portfolios. The study findings indicated that objective paper and pencil items were found to be less useful in addressing instructional decisions than both performance assessments and informal observations, but of more use than essay items, portfolios, and standardized test scores. Gordan (1998) concludes that performance assessment is particularly useful to secondary vocational education teachers. Given the fact that vocational education teachers use a competency-based curriculum, this finding revealed that performance assessment was more useful than the other five methods used in the study to aid in making instructional decisions.

Although the pedagogical advantages of performance assessment in supporting instruction that focuses on higher order thinking skills are obvious, research has consistently indicated unresolved logistic and psychomotor problems, especially with score generalizability (Linn, 1993). Baker (1997) concludes that the very qualities of performance
assessment that make it desirable will cause it to be difficult and expensive to implement. “Teachers would have to be trained to use each rubric, and the technical quality of each task, its fairness, and its reliability would have to be determined if it were to be used for formal testing purposes”. However, teachers tend to avoid creating a rubric that generates a cookie-cutter right answer to a complex topic, particularly because they want to avoid the possibility that there is a “right answer” that can be taught or memorized by those students who wish to cheat the system. Baker’s (1997) quick review of prominent doubts includes the following problems: 1. Performance assessments are difficult and expensive to develop. 2. Performance assessments, because they are open ended, require trained judges to evaluate students’ efforts, and cost far more than other approaches. 3. Many teachers are not prepared to teach in the way performance assessments imply. 4. Many parents believe that performance assessment is a less rigorous method to evaluate students than more familiar multiple choice tests.

Engineering/Technical Graphics instructors often evaluate students using a performance-based type of assessment due to the nature of their courses. These performance assessments take many forms, each focusing on skills in context rather than in isolation (Choate & Evans, 1992). Additionally, these instructors use performance-based assessments to emulate real life problem solving that occurs in industry. For example, assessments found in Engineering/Technical Graphics I and II courses in North Carolina state high schools include: a) creating multi-view and pictorial sketches, creating manual and CAD drawings that demonstrate basic drafting skills, geometric construction, dimensioning, and
orthographic projection techniques, & b) using constraint based CAD software to
demonstrate 3D modeling techniques, manufacturing, dimensioning and tolerances, auxiliary
and section views, and patterns (NCDPI, 2005). These examples of assessments are often
referred to as authentic assessment. According to Meyer (1992), performance assessment
becomes authentic assessment when the task requires the student to demonstrate behaviors in
real-life contexts to meet the realistic demands either within or outside of the classroom.

Assessment in engineering/technical graphics courses is a subject that has not been
studied often by educational professionals. To evaluate students’ work, instructors frequently
emulate the way that they were assessed themselves. Additionally, many professionals will
agree that no two graphics educators will grade the same drawing the same way (Clark and
Scales, 2001). In a study conducted by Clark and Scales (2001), ninety-three members of the
Engineering Design Graphics Division of the American Society for Engineering Education
were surveyed about assessment practices conducted in courses of engineering/technical
graphics. In the study 31.2% have their students submit their work on paper, 8.6% have
students submit work electronically, and 58% have students submit work in both ways.
Additionally, 39.8% of the respondents use common exams in their courses, 74.2% use
written exams, 65.6% use electronic exams, and 19.4% use take home exams. Lastly, 47.3%
include instrument drawings on their exams, and 71% use hands on exams. The researchers
conclude that the inconsistencies in assessment indicate that engineering/technical graphics
instructors are struggling with appropriate methods for assessing student work and it should
be measured against taxonomy appropriate for the subject matter in order to provide direction
and assessment uniformity. Emphasis should also be given to meet industry standards. Industry and education must work together to adjust curricula and assessment to meet the needs of students to secure future employment in engineering/technical graphics areas (Branoff, Hartman, & Wiebe, 2002, 2003).

**Constructivist Learning Theory**

Assessment in education has evolved often because of people’s change of perspective regarding different learning theories. These perspectives change because of the complexity of learning. No one set of characteristics can account for such varied activities as learning (Gagné, 1972). The general function of a learning theory is to serve as a framework for conducting research, provide organization of framework for specific items of information, reveal the complexity and subtlety of simple events, and to re-organize prior experience (Gredler, 1992). Learning and cognitive development are complex events in which the learner may be engaged in several activities. No one learning theory can possibly address all the complexities found in the various settings and contexts in which learning can occur (Gredler, 1992). Therefore, a particular theory is chosen for a situation partly as a result of the activities to be studied.

A widely accepted learning theory in educational communities is labeled constructivism. The concept of constructivism has been influenced by many educational theorists such as John Dewey. His belief was that genuine education comes about through experience, but that all experiences are not genuinely or equally educative. Dewey (1938) states that it is the business of the educator to arrange for the kind of experiences which,
while they do not repel the student, nevertheless, promote having desirable future experiences.

The constructivist theory, more specifically Bruner’s constructivist theory, is based off of the early work by Jean Piaget and describes learning as actively constructing one’s own knowledge (Bruner, 1960). Constructivists believe that students should actively and individually construct their own knowledge rather than copy knowledge by having it transmitted, delivered, or conveyed to them (Garlfield, 1995). According to Jenkins (2000) constructivists hold a commitment to the idea that the development of understanding requires active engagement on the part of the learner. Constructivist teachers are acutely aware of the role of prior knowledge in students’ learning, recognizing that students are not blank slates or empty vessels waiting to be filled with knowledge, but instead students bring with them prior knowledge and beliefs that they use in constructing new understandings (Jones & Brader-Araje, 2002). Constructivism offers instructional approaches that allow teachers to design instruction that goes beyond rote learning to meaningful learning that will lead to deeper, long lasting understandings.

Constructivist learning approaches may be designed for multiple levels of learning, including verbal information and discrete skills as well as higher-order problem solving, cognitive strategies, and attitudes, but focus in learning activities is on application and active use of knowledge (Reeves & Okey, 1996). For example, Olkun (2003) suggests that current geometry curricula do not provide enough opportunities for the development of spatial abilities. The kinds of activities that are said to improve spatial ability are very similar to
what are being used to teach engineering drawings. Olkun (2003) uses engineering drawings as a context for two reasons: First, it is a practical base in real life situations and involves skills representing objects in pictorial forms and visualizing objects from their drawings. Second, concrete experiences with geometrical objects and representing them in two-dimensional space are proved helpful in improving students’ performance in spatial visualization. He concludes by stating that spatial abilities can be improved by these appropriate activities. The article summarized takes a constructivist learning approach to traditional curricula with more emphasis on active understanding then verbal principle to instruct students.

The constructive learning approach is often connected with alternative assessments. According to Reeves & Okey (1996), if the artificial distinction between learning and assessment is put aside, the same or similar activities may legitimately be used for either purpose. They conclude that constructivist learning environments and alternative assessments help blur the division between learning and assessment that is common in most instructional settings.

**Summary**

This chapter has looked at current CTE assessment, the role of assessment in education, and the constructivist learning theory. The review indicated that performance assessments may allow student learning to be enhanced and more accurately gauge true student competence and ability. The literature also provides evidence that performance assessment is compatible with the constructivist learning theory. The review has reinforced
the belief that further information is needed to show that performance assessment can be utilized as a viable form of assessment in courses in engineering/technical graphics areas.
CHAPTER 3
METHODOLOGY

Introduction

The review of literature led the researcher to conclude that alternative types of assessment could be used to gauge student competence and ability in addition to traditional standardized curricular testing. One alternative includes performance assessment. Constructivist learning theory offers instructional approaches that allow teachers to design instruction that includes performance assessment leading to deeper, long lasting understanding. The review of literature has suggested that performance assessments will give students the opportunity to learn through a more active process that enhances learning and gives the instructor the ability to more accurately gauge true student competence and ability. Further investigation is needed in the field to identify how performance assessment can be utilized as a viable form of assessment in courses in engineering/technical graphics areas.

This chapter describes the methodology used in devising and conducting a study to identify possible differences in performance assessment and cognitive (VoCATS) assessment scores in the 3D-Modeling unit (Competency B) of the North Carolina state high school Drafting II-Engineering course curriculum (NCDPI, 2005).

Purpose of the Study

Standardized curricular tests are generally used at the state level for school accountability and to better assess students’ mastery of approved skills and knowledge. However, educational researchers have observed that most items on standardized curricular
tests often require little more than students to be able to recall facts to arrive at a correct answer (Masters & Mislevy, 1993). Kiker (2007) notes that business and industry leaders, as well as school reform advocates, generally agree that in order for students to be successfully prepared for further education and the workplace requires more than traditional core academic skills. In order to gauge successful development of performance skill, assessments must accurately measure what knowledge students have learned and can demonstrate, whether academic or career oriented.

This study investigated identifiable differences in performance assessment and cognitive (VoCATS) assessment scores in the 3D-Modeling unit (Competency B) of the North Carolina state high school Drafting II-Engineering course curriculum in schools that are members of the Wake County Public School System. This study provided further investigation to identify the need of skill-based assessments in engineering/technical graphics courses to possibly increase accuracy in evaluating student’s factual and conceptual knowledge. Additionally, both cognitive and performance assessments should be held as equally important measures of student outcome when considering curricular revisions and additions as well as assessment procedures (Ernst, 2008). Industry and education must work together to adjust curricula and assessment to meet the needs of students to move on to further education and secure future employment.

**Research Question and Hypotheses**

The researcher cast the question examined in this study as: Is there an identifiable difference between performance assessment scores and cognitive (VoCATS) assessment
scores in the 3D-Modeling unit (Competency B) of the North Carolina state high school Drafting II-Engineering curriculum in Wake County Public School System?

To further investigate that question, the following research hypotheses were proposed:

1. There is no significant difference in means of the student participants’ performance and cognitive (VoCATS) assessment scores in the 3D-modeling unit (Competency B) of the North Carolina state high school Drafting II-Engineering curriculum in the Wake County Public School System.

2. There are no significant differences in means of the student participants’ performance and cognitive (VoCATS) assessment scores in the 3D-modeling unit (Competency B) of the North Carolina state high school Drafting II-Engineering curriculum in the Wake County Public School System between grade levels.

Null Hypotheses

**Null Hypothesis #1.** There is no significant difference in means of the student participants’ performance and cognitive (VoCATS) assessment scores in the 3D-modeling unit (Competency B) of the North Carolina state high school Drafting II-Engineering curriculum in the Wake County Public School System. A paired samples T-test was used to determine if differences existed between the means of the assessments.

**Null Hypothesis #2.** There are no significant differences in means of the student participants’ performance and cognitive (VoCATS) assessment scores in the 3D-modeling
unit (Competency B) of the North Carolina state high school Drafting II-Engineering curriculum in the Wake County Public School System between grade levels. An analysis of variance procedure was used to determine differences in the means of the assessments between grade levels.

**Research Design**

This study was confined to students enrolled in the Drafting II-Engineering course of study in high schools in the Wake County Public School System located in North Carolina and consisted of 92 student participants in grades 9-12. Drafting II-Engineering was the course used in this study because 3D-solid modeling was of interest and is a part of this curriculum. The research design employed in this study used a dependent samples design, using statistics to investigate identifiable differences between the performance and cognitive (VoCATS) assessment scores in the 3D-modeling unit (Competency B) of the North Carolina state Drafting II-Engineering curriculum. The purpose of selecting this design was that the specified subject participants were tested using paired measures and was appropriate to contrast the means of the two dependent samples when the value of the underlying population variance was unknown, and measured against the established critical value of .05 (Agresti & Finlay, 1997).

**Instrumentation**

Since the main subject matter for this study is investigating identifiable differences between cognitive and performance assessments in the North Carolina state high school Drafting II-Engineering curriculum, the state provided assessments included within the
curriculum were used. All CTE assessments were provided by NCDPI in the CMS classroom test bank. All NCDPI cognitive items are aligned with the standard course of study and have undergone a reliability assessment and content validity checks (NCDPI, 2005).

The cognitive (VoCATS) assessment (see Appendix – B) was composed of all 68 multiple choice test items that were provided in the CMS classroom test bank. These align with the objectives set forth for the 3D-modeling unit of the Drafting II-Engineering standard course of study by NCDPI (see Appendix – A). A scanning sheet (see Appendix – B) accompanies the cognitive assessment for more efficient scoring purposes. The scanning sheet is aligned with the correct answers (see Appendix – D) within the CMS test bank so student scores were assigned accurately.

The performance assessment (see Appendix – C) was composed of a 3D-model and was also provided by the CMS test bank. This assessment challenged students to actively demonstrate their understanding of 3D-modeling techniques. The test item was given in the form of a multi-view drawing and required students to construct a 3D-model using the provided constraint based modeling software. The test item was chosen because it is aligned with the objectives set forth for the 3D-modeling unit of the Drafting II-Engineering standard course of study by NCDPI (see Appendix – A) and is part of the curriculum. A standard rubric (see Appendix – C) is provided in the Drafting II-Engineering curriculum to evaluate the 3D-model prescribed. The rubric provided was aligned with the correct answer (see Appendix – D) within the CMS test bank so student scores were assigned accurately.
Target Population

The target population for this study was high school students in Wake County Public School System that enroll in Drafting II-Engineering. This population is of interest to teachers in engineering/technical graphics areas.

Sample

The sample used in this study was 92 high school students in the Wake County Public School System that were enrolled in Drafting II-Engineering for the 2009 spring semester. The 92 student participants consisted of 8 females and 84 males. When broken down by grade level there were 3 freshman, 22 sophomores, 41 juniors, and 26 seniors. The sample was representative of the population because they were enrolled in a high school in Wake County Public School System in a Drafting II-Engineering course and had completed Drafting I as a pre-requisite course. The class rolls for the Drafting II-Engineering Honors section 7972 classes participating in the study were used as the sampling frame.

Procedures

First, an IRB application was submitted to North Carolina State University in order to gain approval for the study. Next, the study topic was discussed with Wake County Public School System professionals. During the traditional school year, high school level career and technical education teachers in the Wake County Public School System meet quarterly with their respective professional learning communities. This venue was utilized to discuss the topic of the study and spur interest among the drafting/aerospace instructors. After gaining IRB approval a survey was handed out to all Drafting II-Engineering course instructors. The
survey inquired about the instructors’ participation interest in serving as test administrators and the approximate student enrollment for the spring semester. All Drafting II-Engineering course instructors volunteered to participate in the study serving as test administrators with a total of 92 student participants. Following the meeting an email was sent to the surveyed instructors to provide further details about the study and to finalize the list of participating instructors.

During the next drafting/aerospace meeting the test materials were provided to the instructors and explained in detail to insure an efficient process. A packet was provided to the participating teachers that included test materials. The test materials included the following items: a) instructions numerically outlining test administration procedures, b) the cognitive (VoCATS) assessment including 68 multiple choice items, c) scanning sheets for students to input their respective answers, c) the performance assessment including a prescribed 3D-model problem, and d) a provided USB flash drive to transport performance assessment data.

This study used existing assessments that all students enrolled in Drafting II-Engineering in North Carolina Public Schools would be administered regardless the presence of this study. However, the testing materials provided to the participating instructors helped ensure proper consistency regarding teacher instruction and test administration. The performance and cognitive (VoCATS) assessments were administered following the completion of the 3D-Modeling unit in the Drafting II-Engineering course curriculum. To ensure that test administration was consistent with all instructors the following test procedures were strongly suggested; 1) Allow no more than 120 minutes for assessments to
be completed, 2) Provide a computer with the county provided constraint-based modeling software to each student, 3) Administer the cognitive (VoCATS) assessment and scan sheets foremost, 4) Administer the performance assessment individually following students completion of the cognitive (VoCATS) assessment, 5) Collect all performance assessment data using the provided USB flash drive, 6) Place USB flash drive with performance assessment data and scanning sheets with cognitive assessment data into the provided manila envelope and mail back to researcher.

During the course of the semester the instructors administered the assessments to the student participants at the culmination of the 3D-Modeling unit (Competency B) of the North Carolina Drafting II-Engineering curriculum. Upon the instructors completing test administration, the testing materials were transferred back to the researcher. Upon receiving the assessment packets from all of the participating instructors, the cognitive and performance data were compiled. The cognitive (VoCATS) assessments were scored by a common scanner and the scores were calculated by state provided CMS software. The performance assessment data was transferred to a North Carolina State University (NCSU) professor to be evaluated using the state provided rubric. This particular professor has worked in industry and is an accomplished Associate Professor at NCSU in the Graphic Communications Program. Additionally, he helped write engineering/technical graphics high school curricula in North Carolina. The professor’s expertise in the field and knowledge of the curriculum provided rationale for him to serve as the evaluator for the performance assessment item. A Methodology Flowchart is provided in Figure 3.1.
Analysis of Data

Data were collected using cognitive and performance testing instruments provided by North Carolina Department of Public Instruction and utilized through their classroom management software. Data were analyzed using an online statistical analysis program. Question 1 was analyzed using a paired samples T-test for a difference in means in the student participants’ performance and cognitive (VoCATS) assessment scores in the 3D-modeling unit (Competency B) of the North Carolina state high school Drafting II-Engineering curriculum. Question 2 was analyzed using a One-Way Analysis of Variance (ANOVA) procedure to analyze data and investigate the differences in means in the student participants’ performance and cognitive (VoCATS) assessment scores in the 3D-modeling
unit (Competency B) of the North Carolina state high school Drafting II-Engineering curriculum between freshman, sophomore, junior, and senior grade levels.

Summary

This chapter has described the methodology used to fulfill the purpose of the study and test the research hypotheses. The study used a dependent samples design to investigate identifiable differences in student scores. The test instrument was the state provided CMS test items for the 3D Modeling unit (Competency B) of the North Carolina state high school Drafting II-Engineering curriculum. The target population for this study was high school students in the Wake County Public School System that enroll in Drafting II-Engineering. The sample was the 92 high school students in the Wake County Public School System that were enrolled in Drafting II-Engineering for the 2009 spring semester. A statistical analysis program was used, employing a paired T-test and ANOVA to analyze data.
CHAPTER 4

PRESENTATION OF DATA

Introduction

In the following chapter, data collected from the study will be presented and analyzed. The results were used to test the null hypotheses presented in Chapter 1 along with a description of the group demographics. The analysis began with a paired samples T-test to investigate the difference in means in the student participants’ performance and cognitive (VoCATS) assessment scores in the 3D-modeling unit (Competency B) of the North Carolina state high school Drafting II-Engineering curriculum. Next, a One-Way Analysis of Variance (ANOVA) procedure was used to investigate the differences in means in the student participants’ performance and cognitive (VoCATS) assessment scores in the 3D-modeling unit (Competency B) of the North Carolina state high school Drafting II-Engineering curriculum between freshman, sophomore, junior, and senior grade levels.

Description of the Participants

The participants in this study were enrolled in Drafting II-Engineering course of study in a North Carolina Public high school in the Wake County Public School System. Drafting II-Engineering introduces students to the use of the graphic tools necessary to communicate, analyze, and understand the ideas and concepts found in the areas of engineering, science, and mathematics. Topics include teaming and communication skills, 3D modeling, manufacturing processes, dimensioning and conventional tolerancing, sectional views, auxiliary views, and pattern development. This course is demanding, requiring the application of complex
visualization and computer skills. These skills are used to assess, communicate, and design virtual and physical models used in science, mathematics, manufacturing, transportation, and structural systems (NCDPI, 2005). The principles learned were applied using a constraint-based modeling program provided by the Wake County Public School System.

The Drafting II-Engineering classes in this research were members of high schools in the Wake County Public School System in North Carolina and were taught in the spring semester of 2009. The assessments administered to the student participants included a section for demographic data where students provided information about age and grade level status. Demographic data are summarized in Table 4.1.

Table 4.1 Demographics of Participants

<table>
<thead>
<tr>
<th>Category</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>8</td>
<td>8.7</td>
</tr>
<tr>
<td>Male</td>
<td>84</td>
<td>91.3</td>
</tr>
<tr>
<td><strong>Class</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freshman</td>
<td>3</td>
<td>3.2</td>
</tr>
<tr>
<td>Sophomore</td>
<td>22</td>
<td>23.9</td>
</tr>
<tr>
<td>Junior</td>
<td>41</td>
<td>44.6</td>
</tr>
<tr>
<td>Senior</td>
<td>26</td>
<td>28.3</td>
</tr>
</tbody>
</table>
The make-up of the participants in this study enrolled in Drafting II-Engineering during the spring semester of 2009 were 8 females and 84 males. These students ranged from 14-19 years old and included 3 freshman, 22 sophomores, 41 juniors, and 26 seniors. There were approximately ten times as many males as females participating in the study. A very low percentage of participants were classified as freshman, likely due to enrollment restriction of Drafting II-Engineering until completion of the pre-requisite Engineering/Technical Graphics I course. A high percentage of participants were classified as juniors and seniors due to the likelihood that engineering/technical graphics instructors often suggest that students complete a geometry course which is traditionally a sophomore level math prior to enrolling in Drafting II-Engineering.

**Analysis of Scores**

The 3D-Modeling unit (Competency B) of Drafting II-Engineering performance and cognitive data was investigated to find identifiable differences in the means. A scatter plot (Figure 4.1) of cognitive (VoCATS) assessment scores and performance assessment scores was constructed to provide a visual representation of the array of student achievement for the 92 Drafting II-Engineering student participants. The scatter plot of the data does not display a clear linear alignment but does reveal clusters of scores and some outliers. The clusters demonstrate that many students scored well on the performance assessment but do not exhibit clear relationships between the assessments. However, the scatter plot does reveal some unusual outliers.
Table 4.2 Summary Statistics

<table>
<thead>
<tr>
<th>Column</th>
<th>n</th>
<th>Mean</th>
<th>Variance</th>
<th>Std. Dev.</th>
<th>Std. Err.</th>
<th>Median</th>
<th>Range</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>VoCATS</td>
<td>92</td>
<td>84.565216</td>
<td>115.76493</td>
<td>10.759411</td>
<td>1.1217462</td>
<td>87.5</td>
<td>51</td>
<td>49</td>
<td>100</td>
</tr>
<tr>
<td>Performance</td>
<td>92</td>
<td>84.934784</td>
<td>422.43527</td>
<td>20.55323</td>
<td>2.1428223</td>
<td>94</td>
<td>85</td>
<td>15</td>
<td>100</td>
</tr>
</tbody>
</table>

The average of the cognitive (VoCATS) assessment scores (84.57 of a possible 100) for the 92 engineering/technical graphics student participants were noticeably similar to the performance assessment scores (84.93 of a possible 100). The variance (115.76) and standard deviation (10.76) of the cognitive (VoCATS) assessment scores is small in comparison to the variance (422.44) and standard deviation (20.56) of performance assessment scores indicating a larger spread of the engineering/technical graphics student participation scores on the performance assessment. The standard error (1.12) of the cognitive (VoCATS) assessment scores is much less than the standard error (2.14) of the performance assessment scores.
scores uncovering a larger variation in score values from participant to participant for the performance assessment. The median and means of the cognitive (VoCATS) assessment exhibit minimal deviance suggesting a rather symmetrical score distribution for this assessment. However, the median for the performance assessment is much higher than the mean suggesting that there are a larger number of high scores for the performance assessment than the cognitive (VoCATS) assessment. The range is calculated based on the minimum and maximum scores on the cognitive (VoCATS) assessment and performance assessment. The minimum score (15) on the performance assessment is much lower than the minimum score (49) of the cognitive assessment (VoCATS) reiterating the unusual outliers. The lower range (51) on the cognitive (VoCATS) assessment in relation to the performance assessment (85) supports the degree of difference in the variability of engineering/technical graphics student participants between the two assessments (refer to Table 4.2).

Figure 4.2 and Figure 4.3 represent the rate of occurrence for VoCATS scores and performance scores for engineering/technical graphics student participants.
Both histograms are skewed to the left indicating an upper limit, in this case a maximum score of 100. A histogram representing a distribution is skewed if one of its tails is extended for the lowest or highest values. This non-symmetric distribution is said to be positively skewed if the histogram has a distinguishable tail in the positive direction and negatively skewed in the negative direction (Agresti & Finlay, 1997). Negative skewness is common in education where students are evaluated after a progression of learning exercises. The performance histogram exhibits a greater skew than the VoCATS histogram due to the four engineering/technical graphics student participant’s scores of 15 of 100. A hypothesis test was conducted given the clear similarities in the means with clear differences in the standard deviations of the engineering/technical graphics participant cognitive (VoCATS) and performance assessments indicated in Table 4.2. A paired samples T-test was used to evaluate **Null Hypothesis #1**: There is no significant difference in means of the student participants’ performance and cognitive (VoCATS) assessment scores in the 3D-modeling unit (Competency B) of the North Carolina state high school Drafting II-Engineering curriculum in the Wake County Public School System. Table 4.3 summarizes the results of the analysis.

<table>
<thead>
<tr>
<th>Difference</th>
<th>Sample Diff.</th>
<th>Std. Err.</th>
<th>DF</th>
<th>T-Stat</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>VoCATS - Performance</td>
<td>-0.36956522</td>
<td>2.235412</td>
<td>91</td>
<td>-0.16532311</td>
<td>0.8691</td>
</tr>
</tbody>
</table>
Based on the analysis of the T-statistic (-0.17) and the proportional value (0.87), we fail to reject **Null Hypothesis #1** providing evidence that there is no significant difference in the means of the student participants’ performance and cognitive (VoCATS) assessment scores in the 3D-modeling unit (Competency B) of the North Carolina state high school Drafting II-Engineering curriculum in the Wake County Public School System.

Dot Plots (see Figures 4.4, 4.5, and 4.6) of the cognitive (VoCATS) assessment scores, performance assessment scores, and difference in assessment scores were constructed to provide a visual representation of the array of student achievement for the 92 engineering/technical graphics student participants divided by freshman, sophomore, junior, and senior grade level status. Figures 4.4, 4.5, and 4.6 reiterate that there are more student participants with junior and senior grade status. Figure 4.4 displays the cognitive (VoCATS) assessment scores divided by grade level status and exhibit similarities in concentrated grouping around the 90 percentile reiterating the negative skewness in Figure 4.2.

![Figure 4.4 VoCATS Dotplot](image)
Figure 4.5 displays the performance assessment scores divided by grade level status and exhibit similarities in concentrated grouping in the upper 90 percentile reiterating negative skewness in Figure 4.3.

Figure 4.6 displays differences in performance and cognitive (VoCATS) assessment scores divided by grade level status and exhibit similarities in concentrated grouping near zero providing some visual evidence that there is little or no difference between the scores of the performance and cognitive (VoCATS) assessments between grade levels.
An additional hypothesis test was conducted based on the differences in the means of Drafting II-Engineering participant performance and cognitive (VoCATS) assessment scores between freshman, sophomore, junior, and senior grade levels. A One-Way Analysis of Variance (ANOVA) procedure was used to calculate the F-statistic to evaluate Null Hypothesis #2: There are no significant differences in means of the student participants’ performance and cognitive (VoCATS) assessment scores in the 3D-modeling unit (Competency B) of the North Carolina state high school Drafting II-Engineering curriculum in the Wake County Public School System between grade levels. To assist in explanation, Tables 4.4, 4.5, and 4.6 are utilized to investigate identifiable differences in means of cognitive (VoCATS) assessment scores, performance assessment scores, and difference of assessment scores between grade levels.
<table>
<thead>
<tr>
<th>Grade</th>
<th>n</th>
<th>Mean</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshman</td>
<td>3</td>
<td>82.333336</td>
<td>7.2188025</td>
</tr>
<tr>
<td>Sophomores</td>
<td>22</td>
<td>89.454544</td>
<td>1.9942855</td>
</tr>
<tr>
<td>Juniors</td>
<td>41</td>
<td>84.268295</td>
<td>1.6853112</td>
</tr>
<tr>
<td>Seniors</td>
<td>26</td>
<td>81.15385</td>
<td>2.1047144</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source</th>
<th>F-Stat</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatments</td>
<td>2.5648289</td>
<td>0.0597</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Grade</th>
<th>n</th>
<th>Mean</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshman</td>
<td>3</td>
<td>82.666664</td>
<td>6.960204</td>
</tr>
<tr>
<td>Sophomores</td>
<td>22</td>
<td>82.72727</td>
<td>5.739731</td>
</tr>
<tr>
<td>Juniors</td>
<td>41</td>
<td>84.12195</td>
<td>2.886722</td>
</tr>
<tr>
<td>Seniors</td>
<td>26</td>
<td>88.34615</td>
<td>3.6819487</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source</th>
<th>F-Stat</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatments</td>
<td>0.3492449</td>
<td>0.7898</td>
</tr>
</tbody>
</table>
Table 4.6 Analysis of Variance results (Differences)

<table>
<thead>
<tr>
<th>Grade</th>
<th>n</th>
<th>Mean</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshman</td>
<td>3</td>
<td>0.33333334</td>
<td>3.8441875</td>
</tr>
<tr>
<td>Sophomores</td>
<td>22</td>
<td>-6.7272725</td>
<td>5.839551</td>
</tr>
<tr>
<td>Juniors</td>
<td>41</td>
<td>-0.14634146</td>
<td>2.8153675</td>
</tr>
<tr>
<td>Seniors</td>
<td>26</td>
<td>7.1923075</td>
<td>4.0504584</td>
</tr>
</tbody>
</table>

ANOVA Table

<table>
<thead>
<tr>
<th>Source</th>
<th>F-Stat</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatments</td>
<td>1.729463</td>
<td>0.1668</td>
</tr>
</tbody>
</table>

Table 4.4 investigates identifiable differences in the means of the cognitive (VoCATS) assessment scores between grade levels. Although, the mean of sophomore participant scores (89.45) is significantly higher than the means of freshman, junior, and senior grade level participants, the proportional value (0.06) is greater than the established critical value (.05) providing evidence that there are no significant differences in the means of the cognitive (VoCATS) assessment between grade levels.

Table 4.5 investigates identifiable differences in the means of the performance assessment scores between grade levels. Although, the mean of senior participant scores (88.35) is significantly higher than the means of freshman, sophomore, and junior grade level participants, the proportional value (0.79) is greater than the established critical value (.05).
providing evidence that there are no significant differences in the means of the performance assessment between grade levels.

Table 4.6 investigates identifiable differences in the means of the differences of assessment scores between grade levels. Based on the analysis of the F-statistic (1.73) and proportional value (0.17), we fail to reject **Null Hypothesis #2** providing evidence that there are no differences between the means of the Drafting II-Engineering student participants’ performance assessment scores and cognitive (VoCATS) assessment scores between grade levels.

The researcher chose not to investigate identifiable differences in means between performance assessment and cognitive (VoCATS) assessment scores in Drafting II-Engineering between genders due to the low numbers of female participants (8) making up only 8.7 percent.

**Summary**

This chapter has presented the demographic data on the participants and has tested the research hypotheses. To analyze data, a paired samples T-test and ANOVA were used. A paired samples T-test were used to evaluate **Null Hypothesis #1**: There is no significant difference in means of the student participants’ performance and cognitive (VoCATS) assessment scores in the 3D-modeling unit (Competency B) of the North Carolina state high school Drafting II-Engineering curriculum in the Wake County Public School System. Based on the analysis of the T-statistic and the proportional value, there was no
significant difference in the means of the student participants’ performance and cognitive (VoCATS) assessment scores. An ANOVA was used to evaluate \textbf{Null Hypothesis #2}: There are no significant differences in means of the student participants’ performance and cognitive (VoCATS) assessment scores in the 3D-modeling unit (Competency B) of the North Carolina state high school Drafting II-Engineering curriculum in the Wake County Public School System between grade levels. Based on the analysis of the F-statistic and proportional value, there were no differences between the means the participants’ performance assessment scores and cognitive (VoCATS) assessment scores between grade levels.
CHAPTER 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Introduction

Improvement of assessment practice in education is commonly discussed among practitioners as an area where further research is required to add to the transformation of educational practice and instruction (Firestone & Schorr, 2004). The problem with current assessment practice is that too frequently only standardized cognitive assessments are used to gauge student competency and ability. This often encourages narrow, instrumental approaches to learning that emphasizes the reproduction of what is presented, at the expense of critical thinking, deep understanding, and independent activity (Boud, 1990). Performance assessment can be used as an alternative to or paired with existing standardized cognitive assessment to measure a student’s range of skills and knowledge in a content area.

Although engineering/technical graphics instructors use standardized cognitive assessments for end of course testing, students are often evaluated using performance assessments. This may allow students the opportunity to learn through a more active process involving a students’ construction rather than a selection of responses.

The purpose of this study was to provide further investigation of the need of skill-based assessments in engineering/technical graphics courses to possibly increase accuracy in evaluating student’s factual and conceptual knowledge to be successfully prepared for the workplace. Additionally, both cognitive and performance assessments should be held as
equally important measures of student outcome when considering curricular revisions and additions as well as assessment procedures (Ernst, 2008).

Statement of the Problem

Engineering/technical graphics courses in North Carolina public high schools possess performance components that are fundamental in the measurement of skill-based technical proficiencies; however, our current school accountability measurement system leans heavily in favor of standardized cognitive assessment. By utilizing both cognitive and performance assessments, student learning can be enhanced and true competence and ability can be more accurately gauged.

The purpose of this study was to investigate identifiable differences of cognitive and performance assessments in engineering/technical graphics areas. The sample was confined to students enrolled in the Drafting II-Engineering course of study high schools in Wake County Public School System located in North Carolina and consisted of 92 student participants in grades 9-12. The research design employed in this study used a dependent samples design, using statistics to investigate identifiable differences between the performance and cognitive (VoCATS) assessment scores in the 3D-modeling unit (Competency B) of the North Carolina state Drafting II-Engineering curriculum.

Research Question and Hypotheses

The researcher cast the question examined in this study as: Is there an identifiable difference between performance assessment scores and cognitive (VoCATS) assessment
scores in the 3D-Modeling unit (Competency B) of the North Carolina state high school Drafting II-Engineering curriculum in Wake County Public School System?

To further investigate that question, the following research hypotheses were proposed:

1. There is no significant difference in means of the student participants’ performance and cognitive (VoCATS) assessment scores in the 3D-modeling unit (Competency B) of the North Carolina state high school Drafting II-Engineering curriculum in the Wake County Public School System.

2. There are no significant differences in means of the student participants’ performance and cognitive (VoCATS) assessment scores in the 3D-modeling unit (Competency B) of the North Carolina state high school Drafting II-Engineering curriculum in the Wake County Public School System between grade levels.

Hypothesis #1 was evaluated using a paired samples T-test for a difference in means in the student participants’ performance and cognitive (VoCATS) assessment scores in the 3D-modeling unit (Competency B) of the North Carolina state high school Drafting II-Engineering curriculum. Hypothesis #2 was evaluated using a One-Way Analysis of Variance (ANOVA) procedure was used to analyze data and investigate the differences in means in the student participants’ performance and cognitive (VoCATS) assessment scores in the 3D-modeling unit (Competency B) of the North Carolina state high school Drafting II-Engineering curriculum between freshman, sophomore, junior, and senior grade levels.
Procedures

First, an IRB application was submitted to North Carolina State University in order to gain approval for the study. Next, the study topic was discussed with the Wake County Public School System professionals. During the discussion a survey inquired about the instructor’s participation interest. All course volunteered to participate in the study serving as test administrators. During the next drafting/aerospace meeting the test materials were provided to the instructors and explained in detail to insure an efficient process. The performance and cognitive (VoCATS) assessments were administered following the completion of the 3D-Modeling unit in the Drafting II-Engineering course curriculum. Upon the instructors completing test administration the testing materials were transferred back to the researcher. Upon receiving the assessment packets from all of the participating instructors, the cognitive and performance data were compiled. The cognitive (VoCATS) assessments were scored by a common scanner and the performance assessment data was transferred to a North Carolina State University (NCSU) professor to be evaluated using the state provided rubric.

Demographic Data on the Participants

The choice of this population was made for practical considerations that involved the interest of the curriculum, availability and willingness of teacher participants, and existing requirement of students to be administered the assessments in the Drafting II-Engineering curriculum.
The final make-up of the student participants in this study enrolled in Drafting II-Engineering during the spring semester of 2009 were 8 females and 84 males. These students ranged from 14-19 years old and included 3 freshman, 22 sophomores, 41 juniors, and 26 seniors.

There were approximately ten times as many males (8.7%) as females (91.3%) participating in the study. This is probably due to the fact that engineering/technical graphics courses (from which the sample was drawn) attract considerably more male students than female students. A very low percentage of participants (3.2%) were classified as freshman, likely due to enrollment restriction of Drafting II-Engineering until completion of the pre-requisite Engineering/Technical Graphics I course. A high percentage of participants (72.9%) were classified as juniors and seniors due to the likelihood that engineering/technical graphics instructors often suggest that students complete a geometry course which is traditionally a sophomore level math prior to enrolling in Drafting II-Engineering.

Analysis

Hypothesis #1 – There is no significant difference in means of the student participants’ performance and cognitive (VoCATS) assessment scores in the 3D-modeling unit (Competency B) of the North Carolina state high school Drafting II-Engineering curriculum in the Wake County Public School System. It was hypothesized that there would be no significant difference in the means of student participants’ performance and cognitive (VoCATS) assessment scores in the 3D-modeling unit (Competency B) of the North Carolina state high school Drafting II-Engineering curriculum. Analysis using a paired samples T-test
between the cognitive (VoCATS) and performance assessments indicated there was no significant difference between the cognitive (VoCATS) and performance assessments (t=-0.17, p=0.87). The failure to reject the null hypothesis indicated there was no significant difference between the participants’ scores on the cognitive (VoCATS) assessment and performance assessment in the 3D-modeling unit (Competency B) of the North Carolina state high school Drafting II-Engineering curriculum. The findings support the null hypothesis.

Hypothesis #2 – There are no significant differences in means of the student participants’ performance and cognitive (VoCATS) assessment scores in the 3D-modeling unit (Competency B) of the North Carolina state high school Drafting II-Engineering curriculum between grade levels. It was hypothesized that there would be no significant difference in the means of student participants’ performance and cognitive (VoCATS) assessment scores in the 3D-modeling unit (Competency B) of the North Carolina state high school Drafting II-Engineering curriculum between grade levels. Analysis using a One-Way Analysis of Variance (ANOVA) procedure investigates identifiable differences in the means of the differences of assessment scores between grade levels indicated there was no differences between assessment scores between grade levels (f=1.73, p=0.17). The failure to reject the null hypothesis indicated there were no significant difference between the participants’ scores on the cognitive (VoCATS) assessment and performance assessment in the 3D-modeling unit (Competency B) of the North Carolina state high school Drafting II-Engineering curriculum between grade levels. The findings support the null hypothesis.
Conclusions and Discussion

Based on the results of this study, the following explanations could be made. First, although each assessment construct is different, the data suggests that students’ access of their content knowledge is consistent in performance and cognitive (VoCATS) assessments in engineering/technical graphics. Second, students in freshman, sophomore, junior, and senior grade levels form skill-based knowledge in a consistent manner during instruction. Additionally, the data suggests that students in all high school grade levels access their content knowledge consistently in performance and cognitive (VoCATS) assessments.

Performance assessment is a requirement for most skill-based courses in Career & Technical Education to properly gauge student competence and ability. This type of assessment often allows students the opportunity to learn through a more active process involving a students’ construction rather than a selection of responses. Learning in this fashion can be explained with the constructivist learning theory which in turn is often connected to performance assessment. By utilized this learning theory teachers in CTE are offered with instructional approaches that allow them to design instruction that goes beyond rote learning to meaningful, deeper long lasting understanding. In addition to being connected to the constructivist learning theory, skill-based courses in CTE that utilize performance assessment commonly attract kinesthetic learners. Students associated with this predominant type of learning style learn by students actually carrying out the physical activity and benefit from performance assessment because it caters to their strengths.
When compared to a similar study conducted by Ernst (2008) it was found that the results had no similarities. Both studies used similar content areas, methodologies, and employed similar hypotheses suggesting that there were no significant differences between performance and cognitive assessments. When Ernst (2008) conducted his study, the null hypothesis was rejected finding significant differences between assessments with a much lower mean of the cognitive assessment scores than the performance assessment. There also appeared to be more variance of cognitive assessment scores than performance assessment scores. In addition, the data provided evidence that the cognitive and performance assessment tend to increase or decrease together. This particular study resulted in an opposite finding. When evaluated the null hypothesis failed to be rejected resulting in no significant differences in the mean between the scores of the assessments with almost identical means. There also appeared to be more variance of performance assessment scores then cognitive assessment scores.

Some distinctions in the studies can help explain these conflicts. First, this study used assessment items from a singular unit as opposed to the other which used an entire curriculum. This could affect the results because the knowledge of an entire curriculum requires the proficiency of a larger amount of skills. Second, although the content area is similar, the study conducted by Ernst (2008) targeted an introductory engineering/technical graphics course as opposed to an honors second level course. The introductory course focuses on manual drafting skills and 2D CAD versus the Drafting II-Engineering course of study which requires a higher level of computer skills and the understanding of 3D-solid
modeling. Third, this study’s sample can only be generalized to Wake County, not the entire state of North Carolina. This could affect the results because of the amount of resources, quality of instruction, and demographical differences.

Although, there is much dissimilarity, both studies possess similar elements regarding performance assessment that can further add to the knowledge base. Research in assessment practice has spurred the developments of many types of common assessment procedures. Although numerous assessments are proved reliable through repeated application they must be constantly revisited. As a result of revisiting assessment practices, cognitive or performance, student competence and ability can be more accurately gauged.

**Recommendations for Further Research**

This study investigated identifiable differences between the performance and cognitive (VoCATS) assessment scores in the 3D-modeling unit (Competency B) of the North Carolina state high school Drafting II-Engineering curriculum. Although this particular study displayed no significant differences between the two types of assessments, they do possess similar elements useful in gauging student competence and ability. The conclusions reached by the researcher suggest several areas of further research.

1. A larger sample that includes more females should be examined to investigate identifiable gender differences.
2. The study needs to be replicated including a population that can be generalized to the state of North Carolina.
3. The study needs to be replicated to include the entire Drafting II-Engineering curriculum in high schools in the state of North Carolina.

4. The study needs to be replicated to include other Career & Technical Education courses.

5. Have teachers evaluate 3D solid models to observe teacher consistency versus evaluation by an expert or panel of experts.

6. Utilize a common teacher created performance assessment as a treatment in addition to the state provided assessment instruments to measures a larger variety of 3D solid modeling skills.

7. Create a longitudinal study that tracks a sample of students through multiple levels of engineering/technical graphics courses to see how performance assessment scores change from one level to another.

Future research like this can open the possibility of modifying assessment practice given the need for varied assessment for individual and school accountability. More research in engineering/technical graphics areas and other areas in Career & Technical Education is necessary to further develop and implement performance-based assessments that require students to exhibit both skills and knowledge.
REFERENCES


Gordan, R. H. D., Yocke, R. J., Madonado, C., & Saddler, S. J. (2007). Selected career and technical education teachers’ perceptions of the No Child Left Behind Act (Public


APPENDIX – A

EXPLANATION OF OBJECTIVES FOR THE ASSESSMENTS
EXPLANATION OF OBJECTIVES FOR THE ASSESSMENTS

Course: 7973 Drafting II: Engineering

Cognitive Assessment Objectives

1. Explain techniques for creating 3D geometry.

2. Explain techniques for modifying and duplicating 3D geometry.

More specifically these test items will assess students’ knowledge on extruding and revolving a profile, making linear cuts to remove material, creating new construction planes or work planes, lofting, sweeping, shelling, creating a helix or coil, fillets, chamfers, patterns and arrays, and mirroring.

Performance Assessment Objective

1. Construct a 3D-Model.

This test item will assess students’ understanding of the CAD software, 3D modeling construction technique, and more specifically loft creation, circular patterns, fillets, and chamfers.
APPENDIX – B

COGNITIVE ASSESSMENT MATERIALS:
   i) SAMPLE OF COGNITIVE ASSESSMENT (CA) ITEMS
   ii) SCANNING SHEET
i) SAMPLE OF COGNITIVE ASSESSMENT ITEMS

3D-MODELING UNIT TEST

Directions for Numbers 1-68. Read each of the following multiple-choice items and the possible answers carefully. Mark the letter of the correct answer on your answer sheet or as instructed by your teacher.

1. The most efficient way to create the features in Step 2 is to use a:
   - A) Circular pattern or array.
   - B) Cut/subtract command.
   - C) Linear pattern or array.
   - D) Mirror command.

2. When a helix or coil is used to produce threads, the helix or coil should be specified by height and:
   - A) Depth.
   - B) Length.
   - C) Pitch.
   - D) Taper.

3. The most efficient way to create the features in Step 2 is to use a(n):
   - A) Circular pattern or array.
   - B) Extrude command.
   - C) Linear pattern or array.
   - D) Mirror command.

4. An efficient way to model the object below is to use:
   - A) Four mirror commands.
   - B) Repeated extrude and cut/subtract commands.
   - C) Two circular patterns or arrays.
   - D) Two linear patterns or arrays.
ii) SCANNING SHEET
APPENDIX – C

PERFORMANCE ASSESSMENT MATERIALS

iii) PERFORMANCE ASSESSMENT (PA)
iv) PERFORMANCE ASSESSMENT RUBRIC
iii) PERFORMANCE ASSESSMENT

### 3D Modeling

**Requirements:** Each student is required to construct a 3D solid model of the BEARING. The part must include a loft, a circular pattern (polar array), a fillet, and a chamfer.

1. Using an appropriate 3D solid modeling program, create a solid model of the BEARING that includes a loft, a circular pattern (polar array), a fillet, and a chamfer.
2. Add your name, problem number (D402.03.001), and date in the file.
3. Time Limit = 90 minutes.

4. Your work will be evaluated on accuracy of the geometry, the correctness of the loft, circular pattern, fillet and chamfer, and the text added to the file.

**Assessment:** The problem will be evaluated based on the following criteria:

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Point Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy of geometry</td>
<td>50 points</td>
</tr>
<tr>
<td>Loft created correctly</td>
<td>20 points</td>
</tr>
<tr>
<td>Circular pattern (polar array) of holes created correctly</td>
<td>15 points</td>
</tr>
<tr>
<td>Fillet and chamfer created correctly</td>
<td>10 points</td>
</tr>
<tr>
<td>Name and file information</td>
<td>5 points</td>
</tr>
<tr>
<td><strong>TOTAL:</strong></td>
<td><strong>100 points</strong></td>
</tr>
</tbody>
</table>
iv) PERFORMANCE ASSESSMENT RUBRIC

**Rubric for 3D Modeling – Construct a 3D Solid Model – 402.03.001**

### Accuracy of geometry

<table>
<thead>
<tr>
<th>Construction circles and lines are not accurate. Construction geometry is not created on appropriate planes. Modeling procedure is inefficient.</th>
<th>Most construction geometry was created accurately.</th>
<th>All construction circles and lines are created accurately on the correct construction planes. An efficient modeling procedure was used.</th>
<th>Total Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-35 points</td>
<td>36-45 points</td>
<td>46-50 points</td>
<td></td>
</tr>
</tbody>
</table>

### Loft created correctly

<table>
<thead>
<tr>
<th>Loft was not used to construct the tapered cylinder.</th>
<th>Construction planes for the loft feature are not in the appropriate place.</th>
<th>Loft feature is correctly used to create the tapered cylinder. Construction planes are correctly placed to create the loft.</th>
<th>Total Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-14 points</td>
<td>15-18 points</td>
<td>19-20 points</td>
<td></td>
</tr>
</tbody>
</table>

### Circular pattern of holes created correctly

<table>
<thead>
<tr>
<th>Circular pattern was not used to create the holes in the BEARING.</th>
<th>Circular pattern was used to create the holes in the BEARING, but with one error.</th>
<th>After constructing one hole, circular pattern was correctly used to create the other 3 holes.</th>
<th>Total Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10 points</td>
<td>11-13 points</td>
<td>14-15 points</td>
<td></td>
</tr>
</tbody>
</table>

### Fillet and chamfer created correctly

<table>
<thead>
<tr>
<th>Fillet and/or chamfer not added.</th>
<th>Size of fillet and/or chamfer is incorrect.</th>
<th>Fillet and chamfer correctly added to the part.</th>
<th>Total Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-7 points</td>
<td>8-9 points</td>
<td>10 points</td>
<td></td>
</tr>
</tbody>
</table>

### Name and file information

<table>
<thead>
<tr>
<th>No name or assignment information present.</th>
<th>Name or assignment information missing.</th>
<th>File saved properly. Name and assignment information attached to file properly.</th>
<th>Total Points</th>
</tr>
</thead>
<tbody>
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82
APPENDIX – D

ASSESSMENT SOLUTIONS

v) CA SOLUTIONS

vi) PA SOLUTION – (overview)
### 3D-MODELING UNIT TEST

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vi) **PA SOLUTION** – (overview)

**CRITERIA**

**Accuracy** – **50 points** (dimensions in 3D-model should reflect image below)

---

**Loft created correctly** – **20 points** (highlighted parts of the image accurately reflect the loft)
Circular pattern (polar array) of holes created correctly – 15 points (highlighted parts of the image accurately reflect the circular pattern) A – seed  B – circular pattern

Fillet and chamfer created correctly – 10 points (highlighted parts of the image accurately reflect the fillet and chamfer)