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THE IMPACT OF LEARNING ENVIRONMENT ON STUDENT SUCCESS IN DEVELOPMENTAL MATH

By

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DISSERTATION APPROVAL FORM

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ABSTRACT

THE IMPACT OF LEARNING ENVIRONMENT ON STUDENT SUCCESS IN DEVELOPMENTAL MATH

Jean Ashby

Increasing enrollments in community colleges has led to an increase in distance education courses. The developmental coursework necessary for many community college students is being offered both in online and hybrid environments. These students face challenges with the content and now find themselves needing to learn in a virtual classroom. Current research (Chernish, DeFranco, Lindner, & Dooley, 2005; Frederickson, Reed, & Clifford, 2005; Herman & Banister, 2007; Kromrey & Purdom, 1995; Scheetz & Guntner, 2004) shows that there is no difference in student success based on the learning environment, but this was completed primarily with upper-class and graduate students. This study investigated student success in a developmental math course taught in the face-to-face, hybrid, and online environments at a mid-Atlantic community college. Cognitive Load Theory was used during the design of the course and its principles were maintained in all of the learning environments. The sample was 167 students with an average age of 25 years, 58% were female, 49% were Caucasian and 43% were African-American.

The focus was on student success, but the impact attrition had on the results of the study is discussed. The study also investigated student characteristics and their relationship to success. Age, gender, race, student status, placement scores, financial aid, learning style, locus of control, and technology skills are all compared between successful and unsuccessful students to determine if specific traits were more beneficial within a particular environment.

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CHAPTER I. INTRODUCTION

Institutions of Higher Education are seeing continual increases in enrollment. During the 1990s, institutions of higher education saw a growth of 9%, while community colleges specifically experienced 14% growth (ACE, 2004). During the current decade (1999 – 2009), community colleges are projected to have an even more significant increase (22%) in enrollment growth (NCES – Participation in Education, 2008). With the current downfall in the economy, many community colleges have seen 10 – 20% increases in enrollment between Fall 2008 and Fall 2009 (Hoover & Wilson, 2009). Community colleges are increasing their enrollment faster than four-year universities, thereby increasing the percentage of all undergraduates (two-year and four-year institutions) from 41% (ACE, 2004) to 46% (AACC, 2008).

With their open-door admissions, community colleges serve a population with diverse needs and a wide range of skills. In order to prepare this diverse population for college-level courses, community colleges offer non-credit courses in math, reading, and writing. 79% of students entering community colleges will need these remedial courses (Jenkins & Boswell, 2002). In the three years from Fall 1995 to 1998, the percentage of students enrolled in at least one remedial course went from 29% (Phipps, 1998) to 36% (Shults, 2001). When enrolled in only one remedial course, it is more likely to be math than reading or writing (Phipps, 1998). The number of students needing developmental coursework continues to grow while the research on their success rates is very limited (Barnett, 2008; Esch, 2009).

In addition to the growth in higher education over the past decade, there has been a growth in online learning across all of academia. In one year (2005 – 2006), enrollment in higher education increased 1.5% while enrollment in online courses increased 9.7% (Allen & Seaman, 2007). Students that were taking face-to-face courses are moving to the online environment. According to a study on online enrollments sponsored by The Sloan Consortium (2007), community colleges have the highest growth rate in online learning and account for over 54% of all online enrollments in higher education (Allen & Seaman, 2007).

The growth in higher education enrollment and in online course offerings complements each other. In order to meet the demand for remedial courses, community colleges and universities are looking to alternative learning environments. Many of the publishers of books for developmental courses are offering commercial online courseware to accompany their textbooks (Olsen, 2000). Community colleges are increasing the number of developmental classes that are already offered online or are creating online versions of the traditional face-to-face developmental classes (Caldera, 2009).

The increase in community college enrollment, specifically in developmental and online courses, points to a need for research to be completed with this population. Two-year institutions represent almost half of all undergraduates, more than two thirds of all developmental students (Parsad, Lewis, & Greene, 2003), and over half of all online students; and yet, this population is not well represented in the educational research (Allen & Seaman, 2007; Caldera, 2009).

This research studied the developmental student population at a mid-Atlantic community college. Three different learning environments (traditional, hybrid, and online) used to teach a developmental math course were studied. The research was designed to determine if the learning environment had an impact on student success; more specifically if the student success rate in the course was the same regardless of the learning environment. This chapter is composed of the following sections: Background, Statement of the Problem, Purpose of Research, Significance, Research Design, Research Questions, Limitations, Researcher's Personal Statement, and Definition of Terms.

Background

In the State of Maryland, higher education institutions have agreed on the skills necessary to enroll in college-level math courses. There are three levels of skills: basic college math, introductory algebra, and intermediate algebra. The last course in the developmental math sequence is Intermediate Algebra and after its successful completion, a student is eligible to enroll in college-level math courses at any state institution. Maryland is the only state that requires students to complete remedial courses before taking college-level courses (Jenkins & Boswell, 2002).

With the increasing number of students needing developmental math courses and the finite physical classroom space, distance education has become a popular alternative environment for administrators to offer the necessary courses. While it is a worthwhile endeavor to offer developmental students alternatives, the question needs to be investigated if these students can be as successful in these alternate environments as they can be in a traditional face-to-face learning environment.

Developmental students have already struggled with the content and need to be given the best chance at success. Identifying the impact the learning environment has on the potential for student success is critical. Research has been conducted on different learning environments. Some focused on Interactive Television (ITV) classes in comparison to face-to-face classes (Hodge-Hardin, 1997), to online classes (Mash, Marais, VanderWalt, VandeVenter, Steyn, & Labradarios, 2006), and to both face-to-face and online (Chernish, DeFranco, Lindner, & Dooley, 2005). Other studies have focused on success of students in online versus face-to-face courses (Dutton, Dutton, & Perry, 2002; Frederickson, Reed, & Clifford, 2005; Herman & Banister, 2007; Neuhauser, 2002; Scheetz & Gunter, 2004). Still others have investigated hybrid versus face-to-face courses (Kromrey & Purdom, 1995; Sauers & Walker, 2004). Most of these studies involved a comparison of only two learning environments (Dutton et al., 2002; Frederickson et al., 2005; Herman & Banister, 2007; Hodge-Hardin, 1997; Kromrey & Purdom, 1995; Mash et al., 2006; Neuhauser, 2002; Sauers & Walker, 2004; Scheetz & Gunter, 2004). In all the studies, the common result was no significant difference in student success between the different learning environments.

The limitations of the present body of research include the types of learning environments, the population, and the institution studied. The only study that researched three learning environments included the ITV classes instead of hybrid courses (Chernish et al, 2005). The populations were typically upper-class and graduate students at four year universities and colleges (Chernish et al, 2005; Dutton et al., 2002; Frederickson et al, 2005; Herman & Banister, 2007; Hughes & Hagie, 2005; Kromrey & Purdom, 1995; Mash et al, 2006; Sauers & Walker, 2004; Scheetz & Gunter, 2004). There were two studies that involved developmental students; one involved developmental math students at a four year university (Hodge-Hardin, 1997) and another studied developmental writing students at a Midwestern community college (Carpenter, Brown, & Hickman, 2004). Considering they represent more than half of all online enrollments at higher education institutions community colleges are underrepresented in the research (Allen & Seaman, 2007).

Studies have explored other areas of community colleges. Research has determined attendance, retention, and success rates across a statewide community college system with the success rate (29 – 64%) being the lowest factor (Waycaster, 2001). Race is also a commonly researched topic in community colleges, especially in the developmental population where the African-American students are almost twice as likely to be enrolled in developmental math as their Caucasian counterparts (Grimes, 1997) and community colleges overall have a much more ethnic diversity (Sullivan, 2001). This research helps to identify trends in community colleges, but does not investigate what may change the success rates of the developmental population.

The present research on learning environments minimizes the role community colleges have in undergraduate education. The results of the studies that do involve community colleges emphasize the differences between them and the four-year colleges and universities. The demographics, student perseverance, family responsibilities, and pre-requisite skill level at the community college does not compare to upper-class and graduate students. With the clear distinctions in the populations, the present research on learning environments cannot be applied to developmental students.

Statement of the Problem

Community college enrollments are growing more than any other area of higher education. As the overall enrollments surge, the number of students who are required to take developmental math courses is also increasing. With no physical space to hold more classes, offering developmental classes in online and hybrid formats is the only way to meet the growth. Presently no research looks at whether these students can be successful in online learning environments. Taking such a course in online or hybrid environments may produce a greater difficulty for developmental students that were already challenged by the content. Evidence needs to be provided to ensure that the learning environment does not have a negative impact on success.

Purpose of Research

The purpose of this research is to determine if there is a difference in student success when a developmental math course is delivered in an alternative environment, such as online and hybrid. As the shift to different learning environments continues, it would be beneficial to have evidence that the change is not detrimental to developmental students. Without this research, developmental math student success rates could worsen, lengthening the time needed to complete a degree and increasing attrition.

Significance

This research will help determine if the developmental population at community colleges can be successful in online and hybrid learning environments. The collection and analysis of data regarding internal and external characteristics of this population enrolled in the different learning environments will help determine if certain characteristics are more beneficial than others. The results of this will help to guide administrative decisions regarding how developmental courses should be offered. The results will also help in advising students as to which learning environment is most appropriate for their specific characteristics. While the results may lead to a conclusion that all learning environments do not have the same success rate, a specific subset of the population may find success, making the offering of the different learning environments still feasible.

Research Design

This research study used quantitative methodologies and a sample of convenience. There were 251 community college students enrolled across eleven sections (five online, three hybrid, and three face-to-face) of Intermediate Algebra, a developmental math course; of which 167 participated in this study. The students self-selected into the learning environment of the course, but all met the pre-requisites for Intermediate Algebra. Students were asked to complete three surveys during the first few weeks of the semester: the Visual, Auditory, Reading/Writing, and Kinesthetic (VARK) learning styles inventory, the Technology and Internet Assessment (TIA), and Rotter's Locus of Control (RLC). The VARK identified the student's preference for learning, including if they had more than one preferred learning style. The TIA was used to determine differences in technology skills among the different delivery methods. A student's locus of control identifies if a student accepts responsibility for the good and bad outcomes in his or her life, or if instead blames others for their situation. Students were also asked if they received any type of financial aid for their college courses.

Students that chose to participate in this study were informed that additional data (age, gender, course load, courses completed, placement scores, previous math courses) would be collected from the institution. This data, as well as attendance, test scores, final exam grades, and course grades from the Intermediate Algebra course, were used to determine differences and similarities among the learning environments.

Institutional Review Board approval was granted by both Towson University and the Community College of Baltimore County. Towson University's Institutional Review Board (IRB) for Research Involving the Use of Human Participants was approved under

Exemption Number 09-1X20 on February 24, 2009 (Appendix A). The Community College of Baltimore County approved the study on February 27, 2009 (Appendix B).

Research Questions

In order to determine student success in the different learning environments as well as any traits associated with the successful student, the research was guided by the following questions:

1) Are three different learning environments (face-to-face, hybrid, fully online) equally effective as measured by course grades?
2) Which external characteristics (e.g. gender, age, ethnicity) are significant in determining student success in each of the three learning environments?
3) Which internal characteristics (e.g. learning style, motivation) are significant in determining student success in each of the three learning environments?

Limitations and Assumptions

This research was conducted in an attempt to control as many factors as possible. The intent was to use the same syllabus, textbook, assignments, activities, lessons, tests, and final exam across all the learning environments. This study acknowledges the following limitations:

- With multiple Intermediate Algebra courses being offered, students registered for a specific one based on a variety of factors. Students self-selected the learning environment in the majority of the classes, but in some instances enrollment was based on availability and not because they wanted the specific learning environment. The reasons a student chose a particular learning environment may lead to differences within the group samples. Student’s prior success or preconceptions about the different learning environments may have influenced their decision during registering for class.

- Due to the need for a specific population and the ability for consistency across the different learning environments, the research used a sample of convenience so results may not be generalizable beyond this sample.
- In order to increase the sample size, more Intermediate Algebra classes were accessed through the use of two instructors. Every effort was made to standardize the material as well as the presentation style, but with two instructors there are inherent differences. The research attempted to control for as much as possible.

Researcher's Personal Statement

The researcher for this study also served as an instructor for five of the eleven sections. Thus, the implementation of the instructional unit and the interpretation of the results of this study were subject to my perceptions, biases, beliefs, and experiences. In order to assist the reader in determining any impact my role as researcher participant may have, the following statement is provided; a statement by the instructor of the remaining classes is included in Appendix C.

First and foremost my experience has led me to believe that many students enrolled in this course struggle with and have a dislike of math. Many of the students have traditionally had bad experiences with math. This course is required (based on their placement level) but it is not connected to the student's major or interests. However, I am a firm believer that all students can be successful provided the right set of circumstances. In all my math classes, I strive to provide a safe environment where students are able to ask questions and seek answers without repercussions from classmates. In most cases, I find the students that are willing to seek help and ask questions comprehend the topics better and do well overall in the course.

I have been teaching math for over fifteen years. I began to teach online courses more than six years ago and hybrid courses about three years ago. In the beginning, I was concerned with the success of online developmental students. It seems that in recent years the online students truly choose that learning environment for various reasons and can find success in the course. The hybrid class, however, still seems to have a majority of students that were looking for an open section, not realizing that it was not a traditional class; these students did not select the learning environment and therefore sometimes struggle with learning the course structure and the course content.

Summary

Community colleges are experiencing enrollment surges at the same time that online and hybrid learning environments are beginning to become more popular. The growth in these two areas is linked. Due to increasing enrollments in finite physical class space, more courses are being offered through different learning environments. Distance education courses have been shown to be just as successful for students as face-to-face courses. However, the previous research has been completed with upper-class and graduate students within courses required for their major. The research has not been conducted with developmental math students.

This research will help determine if the developmental population can also be successful in the distance learning environment. These students deserve the best chance at success and this research will help identify if that is in online or hybrid learning environments.

Definition of Terms

In order to use terms that are prevalent in society today within this research, definitions have been provided. These definitions will offer a clear understanding of how these terms are used throughout the research. Some of the terms used within the specific discipline and population of this study have also been provided to clarify terms that may seem foreign to those outside the developmental math department.

Developmental Math – The non-credit courses offered at the college level to bring the skills of the student to the college level math course.

Developmental Student – A student that places into at least one developmental course. There are developmental courses offered in Math, Reading, and English. A developmental student may only need coursework in one discipline, but others need work in two or all three disciplines.

Face-to-face or Traditional Course – A course that meets in a classroom and is taught without any technology requirement (e.g. online homework assignments) of the students.

Hybrid Course – A course that combines online and face-to-face class sessions in a regularly scheduled pattern.

Online Course – A course that is completely online – all materials, quizzes, and tests are completed through the internet. Students enrolled in an online course must take the final exam at a proctored testing location during final exam week.

Basic College Mathematics – This is the first course in the developmental math sequence at the community college level. It has the smallest enrollment of the three courses.

Introductory Algebra – This is the second course in the developmental math sequence. The course covers topics from Algebra I and some topics in Algebra II.

Intermediate Algebra – This is the final course in the developmental math sequence. A student that successfully completes this course is eligible for credit level math. This course covers parts of Algebra II as well as what would be covered in the fourth year of high school math (not required to graduate from high school).

Success – Students earning a C or better in a developmental math course are eligible to continue into a college-level math course. Students earning a passing grade (A, B, or C) in the Intermediate Algebra course will be considered successful.

CHAPTER II. LITERATURE REVIEW

Enrollments at community colleges are increasing faster than at four-year institutions (Hoover & Wilson, 2009). Of the students enrolling in community colleges, almost 80% needed developmental courses (Jenkins & Boswell, 2002). Developmental courses aid students, weak in specific skills, prior to advancing into college-level courses. Developmental courses are offered in Reading, English, and Math. Some students need to take developmental courses in two or three subjects. Typically, a student needing just one area needs developmental math (Phipps, 1998). As the student population at community colleges increases, additional sections of developmental math courses must be added in order to meet the needs of the students, but often there is no physical space for the classes to be held. In order to meet this challenge, alternatives to the traditional classroom need to be offered. Options of online and hybrid courses can be used in order to minimize the need for physical space.

According to current research (Carpenter et al., 2004; Chernish et al., 2005; Dutton et al., 2002; Frederickson et al., 2005; Herman & Banister, 2007; Hodge-Hardin, 1997; Neuhauser, 2002; Sauers & Walker, 2004; Scheetz & Guntner, 2004), there is no significant difference in success rates of students in different learning environments. The results of current research have encouraged higher education institutions to expand online course offerings without concern for lowering student completion rates, heterogeneous student populations, diverse learning styles, or varying levels of students' technical skill. The question becomes whether this research conducted with students at four-year institutions can be applied to the developmental student population at community colleges.

Developmental courses differ from courses juniors and seniors at four-year colleges may take. Developmental courses have lower success rates than many college-level courses. Success in developmental math courses range from 29% to 64% (Waycaster, 2001). Success is not the only issue facing developmental students. These students may register for their developmental sequence, but not complete them (Russell, 2008), deciding to not pursue a college degree. The developmental student may be a recent high school graduate without college-level skills (ACT, 2006; Parker, 2007; Russell, 2008) or a student that has been out of the classroom for some time (Jenkins & Boswell, 2002). In either case, the student skills are weak and need to be improved in order for the student to be eligible for college courses. Developmental students struggle with the content. With the increase in enrollment, alternative learning environments need to be explored so we can at least ensure the success rates of these students are maintained.

The number of students enrolling in developmental math is increasing. The number of classrooms in community colleges cannot increase as quickly. Creative scheduling and alternative delivery methods are the only way to meet the present need for classes. This literature review will explore both online and developmental education with sections focused on community college students, student characteristics and achievement, including external and internal characteristics, cognitive load theory, and various learning environments.

Community College Students

Community college students represent 46% of all United States undergraduates (AACC, 2008). In 1989, community colleges were only 39% of the undergraduates which rose to 41% in 1999. During the 1990s, community colleges grew by 14% while all of higher education only saw a 9% increase (ACE, 2004). In order to offer classes to their growing student body, community colleges are moving into the world of distance education. Forty-one percent offer a fully online degree and 92% offer at least one online course (AACC, 2008). Students in community colleges represent almost half of the undergraduates in the United States, but are not equally represented in the research.

The community college setting offers educational opportunities to students that may not qualify for four-year universities for various reasons, including admissions policies and financial assistance. Community colleges have an open-door policy meaning that all students that apply are accepted to the college. These students have recently graduated from high school or are older students returning to school in order to change jobs or improve their current job. The community college student may be enrolled in a university, but interested in taking some courses while home for the summer. Some students may have been accepted to the university of their choice, but for financial reasons decided to begin their higher education at the community college. Without admission criteria, the community college needs to meet these students where they are and offer access to the college-level courses that meet their needs and goals.

When students without the necessary skills to take college-level math began enrolling at community colleges, developmental courses were created to bridge the gap between where students were and where they needed to be. The faculty created a list of the necessary pre-requisite skills which became the framework for the developmental courses. These courses were created in Reading, Writing, and Mathematics in order to increase student skills, thereby increasing their chance of success in college-level courses. Of the students that complete college preparatory courses in high school and immediately attend a community college, 40% need developmental math courses (Phipps, 1998). The American Diploma Project (2005) piloted a national exam, finding only 15% of present high school students are prepared to take entry level college math courses. National data from 2000 shows that 42% of community college students need at least one developmental course compared to 20% of public 4-year institution students (Russell, 2008). The success in the developmental course(s) has an impact on all courses, regardless of the discipline (Illich, Hagan, & McCallister, 2004). Students failing their developmental course tend to fail their college-level courses as well, while students that pass their developmental course do as well as the non-developmental student in their credit courses (Illich et al., 2004). This was true for credit courses such as music or physical education courses that were not connected to the developmental courses.

Waycaster (2001) studied developmental math students in the Virginia community college system. These students had a 29 – 64% success rate, a 56 – 81% attendance rate, and a 61.9 – 80.6% retention rate. Over 40% of the students that graduated from the system had taken at least one developmental course. Once in a college-level course, the developmental students did as well as, or better than, the non-developmental students in the credit course (Waycaster, 2001). The developmental math students are predominantly minority students. Only 27% of the Caucasian students placed into developmental math as compared to 41% of the African American students (Grimes, 1997).

Students placing into developmental courses need longer to complete their degree since there may be as many as six additional courses needed. The developmental courses have lower success rates than the college-level courses. As college enrollments continue to grow, the need for developmental courses increases. In order to meet the demand, community colleges are now offering these courses online. The determination needs to be made if the developmental students in distance learning environments are as successful as in the traditional face-to-face class.

Student Characteristics and Achievement

Student characteristics and background may also have an impact on student success in college. These characteristics involve demographic information or external observable characteristics (Dutton et al., 2002) such as gender, age, ethnicity, family, and financial resources. The internal or more academic characteristics include their student traits, learning style, placement scores, and their status as a student. These characteristics have primarily been used to identify the typical online student population and in limited ways linked to student success. The research on distance-based student characteristics will be reviewed in terms of external and internal attributes.

External characteristics. Basic demographic information on students includes the external or observable characteristics of students. This information is on admissions applications and used in various reports to compare the online population to the traditional students at different institutions of higher education. Gender, age, and ethnicity were reviewed in terms of the role each plays in student success. Two other characteristics discussed in the research of online students are family responsibilities such as children or elderly parents, and financial concerns (Dutton et al., 2002; Halsne & Gatta, 2002; Parker, 1999; Sullivan, 2001, Thompson, 1998).

Research results differ on the gender of online students. Some report that online students are more likely to be female (Carpenter et al., 2004; Halsne & Gatta, 2002), but other research finds no difference in gender for face-to-face and online classes (Dutton et al., 2002; Neuhauser, 2002). Both genders recognize the flexibility that online courses offer, with females admitting it would be difficult to achieve their academic goals without online courses (Sullivan, 2001). None of the studies reviewed determined a link between gender and student success in online or face-to-face classes.

With regard to student age, characteristics were used to determine the typical online student population although discrepancies were found in the definition of traditional age college students. Some researchers used 25 as the deciding line (Grimes, 1997; Halsne & Gatta, 2002; Sullivan, 2001) while others used 23 (Chernish et al, 2005; Hodge-Hardin, 1997; Neuhauser, 2002) and one used 22 (Dutton et al., 2002). Research shows that non-traditional students, in comparison to the traditional age student, prefer online classes (Halsne & Gatta, 2002; Sullivan, 2001), have a higher retention rate (Neuhauser, 2002), have a higher GPA (Grimes, 1997), and are less likely to cheat in distance education courses (Lanier, 2006).

In addition to gender and age, ethnicity of students is researched, but to a lesser degree in online environments. Ethnicity is also a factor in studying community colleges as they enroll a much more diverse student body (Sullivan, 2001) than four-year universities. The present research in ethnicity concludes that the online population is predominantly Caucasian with the Hispanic population more prevalent face-to-face (Carpenter et al., 2004; Halsne & Gatta, 2002). Sauers & Walker (2004) identified a population of international and English as a second language (ESL) within one of their sections, but more specific details were not provided. Other research on the distance learning environment does not identify the ethnicity of the sample (Chernish et al, 2005; Dutton et al., 2002; Herman & Banister, 2007; Kromrey & Purdom, 1995; Neuhauser, 2002; Scheetz & Guntner, 2004).

Family responsibilities infer a time commitment that can interfere with the student's ability to complete schoolwork and focus on their studies. Online students are twice as likely to have childcare responsibilities as their face-to-face counterparts (Dutton et al., 2002). Needing to help with family responsibilities or daycare for children is one of the main reasons given for the need of online flexibility (Sullivan, 2001). According to research (Halsne & Gatta, 2002), online students are more likely to be married and have children living at home while face-to-face students typically have never been married and have no children living with them.

Financial issues are a concern for many college students. Balancing a work schedule and school schedule is challenging. Face-to-face students are typically part-time employees and full-time students (Halsne & Gatta, 2002) while online students typically have full-time jobs and are part-time students (Dutton et al., 2002). Besides work status, a student's ability to gain financial aid has an impact on her role as a student. Financial assistance makes a student more likely to be successful in college as adequate financial aid is a predictor of persistence (Parker, 1999; Thompson, 1998).

Internal characteristics. The internal or more academic characteristics have more often been linked to student success. Research has been done to determine which types of students are more successful, the learning styles that are more prevalent in distance environments, and predictors of withdrawal versus success. These characteristics may be used to help a student determine if she is a good candidate for one learning environment over another.

The internal characteristics are based on how an online student works and what type of learner they are. Online learners should be self-disciplined (Dutton et al., 2002; Hughes & Hagie, 2002; Leh, 2002; Sullivan, 2001) and complete tasks on time (Hughes & Hagie, 2002; Leh, 2002). A student's opinion of his self-management, self-direction, and initiative as a learner predict success in an online course (Bernard, Brauer, Abrami, & Surkes, 2004; Parker, 2003). Online students that have a more internal locus of control are more likely to persist in the course and increase their self-motivation in just one semester of online learning (Parker, 1999; Parker, 2003). Students with an internal locus of control should be encouraged to register for non-traditional learning environments while students with an external locus of control may be better suited to a face-to-face course (Parker, 2003).

Research shows that a student's learning style has an impact on success in specific learning environments. Present research on the VARK Learning Style Inventory defines learning style as a preference rather than rigidly characterizing students into one type of learning over another (Leite, Svincki, & Shi, 2009). Leite et al. (2009) purposely chose to say preferred learning style. This research is in line with that and uses congruent terms. Successful online students typically preferred visual or kinesthetic learning (Neuhauser, 2002) while face-to-face students preferred auditory learning (Dutton et al., 2002; Halsne & Gatta, 2002), but both groups of students state that a positive characteristic about the environment they chose was that it fit their preferred learning style (Hughes & Hagie, 2002). This type of a fit keeps a student from withdrawing and leads to success. Students may have self-selected a specific learning environment based on his or her learning style preference; however Neuhauser (2002) found no relationship between the student's preferred learning style and final grades in the different environments.

Research has found predictors leading to student withdrawal as well as student success in courses, noting that they are not the same set of predictors. Placement scores, delivery method, developmental status and credit load are all useful predictors. A student is more likely to withdraw from taking an online course (Carpenter et al., 2004; Dutton et al., 2002; Taylor & Mohr, 2001), being a non-developmental student (Waycaster, 2001), and having part-time student status (Carpenter et al, 2004; Dutton et al, 2002). Parker (1999) found that locus of control as a single independent variable was able to predict student dropout with an accuracy of 80%. The placement test scores are a predictor of success (Carpenter et al, 2004) rather than persistence.

The Developmental Student

The developmental student encompasses characteristics of all students, but there are some characteristics that make this population different. Financial concerns, locus of control, and ethnicity show differences for this population from the overall college population. Some developmental students have been out of the classroom for some time (Jenkins & Boswell, 2002). These students have work and family commitments that may take priority over their coursework. Developmental students with financial concerns are more likely to dropout (Thompson, 1998). Since these students are more likely to have an external locus of control, they believe they have less control over the events in their life and therefore are less likely to take action, leading to higher attrition and lower course completion (Grimes, 1997).

Ethnicity is the largest difference between the four-year college and the developmental populations. The ethnic diversity in developmental courses comes from the greater enrollment rates by African-American and Hispanic students (Russell, 2008). African-American students have lower placement scores (Grimes, 1997) making them most likely to be referred to developmental courses. While students are referred to developmental education, some choose to not pursue their education or select a different institution. Of the students that are referred, Hispanic students are the ones most likely to actually enroll in the developmental math courses (Achieving the Dream, 2006).

Based on the current research, online students and developmental students are likely to have specific traits. Online students are typically Caucasian (Carpenter et al, 2004; Halsne & Gatta, 2002), have an internal locus of control (Parker, 2003), and have higher placement scores (Carpenter et al, 2004). Developmental students are most likely minority students (Russell, 2008), have an external locus of control, and are not college ready when they enter the institution (Grimes, 1997). Being at opposite ends of the spectrum, it seems that in the current research an online student and a developmental student share few characteristics. One must wonder what the online developmental student characteristics are and their best learning environment. Unfortunately this population has not been researched to provide such information.

Learning Environments

Studies have been conducted comparing the various environments used in distance education with the traditional, face-to-face, classes (Chernish et al., 2005;

Dutton et al., 2002; Frederickson et al., 2005; Herman & Banister, 2007; Hodge-Hardin, 1997; Kromrey & Purdom, 1995; Mash etal., 2006; Neuhauser, 2002; Sauers & Walker, 2004; Scheetz & Guntner, 2004). These studies have been performed on different distance tools as well as various academic courses. The results of this research often show there is no significant difference between students learning in a distance-based environment and students in the traditional environment.

The relationship between online and traditional classes has also been the topic in recent studies (Dutton et al., 2002; Frederickson et al., 2005; Herman & Banister, 2007; Neuhauser, 2002; Scheetz & Guntner, 2004). Most of this research compared classes that were offered online and in lecture format with the same instructor for both classes. Frederickson, Reed, and Clifford (2005) researched one class randomly split in half. For the first part of the semester, half the class learned the lesson online while the other half attended lectures in the traditional classroom. For the second part of the semester, the groups switched so that all students were exposed to both learning environments. Pre- and post-tests were used to measure the amount of learning in each group. The mean score increased 30% from the baseline with no significant difference between the groups. Frederickson et al (2005) and Scheetz & Guntner (2004) used computer labs to serve as their "online" classes, with students coming to the lab to work online with the material. The lab had scheduled class times, but students were able to use the lab at additional times. Scheetz and Guntner (2004) used the labs in order to standardize computer running speed as well as band-width, but it did require the students to travel to campus.

Two other studies comparing online and face-to-face classes also found no significant difference in the learning outcomes. Neuhauser (2002) conducted research on a class that was offered in both environments. The course was a 200-level management course offered at a four-year university. The exams and the delivery method for the exams were the same for both classes. The tests were emailed to students, completed, returned to the instructor by email, and then graded within twelve hours. This allowed the face-to-face section to have more time in class for other activities since testing was done outside of class. However it required the face-to-face students to be familiar with technology and have computer access to receive and submit tests electronically. The results of Neuhauser's study (2002) showed that while there was no significant difference between the two groups, actual test scores of the online students were slightly higher.

Herman and Banister (2007) also found no significant difference between the online and face-to-face classes in their graduate-level course for teachers. This study compared the grades on the final paper. The papers were scored twice using a rubric in order to have grader reliability. Required classes were being offered in different locations for special cohorts. These classes never reached maximum capacity and required travel on the part of the faculty member. Herman and Banister (2007) realized that if both learning environments met with equal success, then the classes could be offered online. Several cohorts could register for the same class allowing it to reach its maximum. By combining several smaller classes into online classes, fewer classes were necessary. Offering four classes online cut the cost per student in half from what it was when all the sections were run face-to-face (Herman & Banister, 2007). While no significant difference was found in the different learning environments, the main focus for the study was on how it would reduce the cost per student to offer the courses.

Two studies comparing online and face-to-face classes found a difference in achievement. Dutton, Dutton, and Perry (2002) looked at a computer programming class offered face-to-face with a lab component and a fully online class. The course was required for technical majors at the university and had a pre-requisite course that covered how to use computer software. All of the tests were proctored and all students had to complete programming assignments. The online instructors were more lenient in late assignments than the face-to-face instructors were due to technical problems. The online students did significantly better on the final exam than their face-to-face counterparts, but the online students were also older, not full-time, and had prior programming experience. Carpenter, Brown, and Hickman (2004) found that their online students were significantly more likely than face-to-face students to succeed in the developmental writing course, but acknowledged a greater withdraw rate in the online class. Looking back at the other characteristics, Carpenter et al (2004) found that the online students had higher placement scores than the face-to-face students. This means that the only two studies reviewed that found a significant difference in achievement also had a difference in the student populations in the two learning environments. This means it is not clear if the difference in achievement is due to the learning environment or the other characteristics.

Hybrid courses, combining online and face-to-face components, have also been studied to determine their success. Kromrey and Purdom (1995) compared a hybrid and face-to-face course for junior year elementary education majors using a pre-test, a post-test, and a delayed (four months after) post-test to determine any differences between the knowledge gained in the two delivery methods. No significant difference was found between the groups in any of the testing. Sauers and Walker (2004) also found no significant difference between their hybrid and face-to-face classes. All of the students, even those in the face-to-face class, needed to use technology as all assignments and communication were completed through Blackboard. They investigated two hybrids. While the regular hybrid contained traditional students, the specialized hybrid was for students that were English as a Second Language students, international students, or Honors students. The specialized hybrid class had the largest gain in test scores of any of the three classes.

Several of the studies investigated beyond just student success to opinions and attitudes of the students in the different learning environments. Students varied in their comfort level with the environments. For the ITV sections, 39% of the students were not comfortable at first but this reduced to only 6% being not comfortable with the format, but the 25% of the students in the online sections that were uncomfortable with the format, remained so throughout the semester (Chernish et al, 2005). Chernish et al (2005) also found that only 50% of the online students felt that delivery method was the best. Neuhauser (2002) found that 95% of all the online students preferred that format, while Bernard et al (2004) found that initial student beliefs about distance education do not change even after taking an online course. Kromrey & Purdom (1995) asked students if they believed that all the learning environments were equal in promoting learning and found one-third of the students agreed, but almost 40% believed that traditional face-to-face courses were superior. These studies point to the fact that student perceptions of the learning environments differ from the research result that they achieve the same level of success.

While students still believed face-to-face sections were superior to online courses, two other results became clear throughout the studies. First, online learning changes a student's behavior in making them better organized, more self-motivated, and more willing to take responsibility for their learning (Bernard et al, 2004; Frederickson et al, 2005; Parker, 2003; Sullivan, 2001). Second, online and hybrid courses required time management on the part of the students. They needed to determine the schedule to use the online materials which in turn could result in less time than face-to-face students or in other cases, considerably more time with the material (Chernish et al, 2005; Mash et al, 2006; Sauers & Walker, 2004; Scheetz & Guntner, 2004; Sullivan, 2001). Both of these results point to the possible benefits of distance education. With no significant difference in success of distance students and face-to-face students, any benefit of one learning environment over another needs further research.

Further research is also needed in the developmental math student population. Only one study was conducted on learning environments for developmental math students. Hodge-Hardin (1997) collected research for seven semesters for students in her Interactive Television (ITV) and traditional classes. The ITV class was offered at multiple sites, connected by technology. Each site could see and hear each other through the media, but the instructor was located at one site. There was no significant difference in success among the students in the traditional class, the students at the ITV site with the instructor, and the students at the ITV site without the instructor. This study was conducted with developmental math students, but at a university. These students met university admissions criteria that are not in place at a community college. This study is also more than ten years old, using technology that is declining in use.

Many of these studies were conducted with a university population with specific pre-requisites to the course being studied (Dutton et al., 2002; Hughes & Hagie, 2005; Neuhauser, 2002; Sauers & Walker, 2004). Some used Junior and Senior level students within a specialized major (Chernish et al, 2005; Kromrey & Purdom, 1995; Scheetz & Guntner, 2004) while others concentrated on Graduate students (Frederickson et al, 2005; Herman & Banister, 2007; Mash et al, 2006). Although essential for the general population, little research has focused on the community college student or the developmental student specifically.

Cognitive Load Theory – Theoretical Implications for Instructional Design

In the end, no student will be successful in any environment without good design. This research uses Cognitive Load Theory (CLT) as the basis for its design and the theoretical foundation for this research. Cognitive Load Theory (CLT) addresses the limitations on learning, retention, and transfer. The theory states that there are two parts of memory, working memory which is where new information is processed and long term memory where information is organized and stored for later use. Working memory is limited and yet it includes processing capabilities as well as the work with new information. In the working memory, information is organized into schemas which can then be stored in long-term memory for future retrieval. Without enough space in working memory, the information cannot be transferred over to long-term memory, so it will not be retained. Information that is in long-term memory and accessed frequently can lead to automation – the ability to process information without conscious effort, using little working memory, allowing for problem solving to proceed with minimal effort (Artino, Jr., 2008; Kalyuga, Ayres, Chandler, & Sweller, 2003). This section will discuss the three types of load as well as some effects that can increase working memory. As the learner moves from novice to more experienced, some changes need to be made to the instructional design or its effectiveness will be random (Kalyuga et al., 2003). In order to produce a quality learning environment, cognitive load needs to be addressed in the planning of the course design. Students need to be provided with enough information to make connections with present schemas, but stopping short of so much information that it cannot be processed and retained. This section will discuss the parts and effects of cognitive load as well as ways to reduce load to improve learning.

There are three types of cognitive load: intrinsic, extraneous, and germane. Intrinsic load is the inherent working memory load required to complete a task (Mishra & Sharma, 2005). This involves the number of elements that are processed in working memory in order to create a schema and then transfer the information into long-term memory. Extraneous or ineffective load is effort used to process instructional materials or complete an activity that is not directly related to learning the material. Germane load is the result of beneficial cognitive processes such as elaborate, infer, and automate. Germane load is only possible when the intrinsic load plus extraneous load is less than the limitations of the student's working memory. The goal is to create instruction with tasks that have low to moderate intrinsic load, while reducing extraneous load, and assist students with active processing to facilitate germane load (Mishra & Sharma, 2005).

Cognitive Load Theory has several effects that can be used to reduce the cognitive load, thereby increasing learning and retention. The modality effect states that working memory has separate auditory and visual channels. This means that information should be presented in both mediums to maximize the size of working memory. The split-attention effect states that information that is split apart (i.e. the legend in a map, the definition of a word in the glossary in the back of a book) increases the need for working memory. The information should be integrated together (i.e. providing the definition of the word within the context of the chapter) in order to decrease the burden on working memory. The redundancy effect is when the exact same information is presented in more than one way. For example if audio is added, it should not merely be reading the text that is already present. In each of these effects, working memory could be overloaded. This means that there would not be enough room for processing the information so it cannot be stored in long-term memory.

By using instructional design that will decrease the cognitive load, the learner will better be able to create schemas to store the information in long term memory. In terms of planning for a class, there are two more effects on cognitive load. The isolated or interacting elements effect deals with the complexity of the topic. The more elements involved in the process, the greater the chance of overload. Instead, the number of elements should artificially be reduced, allowing time for each to be understood. Then all of the interaction among the elements can be covered. The other strategy is the worked example effect. When presented with a problem, students can begin to search for strategies or methods for solving. This then uses up working memory, possibly extraneous load if the strategies will not lead to a solution. By presenting a worked example, the student is directed to a problem state and its associated moves (Kalyuga et al, 2003). Once the student becomes more familiar with the topic, then the design can move into practice problems.

As students become more familiar with a topic, these effects have a different impact on cognitive load. This is called the expertise reversal effect. Design strategies that benefited a novice learner, can cause difficulties for a more experienced learner. This is due to conflicts between the learner's organized knowledge in long-term memory and the organization presented in class. For these learners, it is necessary to be able to reduce the instructional guidance that was crucial for success of novice students.

Strategies have been developed to reduce cognitive load, allowing greater learning and retention. Through the use of these strategies, the instructional design will offer the most benefit to the learners. Suggestions for reducing load include presenting new material by tying it to schemas already in long term memory; practicing enough on a topic to operate under automatic processing, breaking the learning goals into sub-goals to decrease element interaction, using audio and visual presentation of material, and "pretraining" (Artino, Jr., 2008) by providing instruction on pre-requisite knowledge prior to the new topic. Using these strategies to design a course will be ideal for the novice learners, but another crucial part is to offer opportunities with less instructional support. With the use of technology, the course can offer the learner the opportunity to turn off some of the options as they become more experienced with the material. This will help to minimize the expertise reversal effect.

Reducing the strain on cognitive load increases learning and retention. Following the effects in the Cognitive Learning Theory offers the learner the best chance of success with the course. In addition, the design of the course should be tailored to the experience level of the learners. When the course has a heterogeneous group of learners, introducing multiple possibilities for learning activities and assignments will allow the student to meet their needs without being redundant as well as providing a variety of options for the learner that progresses from novice to more experienced. These instructional design principles should be applied to all learning environments.

The Cognitive Load Theory is essential for developmental students. Their non-credit courses are structured as “review” courses that do not earn college credit. However, these students are a combination of those needing a review of the material and those that have never seen the material before. This theory provides a framework that will provide the greatest assistance for those learning the material for the first time while allowing students that are reviewing the material an opportunity to also succeed. The developmental course work serves as a foundation for college level courses and needs to provide adequate structure and time for the transition from working memory to long term memory. The Cognitive Load Theory serves as the framework from which this foundation can be built.

Summary

Research on different learning environments shows no significant difference in student success. However this research is completed on populations at four-year colleges and universities. The community college population, specifically the developmental student, differs in retention, success, finances, and ethnicity from the samples in these studies. These differences, as well as the students being underprepared academically for college, may affect the results these students have in different learning environments.

Present research supports trends in the student characteristics of those choosing online classes. The demographic information is used to create a general picture of the online student but is not used as a predictor of success while the internal characteristics can predict students likely to be successful as well as students likely to withdraw. Gaining information about the online population is beneficial, but knowing what makes them successful would be invaluable to the student advising process. One type of learning environment will not work for all students, so colleges should offer different modes of instruction in order to help students achieve success (Waycaster, 2001). No matter the type of environment, learning follows good instructional design. Incorporating Cognitive Load Theory into course design allows the instruction to be most beneficial to students. Each student has prior knowledge leading to varying degrees of expertise with the material in the course. This diversity requires planning to make certain to offer adequate support for the novice learners without having a negative impact on the more expert learner. This design allows for the creation of quality instruction for the developmental student in all learning environments.

The research finding no significant difference between learning environments is a selling point for distance education, but the present research does not include the developmental student population at community colleges – a succinctly different population than that which is commonly studied. Each learning environment has benefits and limitations, so the attributes that make students successful in each need to be determined. If the developmental students at the community college do not have the attributes, it needs to be determined if they can still be successful in the learning environment. It is the responsibility of the institution to determine if students are being offered less advantageous options. National trends point to supporting success for developmental and at-risk student populations. As the increase in distance-based learning environments continues, the research needs to be conducted to make certain that this does not negatively impact a population in the national spotlight. This research will help to determine the impact both the learning environment and the learner characteristics have on student success.

CHAPTER III. METHODOLOGY

The number of students enrolling in community colleges continues to increase, thereby increasing the students registering for developmental math classes. With a finite number of classrooms, more courses are being offered in online and hybrid learning environments. This research was conducted to determine if the developmental population at community colleges can be successful in online and hybrid learning environments

To determine the effect of delivery method on student success for developmental students at the community college, this study compared student grades for traditional, online, and hybrid Intermediate Algebra courses. The purpose of the research was to determine if there is a difference in success, but also to discover student factors that may aid or hinder success. This chapter describes the research methods for this study and includes the following sections: sample, research setting and procedures, research questions, instruments, limitations and assumptions, pilot study and results, data collection and analysis, and a summary.

Sample

This research study used a sample of convenience. The participants were 167 students enrolled in an Intermediate Algebra class at a Mid-Atlantic community college. The course is the third in a series of three developmental courses offered at the institution. Success in this course (grade of 70% or higher) means that a student has the necessary pre-requisite knowledge to register for college-level math courses. The students in this class either passed the previous developmental course or placed directly into this course based on the scores of their placement test; for some students this may be their second time taking the class, having been unsuccessful the first time.

The population varied in demographic and academic characteristics. Students ranged from recent high school graduates to non-traditional age students returning to school after an extended period away from the classroom. As noted earlier, participants in this study were enrolled in Intermediate Algebra, with just over one-third in the traditional classes (34.7%), more than a third (37.7%) in the online classes and less than a third (27.5%) in the hybrid classes. The sample consisted of 97 females (58.1%) and predominantly Caucasian (48.5%) and African-American (43.1%) students. There was a combination of full-time (80 students) and part-time (87) students as well as 36 new students.

The research was conducted within the same class (Intermediate Algebra), using the same syllabus, same materials, same lessons, same tests, and same grading policy. Meetings between the two instructors took place prior to the beginning of the study as well as weekly to maintain consistency among the classes. Since most of the class components were standard, the learning environment was the major difference among the classes.

Effect Size

In preparation for the study, research was conducted for the literature review. Statistical results gathered from this research (Carpenter et al, 2004; Chernish et al, 2005; Frederickson et al, 2005; Scheetz & Gunter, 2004) was used to calculate a weighted effect size of 1.742. This was used to calculate the sample size necessary for the study to see a comparable effect size. For 95% power, the sample size needed to be 30 participants with 10 in each learning environment. The sample size was 167 participants with more than 45 in each learning environment. The formula and calculations can be found in Appendix D.

The effect size for this study was calculated for mean differences between each pair of learning environments. For the face-to-face to online comparison, the course average favored the face-to-face environment with an effect size of 0.172. For the face-to-face to hybrid comparison, the course average favored the face-to-face environment with an effect size of 0.533. For the online to hybrid comparison, the course average favored the online environment with an effect size of 0.312.

Research Questions

In order to determine student success in the different delivery methods as well as any traits associated with the successful student, the research was guided by the following questions:

1) Are three different delivery methods (face-to-face, hybrid, fully online) equally effective as measured by course grades?
2) Which external characteristics (e.g. gender, age, ethnicity) are significant in determining student success in each of the three learning environments?
3) Which internal characteristics (e.g. learning style, motivation) are significant in determining student success in each of the three learning environments?

Research Setting and Procedures

The research took place during the summer and fall of 2009 in a Mid-Atlantic community college Intermediate Algebra course. Intermediate Algebra is a fifteen-week, non-credit course. Students not meeting the requirements for college-level math courses are required to take non-credit courses to improve their skills. Intermediate Algebra is the last of the developmental courses before students are eligible to enroll in a credit-earning math course. The course content includes factoring, functions, rational expressions, radicals, quadratics, conic sections, and exponential and logarithmic functions. Intermediate Algebra has the highest enrollment of the three developmental math courses offered at the community college. A copy of the course outline and schedule of topics can be found in Appendix E.

The participants self-registered into one of the three delivery methods: traditional, hybrid, and online. Once the semester began, the students were informed of the research and invited to participate. Participation in the study was voluntary. Students were guaranteed that participation or non-participation would in no way effect their course grade. Students were given a letter of consent (see Appendix F) and the survey instruments during the first three weeks of the semester. The traditional and hybrid classes completed the surveys at the end of class time. The online students completed the surveys within the online course by a specified deadline.

The Intermediate Algebra course was divided into units and then each unit was divided into objectives. Based on Cognitive Load Theory, there is a limit to working memory, including the ability to process information. In order to increase learning, the cognitive load needs to be reduced by connecting the new information to material already in long term memory, practicing skills enough that the process becomes automatic, and dividing goals into sub-goals. These three recommendations were used in the creation of this Intermediate Algebra course. All new content referred back to prior skills, e.g. multiplication of rational expressions was linked to multiplication of fractions. Multiple opportunities for practice were provided within the class sessions and as extra practice between classes. The content was broken into sub-tasks, allowing students to review the specific skills needed within the unit prior to combining them into complex problems. By basing the course design on Cognitive Load Theory, student's working memory should be sufficient to transfer the material from working memory to long-term memory.

The same units and objectives were used for all three learning environments. A course calendar was created with test dates, allowing each student the same time between unit tests regardless of learning environment. This calendar also listed the objectives covered each class session to pace the face-to-face classes.

The traditional class met for three hours (either two days or three days of class) a week. No online materials were provided to the traditional students and no part of their grade required the use of online technology. If needed, the instructors used office hours, emails, and phone calls to work with students that needed extra assistance outside of class. The syllabus for the course included all the units and objectives, test dates, as well as problems in the textbook for each objective. The instructors used common methods, instructions, and examples in all the face-to-face classes. After each objective the students were given a five question self-assessment to take home. The answers were provided on the self-assessment. The beginning of each class was used to address student questions from the self-assessment or the textbook. Towards the end of the unit, the instructors passed out a practice test, including answers, to the students in order to assist them in preparing for the unit test. Each unit test was completed in class, then graded and returned to students the following class session.

Students enrolled in the online course accessed all materials through the course management software, never meeting face-to-face. There was an online orientation that covered the technical knowledge necessary for the course as well as course procedures. Each unit was arranged with all its materials in a folder, listing all the objectives, the unit quiz, and unit test. Each objective had several learning activities to assist students: a lecture, transcript, handout, practice problems, and answers. The lecture was a slide show with audio that contained the same materials, instructions, and examples that were used in the face-to-face classes. At the end of the lecture, students were asked five questions on the objective's topic. This self-assessment provided feedback to the students but no grades were sent to the instructor. A transcript was provided for the audio part of the lecture. The handout was a document covering specific examples from the objective that could be printed out. There were 20 – 30 practice problems for each objective and answers were provided. The unit quiz was the same as the practice test given to the face-to-face students. The unit test was timed as it was for the face-to-face students. This online class was certified by Quality Matters, a nationally recognized, peer review process designed to certify quality online courses.

Students in the hybrid class had access to all course materials online as well as weekly class meetings. When registering for the course, it was listed as a hybrid with meetings on Tuesdays and Thursdays. On the first day of class, students were told that class would meet every Tuesday and online work would replace the Thursday sessions. The classroom with computers was available for lab sessions on Thursdays with the instructor available for assistance. Attendance on the lab days was very small. A calendar was provided noting topics covered during the face-to-face classes as well as topics the students were to complete online. The same methods, instructions, and examples used in the face-to-face class (and the online lectures) were used in the face-to-face sessions. The online materials were the same as for the online class. Students were able to review the face-to-face sessions online either before or after class to reinforce the material. The unit quizzes and tests were the same as in the online class.

Every effort was made to ensure that the classes were the same except for the medium used to communicate and complete assignments. All groups used the same syllabus and course content, as well as the same deadline to complete each unit. All unit tests were drawn from the same set of topics and questions. All tests were timed. Online testing was implemented in the hybrid and fully online classes while traditional paper and pencil tests were provided for the face-to-face classes. In order to accommodate students with technical difficulties, test make-ups were offered for online students during final exam week. This same opportunity was available for the traditional and hybrid students.

All of the students took the same final exam. The final exam covered all of the material in the Intermediate Algebra course and each question was marked as correct or incorrect. The traditional classes and the hybrid classes took the final exam based on the college’s exam schedule, proctored by the instructor. The online students took the final exam in a proctored testing situation, scheduling a time during the first four days of the final exam week.

In order to provide a larger sample, two instructors participated in the study. Training was provided to standardize instruction. Printouts of the online lectures maintained consistency across the delivery methods. Both instructors assisted in creating the online materials for the course and taught the course in all three delivery methods during prior semesters.

Institutional Review Board approval was granted by both Towson University and the Community College of Baltimore County. Towson University's Institutional Review Board (IRB) for Research Involving the Use of Human Participants was approved under Exemption Number 09-1X20 on February 24, 2009 (Appendix A). The Community College of Baltimore County approved the study on February 27, 2009 (Appendix B).

Instruments

Four instruments were used to collect data for this study. Three focused on student characteristics, including self-reliance, preferred learning styles, and technology skills. The fourth instrument was an Intermediate Algebra Competency Exam (IACE) used as a cumulative course final exam. The three instruments used to collect data about student characteristics were: Rotter's Locus of Control (RLC), Visual, Auditory, Reading/Writing, and Kinesthetic Learning Styles Inventory (VARK), and the Technology and Internet Assessment (TIA).

Rotter's Locus of Control

Julian Rotter's Locus of Control (RLC) scale (1966) measures how much someone believes that internal or external forces control the outcomes in his or her life. The survey includes 29 items, of which 23 are graded to determine a person's locus of control. The other six are distracter items designed to limit instrument transparency (Kirkpatrick, Stant, Downes, & Gaither, 2008).

Each item contains two statements. The participant is directed to select the statement that he or she believes to be true. The directions specifically state that the selection should be on what the individual believes to be true and not what they would prefer to be true. An example of an item on the RLC is:

___ Many of the unhappy things in people's lives are partly due to bad luck.

___ People's misfortunes result from the mistakes they make.

A statement needs to be selected for each question. Surveys with neither statement selected or with both selected were considered incomplete and not scored.

Scores range from zero to 23. Low scores, ranging from zero to 11, represent an internal locus of control and high scores, ranging from 12 to 23, represent an external locus of control. Scores of zero to three are considered extreme internal, while scores of four to 11 are a healthy internal locus of control. A person with an internal locus of control takes responsibility for the outcomes in his or her life and tends to be more successful. The external locus of control student does not believe they have control over events, but rather that others or fate determine their outcomes. Scores for the RLC for the study are shown in Table 1.

Table 1

Results on Rotter's Locus of Control for All Subjects and by Learning Environment

	N	Score Mean	Score SD	Rating Mean	Rating SD
All Subjects	167	10.024	3.322	1.275	0.499
Face-to-face	58	10.638	3.764	1.379	0.557
Hybrid	46	9.674	3.471	1.174	0.486
Online	63	9.714	2.691	1.254	0.439

Note. The N column lists the number of subjects in the group. The score mean and standard deviation (SD) were determined from the raw scores for each subject. The ratings were determined using 0 for extreme internal, 1 for healthy internal, and 2 for external locus of control.

Since 1966, Rotter's Locus of Control has been the most commonly used instrument for locus of control. The correlation coefficients for test-retest reliability were 0.72 and 0.55 for two data sets, and were 0.69, 0.70, and 0.73 for internal consistency with three data sets (Rotter, 1966). To determine the reliability, Cronbach's Alpha was calculated. For this study, the average inter-item correlation is lower than what researchers have found ($\alpha = 0.614$). This could partially be caused by casual responding. Julian Rotter granted permission (see Appendix G) for the use of his survey as long as it was not published; therefore this instrument was not included in the Appendix.

Visual, Auditory, Reading/Writing, Kinesthetic Learning Styles Inventory

The Visual, Auditory, Reading/Writing, Kinesthetic Questionnaire (VARK) is designed to measure learning styles, specifically how a student prefers to learn: visual, auditory, reading/writing, kinesthetic. The survey was created by Fleming and Mills (1992) with the second version being published in 1997. The VARK is available online for students to complete free of charge (http://www.vark-learn.com/english/index.asp). An individual subscription is available for teachers and managers for a fee and was used for this research.

The survey is comprised of 16 items. Each item describes a situation and offers four response choices. An example of an item on the VARK is:

> You have a problem with your knee. You would prefer that the doctor:
> a. Described what was wrong.
> b. Used a plastic model of a knee to show what was wrong.
> c. Gave you a web address or something to read about it.
> d. Showed you a diagram of what was wrong.

After reading the choices, the participant selects all that apply to him or herself. The situations involve learning information from doctors, web sites, and others; as well as what information the participant would require in order to make a decision. The directions state that the participant may select as many as all four choices to as few as only one choice, and even choose to leave the question blank.

The results are numerical scores for each of the learning styles as well as an overall preference. The higher the number, the stronger the preference is for that learning style. The overall result presents the scores across all four learning styles. If one style is the highest, it is given as the preferred learning style. If the most preferred style is followed closely by a second style, the results state that the participant is bi-modal, preferring two styles. In some cases, the survey will return results where the three or all four styles are equally preferred. These results point only to a preferred learning style and do not suggest that the participant cannot learn in other styles. The scores from the participants are found in Table 2.

Research into the VARK learning styles has resulted in an existing reliability (Leite, Svincki, & Shi, 2009). Since students had the option of choosing more than one response per question, the VARK should be viewed as a questionnaire of testlets. The testlets are formed by grouping together items that share a common stimulus, in this case the specific scenario. The pre-existing Raykov reliability estimates for the scores on the visual, aural, read/write, and kinesthetic subscales were 0.85, 0.82, 0.84, and 0.77, respectively (Leite et al, 2009). Leite, Svinicki, and Shi (2009) show the instrument is valid, especially in its use with students to understand their preference. Because of the design of this instrument, a traditional reliability score cannot be calculated. The VARK can be found in Appendix H.

Table 2

Results on the VARK Learning Styles Inventory for All Subjects and by Learning Environment

	N	Visual	Auditory	Reading/Writing	Kinesthetic
All Subjects	167	6.629 (3.235)	8.323 (3.610)	8.683 (3.306)	8.216 (3.151)
Face-to-face	58	6.345 (3.198)	7.552 (3.393)	7.845 (3.116)	7.931 (3.014)
Hybrid	46	6.478 (3.060)	10.370 (3.686)	8.696 (3.508)	7.935 (3.065)
Online	63	7.000 (3.403)	7.540 (3.771)	9.444 (3.187)	8.683 (3.325)

Note. The N column lists the number of subjects in the group. The score for the learning style is the average for the group and ranges from zero to 16. The value in parentheses under each mean is its standard deviation (SD).

Technology and Internet Assessment

The Technology and Internet Assessment (TIA) is designed to measure technology and internet skills. The data collected from this is grouped into eight sections that the author refers to as scales. Each scale contains specific questions, but the questions are randomly arranged within the survey, not by scale. The eight scales and the number of items within each are: Use of Technology (seven items), Specific Computer Skills (twelve items), Acquisition of Technical Knowledge (six items), Basic Internet Knowledge (eight items), Internet Information Skills (six items), Adapting to Technological Change (six items), Impact of Technology (six items), and Ethics in Technology (nine items). Each of the sixty items provided a statement on technology and the participant needed to identify how much they identified with the statement. An example item from the TIA is:

I would have difficulty attaching a file to an email message.

a. Not at all typical of me
b. Not very typical of me
c. Somewhat typical of me
d. Fairly typical of me
e. Very much typical of me

All of the questions required a selection by the participant in order to be properly scored.

The survey was already in use at the college. The college administration had purchased licenses for the TIA a few years ago and made the survey available to all students to complete through the tutoring and student assistance areas. The survey results provided percentile scores for each of the eight scales, allowing comparisons to other students. A score of 70 means the individual scored higher on that scale than 70% of the students that have completed the TIA. Higher scores indicated a good level of technical skill and knowledge, while lower scores highlighted a lack of knowledge in a particular area. Results from the study are presented in Table 3.

Ealy (2000) conducted test-retest reliability with the TIA over a three-week period. The correlation coefficients for each scale were high and statistically significant. For the purpose of this study, four of the scales were important: Use of Technology, Specific Computer Skills, Acquisition of Technical Knowledge, and Basic Internet Knowledge. These had test-retest correlation coefficients of 0.82, 0.90, 0.73, and 0.88 respectively. The other scales were completed by the participants in the study but were less valuable for the research. Their correlation coefficients were Internet Information Skills (0.66), Adapting to Technological Change (0.72), Impact of Technology (0.67), and Ethics in Technology (0.63) (Ealy, 2000). Content validity for the test items was established through consultation and evaluation with computer education and instructional technology specialists during development of the instrument (Ealy, 2000). To determine the reliability, Cronbach's Alpha was calculated. For this study, the average inter-item correlation is comparable on six of the subscales: Use of Technology (α = 0.785), Specific Computer Skills (α = 0.828), Basic Internet Knowledge (α = 0.778), Internet Information Skills (α = 0.763), Adapting to Technological Change (α = 0.708), and Ethics in Technology (α = 0.685). However for the other two subscales, the correlation is much lower: Acquisition of Technical Knowledge (α = 0.304) and Impact of Technology (α = 0.352). The TIA can be found in Appendix I.

Table 3

Results on the TIA scales for All Subjects and by Learning Environment

	N	UOT[a]	SCS[b]	ATK[c]	BIK[d]	IIS[e]	ATC[f]	IOT[g]	EIT[h]
All Subjects	167	64.5 (25.26)	66.0 (22.17)	45.1 (25.29)	76.5 (19.44)	59.0 (28.54)	59.3 (29.16)	42.6 (26.82)	55.2 (26.71)
Face-to-face	58	62.1 (27.57)	63.4 (24.05)	39.4 (23.55)	71.5 (21.85)	54.3 (26.54)	53.7 (29.79)	37.1 (22.63)	49.1 (24.58)
Hybrid	46	62.2 (23.93)	64.7 (22.74)	42.3 (23.63)	75.1 (19.62)	54.7 (29.03)	55.5 (29.05)	40.7 (27.28)	55.1 (28.83)
Online	63	68.3 (23.89)	69.4 (19.72)	52.4 (26.60)	82.1 (15.39)	66.5 (28.84)	67.4 (27.22)	49.1 (29.00)	60.9 (26.53)

Note. The N column lists the number of subjects in the group. The value in parentheses under each mean is its standard deviation (SD).

[a]Use of Technology. [b]Specific Computer Skills. [c]Acquisition of Technical Knowledge. [d]Basic Internet Knowledge. [e]Internet Information Skills. [f]Adapting to Technological Change. [g]Impact of Technology. [h]Ethics in Technology.

Intermediate Algebra Competency Exam

The Intermediate Algebra Competency Exam (IACE) was created by the Mid-Atlantic community college Math Department to serve two purposes. The first was as a challenge test for students that felt they were incorrectly placed into Intermediate Algebra. As a challenge test, the questions were created based on the Common Course Outline, covering all of the objectives of the course. The test is also used by students that need to repeat Intermediate Algebra because they were not successful the first time. It is an assessment of the skills that the student gained in the course as well as the areas that the student should specifically focus on during the next attempt. The IACE has been in use for over four years.

In an effort to validate these materials, the course outline, the IACE, and a questionnaire were sent out to twelve math experts for feedback. The questionnaire asked about the evaluator's teaching background as well as specific questions on the IACE in terms of difficulty, length, fairness, and coverage of the learning objectives. Nine of the experts responded and returned the completed questionnaire. The experts were math teachers either at the high school or community college level, with an average of 23.6 years experience. Many of the instructors noted that the instrument adequately measured the objectives and that two hours was an appropriate amount of time to complete the exam. Half of the respondents felt that one of the objectives, applications of quadratic equations, was not covered sufficiently. A problem was added to the IACE to address this concern. Several of the respondents expressed concern with the difficulty level of the division of complex numbers problem. This problem was modified based on suggestions of the respondents.

After implementing the revisions based on expert feedback, the IACE had 48 questions. The exam was given in a proctored situation for all the students. The use of a calculator and scrap paper was allowed, but no notes or books were allowed. Each question was graded as correct or incorrect, scoring one or zero points. The number of correct questions divided by the 48 questions was converted into a percent for the exam grade. Results for the IACE across all participants as well as within each learning environment are found in Table 4. The IACE can be found in Appendix J.

Table 4

Results on the Intermediate Algebra Comprehensive Exam (IACE) for All Subjects and by Learning Environment

	N	Number Correct	SD for Number Correct	Percentage	SD for Percentage
All Subjects	167	25.3	14.718	52.6%	30.691
Face-to-face	58	28.9	10.825	60.2%	22.609
Hybrid	46	22.0	16.613	45.8%	34.594
Online	63	24.3	15.832	50.7%	33.018

Note. The N column lists the number of subjects in the group. The number correct is out of 48 problems. For Fall 2009, the success rate across all 104 Intermediate Algebra courses at this institution was 54.7%. The standard deviation (SD) for both the number correct and percentage is provided.

Limitations and Assumptions

This research was conducted in an attempt to control as many factors as possible. The intent was to use the same syllabus, textbook, assignments, activities, lessons, tests, and final exam across all the learning environments. This study acknowledges the following limitations:

- With multiple Intermediate Algebra courses being offered, students registered for a specific section based on a variety of factors. Students self-selected the learning environment in the majority of the classes, but in some instances enrollment was based on availability and not because they wanted the specific learning environment. The reasons a student chose a particular learning environment may lead to differences within the group samples. Student's prior success or preconceptions about the different learning environments may have influenced their decision during registering for class.
- Due to the need for a specific population and the ability for consistency across the different learning environments, the research used a sample of convenience so results may be less generalizable.
- In order to increase the sample size, more Intermediate Algebra classes were accessed through the use of two instructors. Every effort was made to standardize the material as well as the presentation style, but with two instructors there are inherent differences. The research attempted to control for as much as possible.

Pilot Study and Results

A pilot of this research was conducted in Spring 2009. The purpose of the pilot study was to determine if any logistical problems occurred during the study and if any modifications to the research design were needed.

The Intermediate Algebra course was taught in all three learning environments during the spring semester. Two classes in each environment were used in the pilot study with a total enrollment of 121 students: 45 traditional students, 42 online students, and 34 hybrid students. A total of 66 students participated in the study, a response rate of 55%.

The hybrid classes were the only classes not full by the start of the semester. Both institutions involved in the research granted IRB approval after the semester began. The surveys were distributed immediately after the approval was received along with a cover letter explaining the student's choice to participate and that it would not affect their course grade.

The surveys in the traditional classes were to be completed within the course meeting. The first survey completed in class had an 82% (37 students) response rate. With time needed to cover course materials, the other two surveys were distributed for students to complete at home and return the next class meeting. All surveys were collected, completed or not. These surveys had a 24% and 27% response rate.

Information on the research was provided to the online students through an email providing directions to the cover letter and the surveys on the course home page. The three surveys were available from mid-semester to the end of the semester. Sixteen of the 42 online students completed at least one survey. For the three surveys, the response rates were 38%, 19%, and 31%.

The hybrid students were given information about the study during the face-to-face class session and asked to complete the surveys online. An email was sent to all the students reminding them of the study, how to complete the online surveys, and how to access the materials. Thirteen of the 34 hybrid students participated in the study, but all of the surveys had less than 13 completed. For the three surveys, the response rates were 32%, 21%, and 24%.

Demographic information was analyzed on the participants. The students in the traditional face-to-face course were the youngest on average. The average age for the participants was 21.9, 28.6, and 29 years old for the traditional, online, and hybrid courses respectively. Gender differences were found among the participants based on delivery method. The traditional course was evenly distributed with 19 females and 18 males. Both of the other delivery methods were predominantly female. The online class was 14 females and 2 males, while the hybrid class was 10 females and 3 males. With the small sample, it is unclear if these differences were across the entire population, or only for the participants of the study.

As a result of the pilot, several changes were made to the research study. For the online classes, the three surveys were presented as one survey and were available from the beginning of the semester. Since the survey completed during class time in the face-to-face course had the largest response rate, the traditional and hybrid classes completed the surveys during the class session. The hybrid class completed all three surveys at the end of one class. The traditional class completed the longer survey at the end of one class and the other two surveys were completed at the end of another class session. As an added incentive, twenty extra credit points on the lowest test grade was offered to participants in exchange for the completion of all three surveys.

Data Collection and Analysis

The cover letter explaining the study, informed participants that in addition to the survey information, data would be collected from the college. This data included gender, race, age, placement test scores, registration date, prior course history, and current course load. The instructors also kept attendance records of students time in class for traditional and hybrid students. This included information on students arriving late or leaving early from class, as well as hybrid students that attended on the lab days to ask questions. Test grades for each unit, scores on the Intermediate Algebra Competency Exam, and the final course grade were also collected. All information was coded with a participant ID to maintain confidentiality.

Data was collected in a spreadsheet to be analyzed in a statistical software package (SPSS). Differences in student characteristics (gender, race, age, locus of control, learning style, technology skills, course load, attendance) and grades (tests, Intermediate Algebra Competency Exam, overall course grade) were analyzed using analysis of variance (ANOVA). The level of significance for each ANOVA was predetermined to be 0.05.

Summary

This study sought to find out if differences exist in student success in developmental math courses based on delivery method. Students self-selected into a traditional, hybrid, or online Intermediate Algebra class. Every effort was made to standardize all materials, assignments, and tests for the courses, leaving the delivery method as the sole difference. Survey instruments were used to measure student characteristics that may make the student more likely to choose or be successful in a specific delivery method. A common final exam was also used to measure student success in the course. A pilot study was completed. Due to low response rates for the pilot, small modifications to the survey implementation were made prior to the full study. Participation in the study was voluntary. Across five online, three hybrid, and three face-to-face Intermediate Algebra classes, 250 students were registered, 167 participated in the study and 134 completed the course.

CHAPTER IV. RESULTS AND FINDINGS

The purpose of this research was to show if there was a difference in student success when a developmental math course was delivered in an alternative environment, such as online and hybrid. The research also investigated student characteristics to determine if there was a connection between student traits and success in a specific learning environment. Data were collected for students enrolled in the face-to-face, hybrid, and learning environments of an Intermediate Algebra course at a Mid-Atlantic community college.

Students either placed into this course or successfully completed the Introductory Algebra course as a pre-requisite. When the students registered, they chose the learning environment by selecting a traditional, hybrid, or online section. Student characteristics across the learning environments were studied as well as differences between successful and unsuccessful students within each learning environment. This chapter consists of the following sections: descriptive statistics of the respondents overall, and by learning environment, research questions, and a summary.

Descriptive Statistics

Participants were informed that data would be collected from the college in addition to the surveys that were completed. Data were collected on gender, age, race, math placement, previous credit history, present course load, date of registration, and any previous developmental math courses completed. Data were collected during the semester on attendance, test grades, and the Intermediate Algebra Comprehensive Exam (IACE). Three surveys were used to collect data on the student’s technology skills, preferred learning styles, and locus of control. Information will be presented for the entire sample and then for the specific learning environments.

Description of Respondents

Out of a total of 251 students enrolled in the course, 193 agreed to complete the surveys during the first two weeks of the course, providing a 77% response rate. However, 18 were no longer on the course roster by the third week of the semester and 8 others changed their mind about participating in the study, resulting in a final total of 167 subjects. The gender of the sample was 58.1% female and 41.9% male. The average age was 25.5 years old. Most of the students were Caucasian (48.5%) or African-American (43.1%) with only three Hispanic (1.8%), five Asian (3.0%), one American Indian (0.6%), and the final five had selected Other or Unknown. Participants were asked if they received financial aid with 44 (26.3%) not answering, 86 (51.5%) receiving some form of financial aid, and 37 (22.2%) with no financial aid. The average course load during the semester studied was 9.6 billable hours and credits combined, with 80 students (47.9%) being full-time during the studied semester. In terms of courses taken prior to the studied semester, the average was 23.8 hours completed, with 36 of the participants (21.6%) enrolling for the first time at the college.

Information was also gathered on the math background. Almost half of the students (49.1%) placed directly into the Intermediate Algebra class. Out of the remaining students, 45 took all three developmental math courses and 41 took the Introductory Algebra course before taking Intermediate Algebra. Of the 167 participants, 42 (25.1%) were repeating the Intermediate Algebra course having withdrawn or failed the course in the previous attempt. Until a student has successfully completed the

Intermediate Algebra class, he or she is not eligible to enroll in a college-level math class. The community college Math Department policy states that students earning a grade of A, B, or C in Intermediate Algebra were successful in the course. Out of the 167 participants, 97 (58.1%) were successful. The final exam was 30% of the course grade and was necessary for the student to be successful. However, all of the students did not take the final exam. Some students stopped attending the course without officially withdrawing; others attended through the last week of classes. In both cases, the students did not complete the course, having a negative impact on their course grade. 18.8% of the students did not take the final, making it impossible for them to be successful. For this sample, 134 of the 167 students or 80.2% completed the course. Of the 134 students that did complete the course, 72.4% were successful.

Description by Learning Environment

The students self-selected their learning environment, with 34.7% enrolling in the face-to-face classes, 27.5% enrolling in the hybrid classes, and 37.7% enrolled in the online classes. There was a significant difference in age by learning environment, $F(2, 164) = 8.194$, $p = .000$, with the online students ($M = 28.75$, $SD = 8.193$) being the oldest group. There was also a significant difference in gender, χ^2 (2, N = 167) = 8.040, $p = .018$, with the online class having the largest percentage of females (71%), over both the face-to-face (47%) and hybrid (54%) environments. No differences were found for either race or financial aid among the learning environments. Demographic information is provided in Table 5.

Table 5

Demographics

	Face-to-face (n = 58)	Hybrid (n = 46)	Online (n = 63)
Gender*			
Male	31	21	18
Female	27	25	45
Race			
Caucasian	22	25	34
African-American	30	18	24
Hispanic	2	0	1
Asian	2	2	1
American Indian	1	0	0
Other/Multi-racial/Unknown	1	1	3
Age Range*			
Under 20	31	13	6
20 – 24	17	18	20
25 – 29	1	5	12
30 – 34	3	3	9
35 – 39	4	3	9
40 – 44	0	2	4
45 – 49	1	1	3
50 and older	1	1	0
Financial Aid			
Received aid	25	21	40
No aid	9	10	18
Not reported	24	15	5
Student Status			
Part-time	19	25	44
Full-time	39	21	19
Enrollment History			
New to the college	16	16	4
Returning student	42	30	59

* $p < 0.05$

Based on math placement scores and previous math courses at the college, there was no statistically significant difference across the learning environments. The number of times previous developmental math courses were taken, the grades earned in them, and the initial math placement level were not statistically different based on learning environment. The algebra score on the placement test was statistically significant, $F(2, 158) = 4.543$, $p = .012$, with the hybrid ($M = 69.32$, $SD = 21.100$) class having the highest average score. This score is used to make placement determinations into math course, so it follows that the hybrid had a statistically significant amount of students place directly into the Intermediate Algebra course, χ^2 (2, N = 165) = 6.302, $p = .043$.

Attendance is usually an issue in developmental courses with a 56 – 81% attendance rate and a 62 – 81% retention rate (Waycaster, 2001). Based on the attendance records, the number of class sessions and online sessions were counted in addition to the minutes spent in class and online (see Table 6). On average, the online ($M = 71.00$, $SD = 40.089$) and hybrid ($M = 70.46$, $SD = 55.647$) students had twice as many sessions as the face-to-face ($M = 35.00$, $SD = 8.146$) class, $F(2, 164) = 16.364$, $p = .000$, but the online students spent the least amount of minutes in the class, $F(2, 164) = 4.427$, $p = .013$. The online students spent 23.98 minutes per session ($SD = 14.326$) as compared to the scheduled 55-minute and 85-minute sessions for the face-to-face classes. The face-to-face students averaged 65.16 minutes per class ($SD = 13.910$). Even the hybrid students, on average, spent less time per session ($M = 34.80$, $SD = 11.652$) than their scheduled 85-minute class sessions.

Current research shows common traits of online students (Carpenter et al., 2004; Dutton et al., 2002; Halsne & Gatta, 2002; Neuhauser, 2002; Parker, 1999; Sullivan, 2001, Thompson, 1998). The three surveys in this study measured locus of control, preferred learning styles, and technology skills. There was no significant difference in locus of control of the students in the different learning environments. For learning styles, Reading was the only significant difference, $F(2, 164) = 3.649$, $p = .028$, with the online students ($M = 9.44$, $SD = 3.187$) having the highest preference for Reading style and the face-to-face students ($M = 7.84$, $SD = 3.116$) having the lowest preference. The technical scores were not significantly different for the Use of Technology, Specific Computer Skills, and Ethics in Technology subscales. However on the other five subscales, the online students had the highest score, significantly higher than the face-to-face and hybrid scores (see Table 3). The subscales of Acquisition of Technical Knowledge, $F(2, 164) = 4.575$, $p = .012$, Basic Internet Knowledge, $F(2, 164) = 4.860$, $p = .009$, Internet Information Skills, $F(2, 164) = 3.551$, $p = .031$, Adapting to Technological Change, $F(2, 164) = 4.063$, $p = .019$, and Impact of Technology, $F(2, 164) = 3.271$, $p = .040$, were all significant. These differences could be why the online students chose that specific learning environment, but it still needs to be discussed in relation to student success.

Table 6

Results for Time on Task for All Subjects and by Learning Environment

	Sessions	SD Sessions	Total minutes	SD Minutes	Time per Session	SD Per Session
All Subjects	58.3	41.884	1971	1063.515	41.3	22.455
Face-to-face	35.0	8.146	2200	424.628	65.2	13.910
Hybrid	70.5	55.647	2098	1261.692	34.8	11.652
Online	71.0	40.089	1667	1245.811	24.0	14.326
p-value	<0.001*		0.013*		<0.001*	

Note. The Sessions column includes the number of times a student logged into the online component plus the number of times they attended a face-to-face session. The total minutes is based on the course management software and attendance records for face-to-face sessions tracking students that left early or arrived late. The time per session was calculated by dividing the total minutes by the number of sessions. $*p < 0.05$

Summary of Descriptive Statistics

The sample for this study was taken from an Intermediate Algebra class offered in face-to-face, hybrid, and online learning environments at a Mid-Atlantic community college. Student gender was 58.1% female, with 71% of the online students being female. The average age of the sample was 25.5 years old, but the online students were the oldest with a mean of 28.7 years old. The sample was predominantly Caucasian (48.5%) and African-American (43.1%) and there was no significant difference in race across the learning environments. Most of the placement information and math course history showed no differences, but the algebra score and the initial course placement was the highest for the hybrid students. This group was the most likely to have placed directly into the Intermediate Algebra course.

The online and face-to-face students were able to control how often and for how long they were "in class" by determining when they logged in to the course. They had twice as many sessions as the face-to-face students, but spent less time overall in the course. The minutes per session for the online (M = 23.98, SD = 14.326) and hybrid (M = 34.80, SD = 11.652) were less than for the face-to-face (M = 65.16, SD = 13.910), but also less than the college scheduled times for face-to-face classes. The online and hybrid students spent less time per session, but were "in class" more times per week than the face-to-face students.

Research Questions

This study focused on student success in developmental math classes when presented in different learning environments. The research investigated characteristics that may make one group of students more likely to be successful in a specific learning environment. This section contains the results pertaining to the research questions for this study: (1) Are three different delivery methods (face-to-face, hybrid, fully online) equally effective as measured by course grades? (2) Which external characteristics (e.g. gender, age, ethnicity) are significant in determining student success in each of the three learning environments? (3) Which internal characteristics (e.g. learning style, motivation) are significant in determining student success in each of the three learning environments?

Research Question 1

This section presents the results for Research Question 1: Are three different learning environments (face-to-face, hybrid, fully online) equally effective as measured by course grades? Data used to answer this question came from the student test grades, the score on the Intermediate Algebra Comprehensive Exam (IACE), and the student average for the course. Data was also used for success and completion with success defined as a course grade of 70% or higher, making the student eligible for college-level math courses, and completion defined as having taken the IACE during final exam week.

When evaluating the scores earned on unit tests and the IACE, as well as the overall average, results of one-way ANOVA revealed that there was a significant difference for the IACE ($p = 0.047$), the overall average ($p = 0.036$), and four of the seven unit tests: Functions ($p = 0.002$), Rational Expressions ($p = 0.036$), Imaginary and Complex Numbers ($p = 0.004$), Parabolas and Circles ($p = 0.023$). The results of the ANOVA are presented in Table 7. For all of the tests, the IACE, and the overall average, the hybrid students had the lowest mean score. Using the course average, there is a statistically significant difference based on the learning environment ($F(2, 164) = 3.399$, $p = .036$), with the hybrid being the lowest score.

Table 7

Results on Unit Tests and IACE by Learning Environment

	Face-to-face	Hybrid	Online	F	p
Test #1[a]	70.10	67.87	77.62	2.211	.113
Test #2[b]	88.66	69.48	74.97	6.540	.002*
Test #3[c]	50.38	45.37	59.33	3.386	.036*
Test #4[d]	67.31[M]	55.57	64.24[M]	2.004	.138
Test #5[e]	83.45	62.20	78.22	5.682	.004*
Test #6[f]	63.78[N]	52.85	64.70[N]	1.824	.165
Test #7[g]	75.47	54.39	64.98	3.857	.023*
IACE	60.24	45.76	50.65	3.146	.046*
Average	68.07	54.54	63.90	3.399	.036*

Note. All of the scores above are percentages. Means sharing the same superscript (M, N) are not significantly different from each other. Effect sizes were calculated on the Average. The effect size for face-to-face to online was 0.172 favoring the face-to-face environment. The effect size for face-to-face to hybrid was 0.533 favoring the face-to-face environment. The effect size for online to hybrid was 0.312 favoring the online environment. *$p < 0.05$. [a]Factoring, [b]Function notation and operations, [c]Rational Expressions, [d]Radicals, [e]Complex and Imaginary Numbers, [f]Solving Quadratic Equations, [g]Parabolas and Circles.

Issues with attrition. Attrition rates are high for community college students, 65 – 71% after one year and 82 – 84% after two years (Mohammadi, 1994). This is a large problem for this population. By adding distance education which increases attrition by 10 – 20% (Angelino, Williams, & Natvig, 2007), these students faced a greater challenge in just remaining in the course for the entire semester. Knowing that this issue existed, this research could not overlook the fact that all students did not complete all the tests and exams for the course. For all of the tests and the IACE, each learning environment had students that did not take the test or exam. All students were given an equal opportunity to make-up tests that were missed during the semester, but at the end of the semester, there were students that still had a test grade of zero. For the face-to-face environment, there were one to five zeros on each test and four students that did not take the IACE, resulting in an overall average of 5% of the grades being zeroes. For the hybrid environment, there were six to 15 zeros on each test and 14 students did not take the IACE, resulting in an overall average of 23% of the grades being zeroes. For the online environment, there were four to 19 zeros on each test and 15 students did not take the IACE, resulting in an overall average of 18% of the grades being zeroes. With so many zeroes in the hybrid and online environments, the impact on their averages would be greater than for the face-to-face environment.

Removing the zero grades and re-analyzing the data, changed the results so that the IACE scores were no longer significantly different ($F(2, 131) = .126$, $p = .882$). For all of the other scores, there were statistically significant differences based on the learning environment, but the hybrid course was no longer the lowest average. For the tests on Unit 2 (Functions), 4 (Radicals), and 7 (Parabolas and Circles), the hybrid students had the lowest average. For the tests on Unit 1 (Factoring), 3 (Rational Expressions), 5 (Imaginary and Complex Numbers), and 6 (Solving Quadratic Equations), plus the course average, the face-to-face students had the lowest average. The impact of removing the zero grades changed the learning environment with the lowest course average from the hybrid to the face-to-face environment. It also changed the highest course average from the face-to-face to the online environment. The full results without zero grades can be found in Table 8.

Table 8

Results on Unit Tests and IACE by Learning Environment, without zero grades

	Face-to-face	Hybrid	Online	F	p
Test #1[a]	72.61	78.05	82.88	5.454	.005*
Test #2[b]	90.21	84.11	87.46	3.487	.033*
Test #3[c]	53.13	56.41	67.96	6.638	.002*
Test #4[d]	70.98	69.08	79.35	4.701	.011*
Test #5[e]	84.91	86.70	92.98	4.893	.009*
Test #6[f]	68.50	73.67	83.18	7.088	.002*
Test #7[g]	81.06[M]	78.19[M]	93.05	7.327	.001*
IACE	64.70[N]	65.78[N]	66.48[N]	.126	.882
Average	73.12	76.17	80.68	5.355	.044*

Note. All of the scores above are percentages. Means sharing the same superscript (M, N) are not significantly different from each other.*$p < 0.05$. [a]Factoring, [b]Function notation and operations, [c]Rational Expressions, [d]Radicals, [e]Complex and Imaginary Numbers, [f]Solving Quadratic Equations, [g]Parabolas and Circles.

Some of the students that had zero scores had stopped attending the course, but had not officially withdrawn. These students impacted the success of the students in each learning environment. In terms of overall success in the course, 59% of the face-to-face students, 48% of the hybrid students, and 65% of the online students were eligible to take college-level math. In terms of completion of the course, 93% of the face-to-face students, 70% of the hybrid students, and 76% of the online students remained in the course throughout the end of the semester and took the final exam. Students that stop attending the course do so for various reasons which were not a part of this study; however this choice impacted the hybrid and online environments more so than face-to-face because as a result they had lower completion rates. Looking at only students that completed the course, 63% of the face-to-face students, 69% of the hybrid students, and 85% of the online students were successful.

After analysis of this data, one can argue that the different learning environments are not equally effective. Students enrolled in the hybrid environment had the lowest IACE grade, course average and were least likely to be successful in the Intermediate Algebra course. However these results cover the intent to treat all subjects. Not all of the subjects remained in the course for the entire semester. When looking at the treated subjects, the face-to-face environment has the lowest success rate. This difference is due to the online and hybrid classes having lower retention rates for the semester.

Research Question 2

This section presents the results for Research Question 2: Which external characteristics (e.g. gender, age, ethnicity) are significant in determining student success in each of the three learning environments? Data used to answer this question was gathered from the college database. Both one-way ANOVA and Chi-Square analysis were completed on the characteristics comparing the successful students to those that were not successful.

When evaluating the external characteristic of gender, results of a Chi-Square test revealed that there was no significant difference between the successful and not successful students, χ^2 (2, N = 167) = .278, p = .598. Results of a one-way ANOVA revealed that there was no significant difference between the successful and not successful students based on age (F(1, 165) = 2.425, p = .121), ethnicity (F(1, 165) = .370, p = .544), when a student registered for the course (F(1, 165) = 3.327, p = .070), or the student's status as full-time (F(1, 165) = .028, p = .868), overall or within any of the learning environments.

The number of credit or billable hours previously taken or taken within the studied semester showed a statistically significant difference for successful and not successful students. Since developmental courses are non-credit, the number of billable hours was counted in place of credits. The number of registered hours of coursework taken prior to the studied semester was statistically significant (F(1, 165) = 4.903, p = .028), with the successful students having a mean of 20.7 hours (SD = 20.663) compared to the not successful students having a mean of 27.8 hours (SD = 21.807). This significant difference did not exist within any of the learning environments, only overall across all participants. When looking at the number of registered hours of coursework during the studied semester, there was no significant difference in success across all participants (F(1, 165) = 1.456, p = .229), however when looking within the learning environments, there was a significant difference for hybrid students (F(1, 44) = 4.574, p = .038) with the successful hybrid students having a mean of 10.7 hours (SD = 3.357) and the not successful hybrid students having a mean of 8.5 hours (SD = 3.477). These results can be found in Table 9.

The only other significantly different characteristic was for students new to the college. This population was enrolled in their first semester at the college during the semester studied. Across all the participants, there was no significant difference between successful and not successful new students (χ^2 (1, N = 167) = 3.768, p = .052). However within the face-to-face learning environment, there was a significant difference (χ^2 (1, N = 58) = 4.665, p = .031) with the successful face-to-face student more likely to be a new student. Being a new student was not statistically significant for successful students in either the hybrid or online environments.

Table 9

P-values for external characteristics of successful vs unsuccessful students

	Face-to-face	Hybrid	Online	Overall
Gender	0.531	0.536	0.452	0.598
Age	0.998	0.233	0.257	0.121
Race	0.344	0.297	0.295	0.544
Financial Aid	0.070	0.709	0.330	0.917
Registration	0.932	0.333	0.868	0.863
Full-time status	0.104	0.080	0.715	0.867
New Student	0.031*	0.404	0.130	0.052
Credits/Billable Hours				
This semester	0.551	0.038*	0.280	0.229
Prior history	0.065	0.208	0.523	0.028*

*p < 0.05

After analysis of this data, this research found that external characteristics were not significantly different between successful and unsuccessful students in the Intermediate Algebra class. Overall successful students were more likely to have taken fewer hours of coursework prior to the studied semester. In the face-to-face learning environment, successful students were more likely to be new to the college than returning students. In the hybrid learning environment, successful students were more likely to carry a larger credit load than unsuccessful students. In the online learning environment, there were no significant differences with regard to success.

Research Question 3

This section presents the results for Research Question 3: Which internal characteristics (e.g. learning style, motivation) are significant in determining student success in each of the three learning environments? Data used to answer this question were gathered from three surveys completed by the subjects: VARK, RLC, and TIA. Scores for each of the learning styles were gathered from the VARK, the individual locus of control score from the RLC, and the technology scores on the eight subscales of the TIA were analyzed across all the participants as well as within each of the learning environments.

Learning styles. To analyze participants' learning styles, a one-way ANOVA was used to determine if there was a significant difference in preference between successful and not successful students. In these cases, the successful student had a weaker preference for the learning style than the student that was not successful. Across all the subjects, only the Kinesthetic learning style was statistically significant between successful and unsuccessful students ($F(1, 165) = 5.120$, $p = .025$), but significance did not exist within any of the specific learning environments. In the face-to-face environment, successful students had a statistically lower preference for Visual ($F(1, 56) = 4.509$, $p = .038$) and Auditory ($F(1, 56) = 13.825$, $p = .000$) learning styles. In the hybrid learning environment, successful students had a statistically lower preference for the Reading/Writing learning style ($F(1, 44) = 4.111$, $p = .049$). The online students were not significantly different in their preferred learning styles between those that were successful and those that were not.

Locus of control. A student with an internal locus of control accepts responsibility for the events in her life while an external locus of control student typically believes things are beyond his control. There were no statistically significant differences between successful and unsuccessful students on locus of control (χ^2 (2, N = 167) = 3.234, p = .198). Within the specific learning environments, there were also no significant differences in locus of control between successful and unsuccessful students.

Technology skills. The TIA was scored based on the eight subscales. There was a significant difference on three of the subscales between successful and not successful students: Use of Technology (p = 0.027), Specific Computer Skills (p = 0.039), and Acquisition of Technical Knowledge (p = 0.033). In all of these cases, the successful student had a lower score on the assessment. Across all subjects, the only subscale with a significant difference was Use of Technology (F(1, 165) = 4.982, p = .027) with the students who were not successful having a higher score. This scale was also statistically significant for the face-to-face learning environment (F(1, 56) = 5.249, p = .026). There was no technology use in the face-to-face class and the students with the higher score on the Use of Technology scale were more likely to be not successful. The Specific Computer Skills subscale was statistically significant only within the hybrid environment (F(1, 44) = 4.525, p = .039) with the successful students having the lower score. The Acquisition of Technical Knowledge subscale was statistically significant only within the online environment (F(1, 61) = 4.771, p = .033) with the higher score being more likely to be successful. The results for all three instruments can be found in Table 10.

Table 10

P-values for internal characteristics of successful vs unsuccessful students

	Face-to-face	Hybrid	Online	Overall
VARK				
Visual	0.038*[M]	0.668	0.539	0.090
Auditory	<0.001*[M]	0.832	0.789	0.088
Reading/Writing	0.131	0.049*[M]	0.920	0.063
Kinesthetic	0.055	0.112	0.432	0.025*[M]
RLC				
Locus of Control	0.270	0.856	0.901	0.501
TIA				
UOT[a]	0.026*[M]	0.460	0.309	0.027*[M]
SCS[b]	0.138	0.039*[M]	0.405	0.140
ATK[c]	0.649	0.119	0.033*[N]	0.573
BIK[d]	0.067	0.065	0.729	0.073
IIS[e]	0.072	0.156	0.647	0.081
ATC[f]	0.386	0.142	0.795	0.380
IOT[g]	0.087	0.963	0.610	0.321
EIT[h]	0.121	0.102	0.838	0.080

[a]Use of Technology. [b]Specific Computer Skills. [c]Acquisition of Technical Knowledge. [d]Basic Internet Knowledge. [e]Internet Information Skills. [f]Adapting to Technological Change. [g]Impact of Technology. [h]Ethics in Technology. *$p < 0.05$ [M]The successful student had the significantly lower score than the unsuccessful student. [N]The reliability score was low, making it difficult to determine what this result means.

After analysis of this data, one can argue that preferred learning style and technology scores have an impact on student success, but the locus of control does not. Whenever there was a significant difference, successful students had lower scores than the students that were not successful. Across all the participants, students with a preference for kinesthetic learning and a higher score on the Use of Technology subscale were less likely to be successful. Within the face-to-face environment, students with a stronger preference for Visual and Auditory learning and a higher Use of Technology score were less likely to be successful. Within the hybrid environment, students with a stronger preference for Reading and Writing learning and a higher Specific Computer Skills score were less likely to be successful. Within the online environment, there is no statistically significant difference based on preferred learning style, but students with a higher Acquisition of Technical Knowledge score were more likely to be successful.

Summary

Students participating in this research were predominantly female (58.1%) with an average age of 25.5 years old. Almost the entire sample was Caucasian (48.5%) or African-American (43.1%). Approximately half of the students were full-time (47.9%) the semester studied. Only 21.6% were students new to the college. More than half of the students (58.1%) were successful. Of the 167 students, only 134 completed the course (80.2%). Of those that completed the course, 72.4% were successful.

Based on this research, the learning environment has an impact on success for the developmental math student. There was a statistically significant difference on four of the unit tests, the Intermediate Algebra Comprehensive Exam (IACE), and overall course average based on the learning environment. The hybrid students had the lowest average score on the IACE and overall course average with only 48% of them being successful in the Intermediate Algebra course. While this research did not study attrition, there was a statistically significant difference in the completion rates of the course based on the learning environment. With the online and hybrid classes having significantly fewer students complete the course, their success rates were impacted. If the research only studied the students that completed the course, there would still be a statistically significant difference in success based on learning environment, but the face-to-face students would have the lowest success rate.

When looking at the external characteristics such as gender, age, and ethnicity, there were no significant differences based on success. With almost 92% of the population being Caucasian or African-American, just these two races were evaluated and still there was no significant difference based on success. Financial aid and full-time status also did not show a statistically significant difference based on success. For the entire sample, the number of hours of coursework registered for prior to the studied semester was significantly different with the lower number of hours for the successful student. In the face-to-face class, the students new to the college were more likely to be successful. In the hybrid class, students registered for more course hours the semester studied were more likely to be successful. The online class had no significant differences based on success for any of the external characteristics.

When investigating the internal characteristics, learning styles, locus of control, and technology scores were analyzed. Across all the subjects, the student with a preference for kinesthetic learning was less successful. Within the face-to-face class, the students that preferred Visual learning or Auditory learning were less successful. Within the hybrid class, the students that preferred the Reading/Writing learning style were less successful. The online students had no significant difference in preferred learning style based on success. The locus of control was not significant overall or in any of the learning environments based on success. The higher Use of Technology score students were less successful across all the participants, but also within the face-to-face environment. Among the hybrid students, a higher Specific Computer Skills score meant a less successful student. Among the online students, a higher Acquisition of Technical Knowledge score meant a more successful student.

CHAPTER V. DISCUSSION

The number of students enrolling in community colleges is increasing, thereby increasing the need for developmental math courses. With large numbers of students needing some developmental coursework, college administration are looking to online and hybrid courses to meet the increasing demand. While present research states that students can be as successful in these distance learning environments, the majority of the research is focused on students in four-year universities (Bernard et al., 2004; Chernish et al., 2005; Dutton et al., 2002; Frederickson et al., 2005; Herman & Banister, 2007; Hodge-Hardin, 1997; Hughes & Hagie, 2005; Kromrey & Purdom, 1995; Neuhauser, 2002; Sauers & Walker, 2004; Scheetz & Gunter, 2004); the developmental student studied in this research represents a very different population (Grimes, 1997; Russell, 2008, Thompson, 1998, Waycaster, 2001).

Developmental math students may be recent graduates or non-traditional students returning to college. Many of these students struggle with math and would not take the course if it were not a requirement. These students bring with them a wide variety of experiences and expectations. Some are technology savvy while others do not even have a computer in their home. The use of technology to learn math may have a very different impact on this population than graduate students taking courses within their major. Current research with this population is limited, especially research with these students in a distance learning environment.

This chapter describes the research results for this study and includes the following sections: research summary, including a discussion of the results, recommendations for future research, and a conclusion.

Research Summary

This study examined student success in face-to-face, online, and hybrid developmental math courses. Differences in success based on the learning environment were investigated as well as specific student characteristics. Students completed surveys on learning styles, locus of control, and technology skills. These results were combined with demographic information gathered from the community college to determine student characteristics that may impact student success in developmental math or in specific learning environments.

The study participants were enrolled in an Intermediate Algebra course, with successful completion making the student eligible for college-level math courses. The course was offered in the traditional face-to-face environment, as well as fully online and a hybrid or blended environment. A total of 167 Intermediate Algebra students agreed to participate in the study with 58 face-to-face, 46 hybrid, and 63 online students. During registration, each course was denoted as face-to-face, hybrid or online and students self-selected the learning environment.

Four instruments were used to collect data for this study. The instruments were the VARK Learning Styles Inventory, Rotter's Locus of Control, the Technology and Internet Assessment, and the Intermediate Algebra Comprehensive Exam (IACE). The VARK, Rotter's Locus of Control, and the Technology and Internet Assessment collected data on student characteristics and were all completed during the first two weeks of the semester. The IACE collected data on student algebra skills and was given during final exam week. All 167 participants completed the first three surveys, but only 134 completed the IACE.

Demographic data was collected for all participants showing similarities and differences between participants in the learning environments. The overall average age for all participants was 25.5 years. The online students were significantly older than the rest of the participants with an average age of 28.7 years. No significant difference with regard to race was found across the learning environments; however the overall sample was predominantly Caucasian (48.5%) and African-American (43.1%). There was no difference across the learning environments in placement level, prior work in developmental math courses, or algebra placement scores. However there was a significant difference in the algebra placement score with the hybrid students scoring the highest. In addition to student differences existing before entering the class, the learning environments showed differences in the time students spent on task once in the class. The online students spent the least amount of time (in minutes) within the course, but logged in to the course more than twice the number of times than the face-to-face students met in the classroom. On average, the face-to-face students spent 65.2 minutes per class session while the hybrid (34.8 minutes) and the online (34.0 minutes) students spent significantly less per session. Rotter’s Locus of Control showed no difference across the learning environments and the VARK showed no difference for visual, auditory, and kinesthetic preferences. For the reading/writing preference, the face-to-face students had the lowest preference and the online students had the highest preference for that style. On the Technology and Internet Assessment, the eight subscales showed the highest scores for the online students and the lowest scores for the face-to-face students. The five subscales showing a significant difference were Acquisition of Technical Knowledge ($p = 0.012$), Basic Internet Knowledge ($p = 0.009$), Internet Information Skills (0.031), Adapting to Technological Change (0.019), and Impact of Technology (0.040).

Discussion of Results

This research investigated students enrolled in a developmental math course to see if there was a difference in success based on the learning environment (face-to-face, hybrid, or online). The study was conducted specifically with a community college population since most of the current research is with students at four-year colleges. The results of this research supported some areas of the current research but also provided some contradictory results. This section will discuss the results in relation to the questions that guided the research: success in each learning environment, external student characteristics linked to success, and internal student characteristics linked to success.

Success in Different Learning Environments

In an effort to respond to research question one, which focused on determining if the different learning environments (face-to-face, hybrid, and online) were equally effective, an ANOVA was used on the seven unit tests, the IACE, and the overall course average. There was a significant difference based on the learning environment for four of the unit tests (Functions, $p = 0.002$; Rational Expressions, $p = 0.036$; Imaginary and Complex Numbers, $p = 0.004$; Parabolas and Circles, $p = 0.023$), the IACE ($p = 0.047$), and the overall course average ($p = 0.036$). For one of the significant unit tests (Rational Expressions, $M = 59.33\%$), the online students had the highest average grade. Face-to-face students had the significantly highest score for the remaining three significant unit tests (Functions, $M = 88.66\%$; Imaginary and Complex Numbers, $M = 83.45\%$; Parabolas and Circles, $M = 75.47\%$), the IACE ($M = 60.24\%$), and the overall course average (M =

68.07%). In all of the significant results, the hybrid students had the lowest average (Functions, M = 69.48%; Rational Expressions, M = 45.37%; Imaginary and Complex Numbers, M = 62.20%; Parabolas and Circles, M = 54.39%; IACE , M = 45.76%; course average, M = 54.54%).

The developmental student population has been shown to be different than the university student population (Russell, 2008; Waycaster, 2001) and it seems that these differences impact student success in distance-based learning environments. The findings of this study contradict the current research finding of no significant difference in success based on learning environment (Chernish et al., 2005; Dutton et al., 2002; Frederickson et al., 2005; Herman & Banister, 2007; Hodge-Hardin, 1997; Kromrey & Purdom, 1995; Neuhauser, 2002; Sauers & Walker, 2004; Scheetz & Gunter, 2004). The results of this research show a significant difference ($F(2, 164) = 3.399$, $p = 0.036$) in success based on the learning environment, with the distance-based students doing worse than the traditional face-to-face developmental math students. The completion rates were also significantly different (χ^2 (2, N = 167) = 10.010, $p = 0.007$) with 93% of the face-to-face students completing the course compared to 70% of the hybrid students and 76% of the online students. This means that research conducted with university populations should not be used to identify best practices with community college students. Instead more research is needed with this population.

These analyses showed that the developmental student was not equally successful in the different learning environments. Students enrolled in the face-to-face environment were more likely to be successful than those enrolled in the distance-based environments. Students enrolled in the hybrid environment had the biggest disadvantage with less than half of them being successful. The completion rates in distance education courses need to be addressed and further research must be conducted especially with the growth and continued pursuit of online courses in community colleges.

Attrition. Two-year college students have attrition rates over 67% (Mohammadi, 1994; Rendon, 1995) during the first year. The rate rises to over 80% after two years (Mohammadi, 1994). The increase in attrition rates has been attributed to lower high school GPAs and to ethnicity (Feldman, 1993; Murtaugh, Burns, & Schuster, 1999). These characteristics are common in the developmental population at community colleges. By offering developmental courses in distance learning environments, the challenges inherently increase. Students taking distance education courses have a 10 – 20% increase in attrition rate over their face-to-face classmates (Angelino, Williams, & Natvig, 2007). The challenges developmental students face causes many to drop out of college and adding the options of online and hybrid courses only increases these challenges.

The ultimate goal for any developmental education program is for students to succeed in the courses and meet the requirements to enroll in college-level courses. The high attrition rate for this population means that many will not reach that goal. Attrition was not a part of a research question for this study, but the impact it had on the students in each learning environments was significant. Each learning environment had students that did not take a test or the IACE. The face-to-face environment had from one to five grades of zero for each test for an average of 5% of their scores. The hybrid environment had from six to fifteen grades of zero for each test for an average of 23% of their scores. The online environment had from four to nineteen grades of zero for each test for an average of 18% of their scores. With such a large number of zero grades, the distance learning environments had much lower averages than the face-to-face environment, impacting their success rate.

When the zero grades were removed, there was a shift in significance. The IACE ($F(2, 131) = 0.126$, $p = 0.882$) was now the only grade that was not significantly different across the learning environments. All of the test grades (Factoring, $p = 0.005$; Functions, $p = 0.033$, Rational Expressions, $p = 0.002$; Radical Expressions, $p = 0.011$; Imaginary and Complex Numbers, $p = 0.009$; Quadratic Equations, $p = 0.001$; Parabolas and Circles, $p = 0.023$) and the overall course average ($p = 0.006$) were now statistically significant based on the learning environment. The face-to-face students had the highest average on the Functions test (M = 90.21%), but had become the lowest score on four tests (Factoring, M = 72.61%; Rational Expressions, M = 53.13%; Imaginary and Complex Numbers, M = 84.91%; Quadratic Equations, M = 68.50%) and the overall course average (M = 73.12%). The online students had the highest grade for six of the seven tests (Factoring, M = 82.88%; Rational Expressions, M = 67.98%; Radical Expressions, M = 79.35%; Imaginary and Complex Numbers, M = 92.98%; Quadratic Equations, M = 83.18%; Parabolas and Circles, M = 93.05%) and the overall course average (M = 80.68%). When focusing on the students that completed the course, there is a significant difference (χ^2 (2, N = 167) = 6.688, $p = 0.035$) in success based on the learning environment. In this case, the online students had a 85% success rate, followed by 69% for hybrid and 63% for face-to-face.

These results showed a difference based on the learning environment. If a student completed the course, he/she was most likely to be successful in the online environment.

Further analysis completed on the participants sought to determine if there was a difference between the students completing the course or not. As expected, there were significant differences in the number of class sessions, time in class, and all of the test, exam, and course grades. The only other variable with a significant difference between students completing the course or not was delivery method ($F(1, 165) = 5.336$, $p = 0.022$). Those that completed the course were most likely to be in the face-to-face class. For all other student characteristics, there was no significant difference for those that completed the course. This study is unable to determine what might make a student more likely to complete the course.

Since developmental students had the best chance of being successful in the online environment, community colleges should increase their online offerings in developmental math with the understanding that attrition must be addressed. Furthermore the hybrid students were slightly more successful than the face-to-face students. This suggests that in order to meet the increasing demand for more courses, community colleges can offer developmental math courses in the hybrid environment without decreasing student success. Developmental students no longer need to put their job before their education. The distance education offerings will allow them to work on their education within the time constraints of their other responsibilities without reducing their chances at success as long as strategies to address attrition are pursued.

Attrition continues to be an issue for the developmental population and clearly the distance learning environments impacts this area. Further research needs to be conducted to determine the reasons these students drop out of their classes. Colleges need to determine what programs or policies could be created to lower the attrition rates for these students. While the online environment does increase the attrition rate, it also increases the success rate for the students that remain in the class. Since none of the student characteristics analyzed in this research impacted success for the online environment, any student could be successful in the online environment regardless of age, race, gender, placement scores, learning style, locus of control, or technology skills. The only factor that impacted success for developmental students in the online environment was completion of the course.

External Characteristics and Success

In an effort to respond to research question two, which focused on connections between success and external student characteristics such as, gender, age, race, financial aid, current and previous course load, new or returning student status, placement scores, and time on task were analyzed using ANOVA and Pearson's Chi-Square to determine if there were significant differences in these traits in relation to success. The analysis was done for all 167 participants and within each of the learning environments, comparing the successful students with those that were not successful. Further analysis was also conducted with the 134 participants that completed the course to determine if there were distinctions between those registered for the course and those that completed the course.

Demographics. This study showed that within the developmental math population, some distinctions in student characteristics are comparable to that of existing research. This study supports the fact that online students were more likely to be female than in the face-to-face or hybrid learning environments. This finding supports previous research (Carpenter et al., 2004; Halsne & Gatta, 2002). Previous research also reported that non-traditional students prefer the online environment (Carpenter et al., 2004; Halsne

& Gatta, 2002; Sullivan, 2001), as did this research with the average age of the online students (M = 28.7, SD = 8.193) significantly higher ($p < 0.001$) than the hybrid (M = 24.7, SD = 8.504) and face-to-face (M = 22.6, SD = 8.756) students. The present body of research with regard to ethnicity argues that the online population is predominantly Caucasian with the Hispanic population more prevalent face-to-face (Carpenter et al., 2004; Halsne & Gatta, 2002). The sample for this research was different in that there were similar distributions of Caucasian and African-American students across all learning environments.

There was no significant difference with regard to gender ($p = 0.601$), age ($p = 0.121$),or race ($p = 0.544$) and their success in the overall group or within any of the learning environments. Financial aid status was reported by 123 of the subjects and showed no significant difference ($p = 0.918$) with regard to success. These results help to show that a student's gender, age, race, or financial status has no impact on their success in developmental math. Male or female, young or old, African-American or Caucasian, the student could be successful in each of the learning environments. This means that the choices in learning environment do not need to be limited for a specific student population. Based on demographics, any student has the same chance of success or failure in any of the learning environments; so all students should be encouraged to choose the environment which is best one for their schedule.

When analyzing the 134 students that completed the course, demographics still showed no significant difference for student success. The online students that completed the course were still most likely to be female and older students, but these characteristics did not impact success. Those students that completed the course showed no demographic distinctions from the overall sample that would aid in understanding why certain students completed the course or why they were successful in the course.

Course History. The number of billable hours taken by participants during the semester studied was only statistically significant for the hybrid environment ($p = 0.038$). The successful students were enrolled in an average of 10.7 billable hours ($SD = 3.357$) while the unsuccessful students averaged 8.5 billable hours ($SD = 3.477$). These results showed that hybrid students carrying a more credits were more likely to be successful. Part-time students may be more likely to have outside factors impact their life, causing them to do poorly in school whereas full-time students may have more time to focus on their academics, leading to more success. When these results are viewed for the 134 students that completed the course, there is no significant difference based on success. This means that for those that complete the course, the number of billable hours taken this semester had no impact on student success in the Intermediate Algebra course.

The overall sample showed a significant difference in previous course load ($p = 0.028$) with the successful Intermediate Algebra students having taken less courses total than the non-successful students. For the 134 students that completed the course, there was now a significant difference in the previous course load for students that were successful or not in the course, only within the face-to-face learning environment. The successful students had completed fewer hours prior to this semester than their counterparts that were unsuccessful but had completed the course. Only the total number of billable hours was gathered, so it is unclear if these differences are in developmental courses or in credit level courses. These results could refer to students that have had to repeat courses or that had low placement scores in more than one subject or that chose to delay their math coursework. Further research is needed in this area to better understand the increase in course history that has a negative effect on success in Intermediate Algebra.

Student status. New student status was significantly different (χ^2 (2, N = 167) = 4.665, p = 0.031) for the face-to-face students with the successful student significantly more likely to be a new student and the non-successful student more likely to be a returning student. This means that in the face-to-face environment, a student new to the college is more likely to be successful in the Intermediate Algebra course. Returning students may have needed prior developmental math courses or may be repeating the Intermediate Algebra course. These students can benefit from the distance-based environments that allow the student to review material. In the face-to-face class, the pace and difficulty of the course may have left the returning students unable to comprehend one concept before being required to move on. A benefit of the distance-based environment is the ability to repeat and even return to previous topics for review.

When the further analysis was completed with the students that completed the course, being a new or returning student had no impact on student success, overall or within a specific learning environment. This means that the new status may have more of an impact on completion than on success, but further research is needed. The benefits of being able to review the material multiple times and have some control in the pace of the distance-based classes needs to be clearly explained to students. These benefits could be the difference in completion of the course, and ultimately success for the returning student.

Placement scores. In order to enroll in Intermediate Algebra, students either successfully completed the Introductory Algebra course or received an adequate score on the algebra placement test. The number of times a student needed to take the Introductory Algebra course was significantly different overall ($p = 0.001$) as well as within the face-to-face ($p = 0.011$) and hybrid ($p = 0.032$) environments. The students that were unsuccessful in the Intermediate Algebra course had, on average, taken the Introductory Algebra course more than once. The algebra placement scores were also significantly different overall ($p = 0.002$) as well as within the face-to-face ($p = 0.020$) and hybrid ($p = 0.028$) environments. The students successful in Intermediate Algebra had an average that was more than ten points higher than the average algebra placement score for the unsuccessful students. For the students completing the course, significant differences still existed in all of the learning environments as well as across all 134 students. For this smaller group, less attempts in the Introductory Algebra course as well as higher algebra placement scores were traits of the successful students.

These results suggest that weaker students struggle with success in the Intermediate Algebra class. The more times needed to pass the pre-requisite class led to less chance of success in the Intermediate Algebra course. However, these results were only found in the face-to-face and hybrid environments, even when looking at those completing the course. The online environment showed no significant difference in success for students repeating the pre-requisite class ($p = 0.249$) or for students with lower algebra placement scores ($p = 0.076$). The results of this research suggest that students that needed to repeat the Introductory Algebra had the best chance of success in the online environment. While a range of scores are used for placement, the students in the lower range should be encouraged to register for the online Intermediate Algebra course. With the ability to review pre-requisite materials, repeat current lessons, and set their own pace, weaker students met more success in the online environment.

Time on task. Attendance has long been an issue for developmental students. Waycaster (2001) found a 56 – 81% attendance rate for this population in the community colleges in Virginia. For this study, class sessions were the number of times the student met in the physical classroom (face-to-face and hybrid environments) plus the number of times he/she logged in to the online component of the course (hybrid and online environments) and class time was the total number of minutes in the class sessions. There was a significant difference ($p < 0.001$) in the number of class sessions for successful ($M = 70.2$, $SD = 44.757$) and unsuccessful ($M = 40.1$, $SD = 25.121$) students and a significant difference ($p < 0.001$) in the class time for successful ($M = 2325$, $SD = 1044.013$) and unsuccessful ($M = 1505$, $SD = 837.231$) students. However when the time per session was calculated, there was no significant difference ($p = 0.378$) in success. These results confirmed traditional teacher beliefs that attendance is crucial to success in class.

The learning environments showed significant differences in class sessions ($p < 0.001$) and class time ($p = 0.013$). The face-to-face students were limited to the scheduled meetings and had the smallest number of class sessions ($M = 35.0$, $SD = 8.146$) but the highest amount of time ($M = 2200$, $SD = 424.628$). The distance learning environments had a comparable amount of class sessions (online, $M = 71.0$, $SD = 40.089$; hybrid, $M = 70.5$, $SD = 55.647$), but the hybrid students ($M = 2098$, $SD = 1261.692$) were closer to the face-to-face students in class time than the online students ($M = 1667$, $SD =$

1245.811). The average time per session was 34.8 minutes (SD = 11.652) for hybrid students and 24.0 minutes (SD = 14.326) for online students, statistically different ($p < 0.001$) from the face-to-face students with 65.2 minutes (SD = 13.910). These results were shown in Table 6 in Chapter IV.

When looking at time on task for students completing the course, the online environment shows a change. The significant difference in time for successful students still exists for the overall sample as well as in the face-to-face and hybrid learning environments. However, there is no longer a significant difference in the number of sessions or the total time for the online environment. This means that for those completing the course, the time spent on the course has no impact on success. For this sub-sample, there was a significant difference for the time per session. This was a new finding since the entire sample of 167 participants showed none. For the group that completed the course, the successful students spent on average 40.4 minutes per class session but the students that did not pass the course even though they completed it spent an average of 50.4 minutes per class session. This could mean that the Cognitive Load was a factor in success, but further research is needed.

These results indicated that the standard practice of classes meeting three-hours per week, two or three times a week may not be necessary. Students in the distance learning environments spent much less time per session than the time imposed on the face-to-face classes. Perhaps the online and hybrid students reached their cognitive load and ended their session. This is an option not available to face-to-face classes scheduled for 55-minute or 85-minute sessions. Using the Cognitive Load Theory, perhaps success in developmental math is about working smarter, not longer. Further research is needed to determine the impact shortened class sessions would have on student success in the face-to-face environment.

Internal Characteristics and Success

In an effort to respond to research question three, which focused on connections between success and internal student characteristics, students completed surveys to determine their locus of control, preferred learning style, and technology skill level. ANOVA and Pearson's ChiSquare were used to determine if there was a significant relationship between the students' scores on each of the instruments and their success in the course. This section will discuss the results from the three surveys.

Locus of control. Previous research showed that students with an internal locus of control should be encouraged to register for non-traditional learning environments while students with an external locus of control may be better suited to a face-to-face course (Parker, 2003). However no significant difference among ($p = 0.103$) the students within the different learning environments existed in this research nor did the locus of control impact student success ($p = 0.244$). Even when the sample was reduced to only those that completed the course, there was still no significant difference.

Whether a student took responsibility for the outcomes in his life (internal locus of control) or blamed external factors for events such as failing a course or losing a job (external locus of control) did not make the student more or less likely to pass the Intermediate Algebra course. This was the case not only overall, with all the participants, but also within each of the learning environments. Students' perception/belief about their ability to take responsibility for their learning and grade had no impact on their success within the course.

Learning styles. Neuhauser (2002) stated that successful online students typically preferred visual or kinesthetic learning, but this research found no significant difference in learning preferences for successful and not successful online students. According to Dutton et al. (2002) and Halsne & Gatta (2002), face-to-face students preferred auditory learning, but this research found a strong preference in auditory learning in face-to-face students among those that were unsuccessful. The successful students had lower scores for the auditory learning style preference.

The learning styles preference showed a significant difference in Kinesthetic ($p = 0.025$) overall, to the entire sample, as well as in Visual ($p = 0.038$) and auditory ($p < 0.001$) within the face-to-face environment and in Reading/Writing ($p = 0.049$) within the hybrid classes. A preference for a particular learning style had no impact on student success within the online class. Students with a strong preference for a learning style typically did not do well in the course. Analysis of data for the whole sample showed that students with a strong preference for kinesthetic learning were more likely to not be successful. However this result did not appear within any of the specific learning environments. In the face-to-face class, students that had a higher preference for visual or auditory learning were more likely to not be successful than students with a lower score in these two areas. This difference was not seen in the other learning environments. In the hybrid classes, students with a stronger preference for the reading learning style were less likely to be successful.

This class is a non-credit course taught as a review of material that students had in high school. Math manipulatives are not used within the course, reducing the kinesthetic appeal. However, because this difference was across the whole sample and not within specific environments, perhaps the students were able to modify their learning strategies to meet the needs of the environment. Across all the environments, when the learning style impacted success, the students with the weaker preference did better. The students with a lower preference for a particular style may have a strong preference in another style, or they may be multi-modal meaning that they have preferences in multiple learning styles. This could mean that the multi-modal student is more likely to be successful than the student with one specific learning style preference. Further research would be needed to confirm this.

Analyzing the learning style preferences for the students that completed the course yielded different results. When studying this smaller sample, the Visual, Reading/Writing, and Kinesthetic learning preferences are no longer significant overall nor within any of the learning environments. Only the Auditory learning preference remained significant and only within the face-to-face learning environment. The successful students still had a lower preference for the learning style than the students that did not pass the course.

Technology and internet assessment. For the technology skills of the students, only two of the eight subscales showed a significant difference with regard to student success. Basic Internet Knowledge, Internet Information Skills, Adapting to Technological Change, and Ethics in Technology had no impact on student success overall or within a specific learning environment. Students with high scores in these scales were as likely to be successful as students with lower scores. The Use of Technology score was significant in student success overall ($p = 0.027$) and in the face-to-face class ($p = 0.026$). In both cases the successful students had a lower Use of

Technology score than the students that were not successful. This means that students with the self-reported ability to use technology did worse. In the face-to-face class, no technology was used at all, not even to present material in the classroom. Perhaps students that were familiar with the use of technology were negatively impacted by the absence of it in the face-to-face course. Using online homework, web supplemental materials, or technology within the face-to-face sessions may improve the strong technology students' chance for success. Further research needs to be conducted with the face-to-face learning environment.

For the hybrid students, the Specific Computer Skills subscale was significantly ($p = 0.039$) different for the successful and unsuccessful students. The unsuccessful students had higher scores on this subscale than those that were successful. The course offers an online orientation to the tools used within the course management software. During the study, students were encouraged to complete the orientation, but were not tracked. The students with higher specific computer skills may have bypassed the orientation, assuming that they already knew how to do it. Making the orientation a requirement may make a difference since there is evidence that students would benefit from a review of the tools.

Further analysis with the students that completed the course led to different results. While the online environment still showed significantly higher technology skills on the subscales, there was no difference when analyzing student success. For all eight subscales, the students successfully completing the course were not significantly different than the students that completed the course but were not successful.

For the online environment, there was no significant difference in success based on the Use of Technology ($p = 0.309$) or Specific Computer Skills ($p = 0.405$) subscales. In fact, none of the subscales had an impact on success for the online students. This contradicts the student readiness assessments being used at institutions such as University of Georgia, Portland State University, and St. Petersburg College, as well as the commercial product READI (Readiness for Education at a Distance Indicator) that colleges can purchase for use by their students considering online courses. In all of these instruments, technical skills are a large component and in most cases they are the beginning set of questions asked. While technical skills are a part of the institution's self-assessment for students interested in taking online courses, this research is contradictory. When studies discuss what a student needs to be successful online, technology skills rarely make the list (Bozarth, Chapman, & LaMonica, 2004; Roper, 2007). This means that regardless of the existing technology skills, students could be just as successful within the online Intermediate Algebra course. While some institutions require training or a technology assessment score in order to register for online classes, the results of this analysis show that the technology expertise of online students played no role in their success. However these students self-selected into the online learning environment and therefore may have specific reasons for choosing it that go beyond their technical skills.

Recommendations for Future Research

The results of this study showed that developmental math students were most successful in the face-to-face learning environment. During the analysis, several questions, rather than answers, developed. These questions pointed to the need for further research within the areas of attrition, learning style preference, and the face-to-face learning environment.

Attrition. Both the online and hybrid environments had significantly higher ($p = 0.007$) attrition rates than the face-to-face environment. Investigation into the reasons that students do not complete the course is recommended. These environments were more successful for the students that did complete the course. This means that attrition accounts for the low success rate in the distance learning environments. For the students that remained throughout the semester, online students had an 85% success rate. With an attrition rate of 24%, it is clear that reasons other than the learning environment impacted success for these students. Further research on strategies to improve student attrition is also important.

Learning style preference. For the purpose of this study, numerical scores for each of the learning styles were used. A high score for a specific learning style indicated a strong preference. A low score for a specific learning style may indicate a weak preference, but it could be that the student preferred multiple learning styles and therefore had lower scores for several styles. The student with more than one strong preference in learning styles is called multi-modal. The analysis showed that students without a strong preference were more likely to be successful. More research is needed to determine if these students had a strong preference for another learning style or perhaps were multi-modal, allowing them to be successful in several learning styles.

Face-to-face sessions. The class schedule offered students the option of meeting twice a week for 85-minutes or three times a week for 55-minutes each time. These times were based on the present meeting pattern used by the college. The distance learning students had more flexibility in the duration and frequency of their class “sessions” online. The successful online and hybrid students spent an average of 25 – 30 minutes per session with an average of twice the number of sessions that the face-to-face students met. Perhaps some alternative face-to-face sessions could be piloted that meet for less time, but more often each week. Future research is needed to determine if the present intensity and duration for face-to-face students is ideal or if more frequent meetings can improve student success.

Conclusion

This research showed that the three different learning environments (face-to-face, hybrid, and online) were not equally effective for developmental math students at the community college. Based solely on a course grade of 70% or higher, the face-to-face environment had significantly ($p = 0.036$) better results. Research in this area has been conducted in the past showing no significant difference in success based on the learning environment with upper-class and graduate students. This research showed that the developmental population has different characteristics requiring this study to be conducted with this population. One of the unique characteristics is the high attrition rate for developmental students, with less than 20% of the students remaining after two years (Mohammadi, 1994). Attrition had a large impact on the students in the distance based environments with only about three-quarters of the students in these environments remaining throughout the semester. For the students that did remain, the online students had the highest success rate (85%), leading one to wonder what could be done to increase the numbers of students completing the online course.

The analyses showed that few student characteristics impacted student success in the developmental math class. Gender, age, race, financial aid, part-time or full-time status, and locus of control had no impact on student success overall in Intermediate Algebra nor within any of the specific learning environments. If attrition rates can be addressed, students with various backgrounds can be encouraged to register for online and hybrid classes without lowering success rates. The online students showed no difference in success based on learning preferences or on technology skills meaning that how a student prefers to learn or what skills he/she brings with them to the class does not put them at a disadvantage.

Community colleges can offer developmental courses in face-to-face, hybrid, and online learning environments. This student population does the best in the traditional classroom, but students in the online and hybrid courses can be successful. Finding a significant difference in attrition ($p = 0.007$) based on the learning environment showed that perhaps it was the students' reasons for dropping out of the class, not the learning environment that caused the difference in success.

APPENDICES

Appendix A

Towson University IRB Approval

TOWSON UNIVERSITY

EXEMPTION NUMBER: 09-1X20

To: Jean Ashby

From: Institutional Review Board for the Protection of Human Subjects, Deborah Gartland, Member

Date: Tuesday, February 24, 2009

RE: Application for Approval of Research Involving the Use of Human Participants

Office of University Research Services

Towson University
8000 York Road
Towson, MD 21252-0001

t. 410 704-2336
f. 410 704-4494

Thank you for submitting an application for approval of the research titled,
The Impact of Delivery Method on Student Success in Developmental Math

to the Institutional Review Board for the Protection of Human Participants (IRB) at Towson University.

Your research is exempt from general Human Participants requirements according to 45 CFR 46.101(b)(2). No further review of this project is required from year to year provided it does not deviate from the submitted research design.

If you substantially change your research project or your survey instrument, please notify the Board immediately.

We wish you every success in your research project.

CC: WM. Sadera
File

Appendix B

Community College of Baltimore County (CCBC) IRB Approval

CCBC
The Community College
of Baltimore County

CCBC Catonsville
800 South Rolling Road
Baltimore, Maryland
21228-5317
4 0.455 6050

CCBC Dundalk
7200 Sollers Point Road
Baltimore, Maryland
21222 4649
4 0.282.6700

CCBC Essex
7201 Rossville Boulevard
Baltimore, Maryland
2 237-3899
4 0.682 6000

CCBC Hunt Valley
O McCormick Road
Baltimore, Maryland
21031 1002
4 0771 6835

CCBC Owings Mills
110 Painters Mill Road
Baltimore, Maryland
21117-4998

August 27, 2009

Ms. Jean Ashby
Associate Professor
School of Mathematics and Science
CCBC Catonsville

Re: CCBC IRB

Dean Jean:

We agree that this is an exempt study and has IRB approval from CCBC to proceed. Would you please send me an electronic version of the proposal for our files? Please keep us informed if there are changes in the study design.

Let me know if there are ways that PRE might be able to support. You have previously asked about downloading student demographics for the CRN sections involved and we may be able to help if these sections are from relatively recent terms.

Please note that IRB approval indicates that it is ok to proceed with other parts of the study (gaining approval from department and other faculty if you will need to use their class time or resources); developing mechanisms for student informed consent, etc.

Good luck.

Dan McConochie
Senior Director
Planning, Research and Evaluation

www.ccbcmd.edu

Appendix C

Second Instructor's Personal Statement

As a mathematics teacher for approximately twenty years at a community college, I feel that my job/goal is to get students to understand the basic knowledge of mathematics, apply that knowledge to their world, and find a love for the subject. The first two parts are the easy part of my job, by explaining the process needed to solve problems, the rules to follow, and then showing them how math affects their lives by introducing applications. The last part is the most difficult, yet I think the most important. Since I teach mostly developmental mathematics, most of my students come into the class with negative feelings about the topic which I think leads to one of the reasons for a lack of motivation to learn. Some of these feelings are justified by their previous experience they have had in math due either to the rigidity of the instruction or the learning process, and this I think has created a "fear" of math which then can turn to "hate". I fell that once I can get them to not hate math, I can get them to see the true beauty it has and how it fits into their lives each day. To achieve this, I believe that learning the basics, the process for solving problems, and then providing various delivery methods (online, hybrids, face-to-face) are the key essentials for student success in not just math, but all courses. In using all types of delivery methods and systems in my classes, I have seen that giving students a choice of how they learn helps students reduce their fear and resistance to learning. This in turn I feel, opens their minds just a bit for the possibilities that math can do for them in achieving their goals.

If at the end of the semester, I have changed just one student's attitude toward mathematics, then I feel I have done my job!

Appendix D

Effect Size Calculations

<u>Chernish et al</u>

Trad SD $(0.765)\left(\sqrt{34}\right) = 4.461$
ITV SD = $(0.811)\left(\sqrt{31}\right) = 4.515$
Online SD = $(1.091)\left(\sqrt{18}\right) = 4.629$

Trad – online =

$$d = \frac{Mean_{trad} - Mean_{online}}{\sqrt{\frac{(n_t)(SD_t)^2 + (n_O)(SD_O)^2}{n_t + n_O - 2}}} = \frac{37.892 - 34.833}{\sqrt{\frac{(33)(4.461)^2 + (17)(4.629)^2}{34 + 18 - 2}}} = \frac{3.059}{4.519} = 0.677$$

<u>Scheetz</u>

$$d = t\frac{n_1 + n_2}{\sqrt{df}\sqrt{n_1 n_2}} = -.011\frac{7+7}{\sqrt{12}\sqrt{7*7}} = -.011(.577350269) = .006$$

<u>Frederickson</u>

F2f – web =

$$d = \frac{16.63 - 17.24}{\sqrt{\frac{(15)(5.04)^2 + (15)(4.27)^2}{28}}} = \frac{-0.61}{4.83} = -0.126$$

<u>Carpenter et al (Developmental Writing at CC)</u>

Online students are significantly more likely than traditional students to succeed in the course (odds ratio of 4.17, $p < 0.0001$)

According to Chinn (2000), an odds ratio can be converted to effect size by dividing by 1.81

Effect size = 4.17/1.81 = 2.303867403 = 2.304 This study had N = 256

<u>Calculate the Weighted Effect size…</u>

Chernish:	N = 52	ES = .677
Scheetz:	N = 14	ES = -.299
Frederickson:	N = 32	ES = -0.126
Carpenter:	N = 256	ES = 2.304

$$WES = \frac{(52)(.677) + (14)(-.299) + (32)(-0.126) + (256)(2.304)}{52 + 14 + 32 + 256}$$

$$= \frac{35.204 - 4.186 - 4.032 + 589.824}{354} = 1.742$$

Appendix E

Intermediate Algebra Course Outline and Schedule of Topics

I. Course Goals

A. Learning outcomes (as listed on the official common course outline):

a. Functions and Relations
   - i. Introduce function notation
   - ii. Identify the domain and range of a function
   - iii. Perform operations on functions

b. Quadratic Functions
   - i. Graph quadratic functions, identifying domain and range using function notation
   - ii. Solve quadratic equations using the square root method, factoring, completing the square, and the quadratic formula
   - iii. Perform operations on complex numbers
   - iv. Solve quadratic equations (including equations with complex number roots)
   - v. Use optimization and simulation methods
   - vi. Solve radical equations

c. Polynomial, Radical, and Rational Functions and Equations
   - i. Perform operations on polynomial expressions and factor
   - ii. Graph power and polynomial functions, identifying domain and range and using function notation
   - iii. Simplify radicals and expressions with rational exponents
   - iv. Perform operations on rational expressions
   - v. Solve rational equations

d. Exponential and Logarithmic Functions and Equations
   - i. Graph exponential functions, identifying domain and range and using function notation
   - ii. Graph logarithmic functions, identifying domain and range and using function notation
   - iii. Evaluate exponential and logarithmic functions

e. Conic Sections
   - i. Graph parabolas and circles
   - ii. Write equations of parabolas and circles

B. Objectives (as listed on the official common course outline):

a. Identify functions and use function notation
b. Determine the domain and range of a function
c. Factor, add, subtract, multiply, ad divide functions
d. Graph linear, quadratic, exponential and logarithmic functions
e. Solve quadratic equations by (1) factoring, (2) completing the square, (3) the quadratic formula, (4) graphing the function
f. Solve applications of quadratic equations
g. Perform operations on radical expressions
h. Perform operations on radical expressions
i. Solve radical equations
j. Simplify, factor, add, subtract, multiply, and divide rational expressions

k. Solve rational equations
l. Recognize and graph conic sections

C. Rationale: Algebra is a branch of mathematics which studies equations and the methods for solving these equations. Algebra has evolved for more than 3000 years and has emerged as a basic tool of modern science, social science, business, and technology. Algebra is a foundation for al higher mathematics, including, but not limited to, trigonometry, calculus, finite mathematics, probability and statistics. Algebra teaches not only skills, but also thought processes that will be used again and again in college level mathematics courses.

II. Schedule of Topics

Unit 1 – Factoring	
1.1 Greatest Common Factor	p. 299 #1 – 20
1.2 Difference of Squares	p. 313 #29 – 46
1.3 Sum or Difference of Cubes	p. 314 #79 – 98
1.4 Trinomial x^2 + bx + c	p. 306 #1 – 28
1.5 Trinomial ax^2 + bx + c	p. 306 #29 – 66
1.6 Factor Completely	p. 317 #1–4, 6, 8–11, 13–17, 19–24, 26, 29–34, 36, 39–41, 47–52
1.7 Solve equation by factoring	p. 326 #1–30
Unit 2 – Functions	
2.1 Domain and Range	p. 172 #1 – 10, 21 – 24
2.2 Relation is a Function	p. 172 #11 – 20
2.3 Evaluate Functions	p. 182 #1 – 26, 33 – 40
2.4 Add and Subtract Functions	p. 190 #1 – 10, 17 – 20, 26 – 28
2.5 Multiply and Divide Functions	p. 190 #11 – 16, 21 – 25, 29 – 30
2.6 Composition of Functions	p. 190 #31 – 36
Unit 3 – Rationals	
3.1 Find Domain	p. 345 #5 – 16
3.2 Reduce Rationals	p. 345 #1 – 2, 17 – 32, 41 – 52
3.3 Multiply Rationals	p. 362 #1 – 2, 7 – 8, 13 – 20, 27 – 32
3.4 Divide Rationals	p. 362 #3–6, 9–12, 21–26, 33–36, 45–64

3.5 Find the common denominator	
3.6 Add and Subtract Rationals	p. 372 #11 – 18, 25 – 64
3.7 Complex Fractions	p. 377 #7 – 22, 27 – 34, 43 – 52
3.8 Solve Rational Equations	p. 384 #1 – 16, 33 – 58
Unit 4 – Radicals	
4.1 Expressions with rational exponents	p. 416 #33 – 56
4.2 Simplify square roots	p. 424 #89 – 102
4.3 Simplify radical expressions	p. 430 #1 – 34
4.4 Add or subtract radicals	p. 435 #1 – 26, 39 – 46
4.5 Multiply radicals	p. 442 #1 – 30, 35 – 40, 43 – 48
4.6 Division without rationalization	
4.7 Division with rationalization	p. 430 #41 – 70, p. 442 #49 – 88
4.8 Solve radical equations	p. 450 #1 – 18
Unit 5 – Imaginary/Complex Numbers	
5.1 Imaginary and Complex Numbers	p. 458 #1 – 14
5.2 Add or subtract complex numbers	p. 458 #25 – 40
5.3 Multiply Complex Numbers	p. 459 #41 – 66
5.4 Divide Complex Numbers	p. 459 #67 – 78
Unit 6 – Solving Quadratic Equations	
6.1 Solve by taking the square root	p. 475 #1 – 16
6.2 Solve by completing the square	p. 475 #17 – 44
6.3 Solve using the quadratic formula	p. 485 #1 – 14, 17 – 18, 23 – 26
6.4 Solve application problems	p. 513 #29 – 31, 33 – 36
Unit 7 – Conic Sections	
7.1 Parabolas	
7.1a Find the vertex, line of symmetry	p. 513 #1 – 20
7.1b Find the intercepts	p. 513 #1 – 12
7.1c Find the min or max	p. 513 #21 – 28
7.2 Circles	

7.2a Use the center and radius to graph	p. 589 #23 – 36
7.2b Write equation given Center and r	p. 589 #13 – 22
7.2c Write equation in standard form	p. 589 #31 – 36
Unit 8 – Exponential & Logarithmic Function	
8.1 Evaluate exponential functions	p. 536 #1 – 8
8.2 Graph exponential functions	p. 536 #9 – 16
8.3 Convert between exp and log fns	p. 553 #1 – 24
8.4 Graph logarithmic functions	p. 554 #37 – 44
8.5 Simplify or solve	p. 553 #25 – 36, 45 – 54

Final Exam – The final exam will cover all the material from all the units in the course.

Appendix F

Participant Letter of Consent

CCBC
The Community College
of Baltimore County

January, 2009

Dear Participant,

A study is being completed in select Intermediate Algebra courses. This letter provides information about the study and your potential participation.

The purpose of this study is to identify student characteristics that may make someone more likely to be successful in an online, hybrid, or traditional face-to-face Intermediate Algebra class. Student success in the different courses will also be compared to see if students in an online or hybrid class are as likely to be successful as students in a traditional class. This study is being conducted as part of my doctoral dissertation work in Instructional Technology at Towson University.

The study involves the completion of a survey. The survey is sixty questions in length and will take approximately 25 – 30 minutes to complete. Data will also be collected from the college if you choose to participate. Your participation is completely voluntary. Your decision to participate or not has no impact on your grade or academic standing. If you choose to participate in the study, all information will be kept confidential. Only group data will be reported. No individual data will be reported.

If you have any questions about the project, you may contact Jean Ashby, 443-840-5969, my dissertation advisor at Towson University, Dr. William Sadera, 410-704-2731, or the Chairperson of the Community College of Baltimore County's Institutional Review, Dr. Dan McConochie, 443-840-4260. The Institutional Review Board at CCBC advocates for the rights and welfare of human research participants. The Board approved this study. A copy of the survey results will be available to you upon request.

Thank you for your time and consideration in participating in this study.

Sincerely,

Jean Ashby
Principal Investigator

Dr. William Sadera
Research Advisor

CCBC Catonsville
800 South Rolling Road
Baltimore, Maryland
21228-5317
410.455.6050

CCBC Dundalk
7200 Sollers Point Road
Baltimore, Maryland
21222-4649
410.282.6700

CCBC Essex
7201 Rossville Boulevard
Baltimore, Maryland
21237-3899
410.682.6000

CCBC Hunt Valley
11101 McCormick Road
Baltimore, Maryland
21031-1002
410.771.6835

CCBC Owings Mills
10 Painters Mill Road
Baltimore, Maryland
21117-4998
410.363.4111

The incredible value of education.

www.ccbcmd.edu

Appendix G

Permission to use Rotter's Locus of Control

Page 1 of 1

You forwarded this message on 1/30/2009 11:34 AM.

Ashby, Jean

From: Coldwell [eleanor.coldwell@uconn.edu] **Sent:** Fri 1/30/2009 8:54 AM
To: Ashby, Jean
Cc:
Subject: Re: Julian B. Rotter
Attachments:

Jean,
Dr. Rotter will grant you permission to use his I-E Scale' providing you agree to the following requests

He asks that you
1) collect all copies of the scale from participants
2) do not publish the scale anywhere
3) use the scale for research purposes only
4) get assistance from someone with previous experience administering and interpreting personality scales if you have none yourself.

The original 1966 article contains the full 29 item scale and instructions. *Psychological Monographs, 1966, 80,* 1-28.

Lindy

Eleanor (Lindy) Coldwell, Ph.D.
Academic Advisor
Psych Dept (100 BOUSFIELD) 486-2188 (during semesters)
&
CLAS [Dean's Office] Academic Services Center 486-2822 (semester breaks)

On Jan 29, 2009, at 8:55 PM, Ashby, Jean wrote:

> Hello,
>
> Your email is listed for Professor Emeritus Julian B. Rotter
>
> I am in a doctoral program in Instructional Technology and am looking towards beginning my dissertation work. I would like to use Rotter's Locus of Control survey as a part of my study.
>
> I know that there are various versions of the survey online, but I wanted to know if I could have permission to use it as a part of my research
>
> Thanks,
> Jean Ashby

Appendix H

The VARK Questionnaire

How do I Learn best?
Questionnaire version 7.0

Choose the answer which best explains your preference and circle the letter(s) next to it. Please circle more than one if a single answer does not match your perception. Leave blank any question does not apply.

1) I like websites that have:
    a. Things that I can click on, shift or try.
    b. Audio channels where I can hear music, radio programs or interviews.
    c. Interesting written descriptions, lists and explanations.
    d. Interesting design and visual features.

2) A group of tourists want to learn about the parks or wildlife reserves in your area. You would:
    a. Give them a book or pamphlets about the parks or wildlife reserves
    b. Show them internet pictures, photographs or picture books.
    c. Take them to a park or wildlife reserve and walk with them.
    d. Talk about, or arrange a talk for them about parks or wildlife reserves.

3) You have a problem with your knee. You would prefer that the doctor:
    a. Described what was wrong.
    b. Used a plastic model of a knee to show what was wrong.
    c. Gave you a web address or something to read about it.
    d. Showed you a diagram of what was wrong.

4) Do you prefer a teacher or presenter who uses:
    a. Handouts, books, or readings.
    b. Question and answer, talk, group discussion, or guest speakers.
    c. Demonstrations, models or practical sessions.
    d. Diagrams, charts or graphs.

5) Remember a time when you learned how to do something new. Try to avoid choosing a physical skill, eg. riding a bike. You learned best by:
    a. Diagrams and charts – visual clues.
    b. Watching a demonstration.
    c. Written instructions – e.g. a manual or textbook.
    d. Listening to somebody explaining it and asking questions.

6) You are planning a holiday for a group. You want some feedback from them about the plans. You would:
    a. Describe some of the highlights.

   b. Give them a copy of the printed itinerary.
   c. Phone, text, or email them.
   d. Use a map or website to show them the places.

7) You are using a book, CD or website to learn how to take photos with your new digital camera. You would like to have:
   a. A chance to ask questions and talk about the camera and its features.
   b. Clear written instructions with lists and bullet points about what to do.
   c. Diagrams showing the camera and what each part does.
   d. Many examples of good and poor photos and how to improve them.

8) You are about to purchase a digital camera or mobile phone. Other than price, what would most influence your decision?
   a. The salesperson telling me about its features.
   b. Trying it or testing it.
   c. Reading the details about its features.
   d. It is a modern design and looks good.

9) You are helping someone who wants to go to your airport, town center or railway station. You would:
   a. Write down the directions.
   b. Tell her the directions.
   c. Go with her.
   d. Draw, or give her a map.

10) You are going to choose food at a restaurant or café. You would:
   a. Listen to the waiter or ask friends to recommend choices.
   b. Choose something that you have had there before.
   c. Choose from the descriptions in the menu.
   d. Look at what others are eating or look at pictures of each dish.

11) You want to learn a new program, skill or game on a computer. You would:
   a. Talk with people who know about the program.
   b. Follow the diagrams in the book that came with it.
   c. Read the written instructions that came with the program.
   d. Use the controls or keyboard.

12) You are going to cook something as a special treat for your family. You would:
   a. Use a cookbook where you know there is a good recipe.
   b. Cook something you know without the need for instructions.
   c. Ask friends for suggestions.
   d. Look through the cookbook for ideas from the pictures.

13) You have finished a competition or test and would like some feedback. You would like to have feedback:
   a. Using graphs showing what you had achieved.

b. Using a written description of your results.
c. Using examples from what you have done.
d. From somebody who talks it through with you.

14) You are not sure whether a word should be spelled ‘dependent’ or ‘dependant.’ You would:
    a. Write both words on paper and choose one.
    b. Think about how each word sounds and choose one.
    c. Find it in a dictionary.
    d. See the words in your mind and choose by the way they look.

15) Other than price, what would most influence your decision to buy a new non-fiction book?
    a. Quickly reading parts of it.
    b. It has real-life stories, experiences, and examples.
    c. The way it looks is appealing.
    d. A friend talks about it and recommends it.

16) You have to make an important speech at a conference or special occasion. You would:
    a. Write a few key words and practice saying your speech over and over.
    b. Make diagrams or get graphs to help explain things.
    c. Gather many examples and stories to make the talk real and practical.
    d. Write out your speech and learn from reading it over several times.

Appendix I

TIA – Technology and Internet Assessment

Try to answer according to how well the statement describes you, not how you think you should respond or how others respond. There are no right or wrong answers to these statements. Please work as quickly as you can without being careless and please answer all items.

To help you decide which responses to select, we would like to explain what is meant by each term.

- By **Not at all typical of me,** we do not necessarily mean that the statement would never describe you, but that it would be true of you only in rare instances.
- By **Not very typical of me,** we mean that the statement generally would not be true of you.
- By **Somewhat typical of me,** we mean that the statement would be true of you about half the time.
- By **Fairly typical of me,** we mean that the statement would generally be true of you.
- By **Very much typical of me,** we do not necessarily mean that the statement would always describe you, but that it would be true of you almost all the time.

2) I am able to move computer files from one folder/directory to another.
   a. Not at all typical of me
   b. Not very typical of me
   c. Somewhat typical of me
   d. Fairly typical of me
   e. Very much typical of me

3) I spend time experimenting with programs I don't know very well in order to increase my knowledge.
   a. Not at all typical of me
   b. Not very typical of me
   c. Somewhat typical of me
   d. Fairly typical of me
   e. Very much typical of me

4) I would have difficulty attaching a file to an email message.
   a. Not at all typical of me
   b. Not very typical of me
   c. Somewhat typical of me
   d. Fairly typical of me
   e. Very much typical of me

5) I am able to evaluate a situation and decide if and which technology will help me solve a problem.
    a. Not at all typical of me
    b. Not very typical of me
    c. Somewhat typical of me
    d. Fairly typical of me
    e. Very much typical of me

6) Whether a work is published in print or from an electronic resource such as the internet, sometimes I am unable to identify an author's expertise in a work.
    a. Not at all typical of me
    b. Not very typical of me
    c. Somewhat typical of me
    d. Fairly typical of me
    e. Very much typical of me

7) I am able to adapt to new technologies without much trouble.
    a. Not at all typical of me
    b. Not very typical of me
    c. Somewhat typical of me
    d. Fairly typical of me
    e. Very much typical of me

8) I think that most jobs in the future that require the use of the computer will require strong thinking skills.
    a. Not at all typical of me
    b. Not very typical of me
    c. Somewhat typical of me
    d. Fairly typical of me
    e. Very much typical of me

9) When using a computer other than my own, I leave it ready for the next user.
    a. Not at all typical of me
    b. Not very typical of me
    c. Somewhat typical of me
    d. Fairly typical of me
    e. Very much typical of me

10) I know the difference between Quitting/Exiting a program and Minimizing a window.
    a. Not at all typical of me
    b. Not very typical of me
    c. Somewhat typical of me
    d. Fairly typical of me
    e. Very much typical of me

11) I can use search engines to locate information on a given topic.
    a. Not at all typical of me
    b. Not very typical of me
    c. Somewhat typical of me
    d. Fairly typical of me
    e. Very much typical of me

12) I can use a word processing program to organize data into a printed report.
    a. Not at all typical of me
    b. Not very typical of me
    c. Somewhat typical of me
    d. Fairly typical of me
    e. Very much typical of me

13) I would have difficulty understanding some of the ethical issues concerning the internet.
    a. Not at all typical of me
    b. Not very typical of me
    c. Somewhat typical of me
    d. Fairly typical of me
    e. Very much typical of me

14) I would have difficulty putting paper into a printer.
    a. Not at all typical of me
    b. Not very typical of me
    c. Somewhat typical of me
    d. Fairly typical of me
    e. Very much typical of me

15) I would feel uncomfortable if my boss or instructor told me that I must learn a new word processing program.
    a. Not at all typical of me
    b. Not very typical of me
    c. Somewhat typical of me
    d. Fairly typical of me
    e. Very much typical of me

16) When using the internet to conduct a search, I can discriminate between consumer information, scholarly or academic research, and propaganda.
    a. Not at all typical of me
    b. Not very typical of me
    c. Somewhat typical of me
    d. Fairly typical of me
    e. Very much typical of me

17) I think most well-paying technology jobs will require workers who are highly skilled.
    a. Not at all typical of me
    b. Not very typical of me
    c. Somewhat typical of me
    d. Fairly typical of me
    e. Very much typical of me

18) I respect copyright issues when using information from electronic resources.
    a. Not at all typical of me
    b. Not very typical of me
    c. Somewhat typical of me
    d. Fairly typical of me
    e. Very much typical of me

19) I am familiar with using a mouse.
    a. Not at all typical of me
    b. Not very typical of me
    c. Somewhat typical of me
    d. Fairly typical of me
    e. Very much typical of me

20) I am able to use a graphic software program to report trends in data.
    a. Not at all typical of me
    b. Not very typical of me
    c. Somewhat typical of me
    d. Fairly typical of me
    e. Very much typical of me

21) Because of my knowledge of technology, I am able to anticipate and respond to rapid changes in school or work environments.
    a. Not at all typical of me
    b. Not very typical of me
    c. Somewhat typical of me
    d. Fairly typical of me
    e. Very much typical of me

22) I would have difficulty transferring files electronically.
    a. Not at all typical of me
    b. Not very typical of me
    c. Somewhat typical of me
    d. Fairly typical of me
    e. Very much typical of me

23) I feel comfortable using a CD-ROM.
    a. Not at all typical of me

b. Not very typical of me
c. Somewhat typical of me
d. Fairly typical of me
e. Very much typical of me

24) I would have difficulty evaluating websites in terms of the validity of the information they provide.
a. Not at all typical of me
b. Not very typical of me
c. Somewhat typical of me
d. Fairly typical of me
e. Very much typical of me

25) I am able to teach others about the responsible use of computer equipment.
a. Not at all typical of me
b. Not very typical of me
c. Somewhat typical of me
d. Fairly typical of me
e. Very much typical of me

26) I believe that almost all businesses will be computerized by 2010.
a. Not at all typical of me
b. Not very typical of me
c. Somewhat typical of me
d. Fairly typical of me
e. Very much typical of me

27) I understand and follow rules concerning passwords.
a. Not at all typical of me
b. Not very typical of me
c. Somewhat typical of me
d. Fairly typical of me
e. Very much typical of me

28) I would have difficulty formatting a disk.
a. Not at all typical of me
b. Not very typical of me
c. Somewhat typical of me
d. Fairly typical of me
e. Very much typical of me

29) I am able to use the skills I have already mastered to help me learn a new program.
a. Not at all typical of me
b. Not very typical of me
c. Somewhat typical of me

   d. Fairly typical of me
   e. Very much typical of me

30) I take advantage of any situation where I can learn about computers, the Internet, and other information technology.
    a. Not at all typical of me
    b. Not very typical of me
    c. Somewhat typical of me
    d. Fairly typical of me
    e. Very much typical of me

31) I know how to subscribe and participate in online mailing lists.
    a. Not at all typical of me
    b. Not very typical of me
    c. Somewhat typical of me
    d. Fairly typical of me
    e. Very much typical of me

32) I don't feel that it is important to follow rules concerning appropriate language when using technology.
    a. Not at all typical of me
    b. Not very typical of me
    c. Somewhat typical of me
    d. Fairly typical of me
    e. Very much typical of me

33) I am able to create a new directory/folder on my computer.
    a. Not at all typical of me
    b. Not very typical of me
    c. Somewhat typical of me
    d. Fairly typical of me
    e. Very much typical of me

34) I would have difficulty making the transition from a desktop computer to a laptop.
    a. Not at all typical of me
    b. Not very typical of me
    c. Somewhat typical of me
    d. Fairly typical of me
    e. Very much typical of me

35) I skip over newspaper or magazine articles that deal with computers and other technologies.
    a. Not at all typical of me
    b. Not very typical of me
    c. Somewhat typical of me
    d. Fairly typical of me

e. Very much typical of me

36) I know how to select a printer to print a document.
  a. Not at all typical of me
  b. Not very typical of me
  c. Somewhat typical of me
  d. Fairly typical of me
  e. Very much typical of me

37) I am aware of the ethical issues when using a network with “secure” areas.
  a. Not at all typical of me
  b. Not very typical of me
  c. Somewhat typical of me
  d. Fairly typical of me
  e. Very much typical of me

38) I understand the need to validate all information I locate on the Internet.
  a. Not at all typical of me
  b. Not very typical of me
  c. Somewhat typical of me
  d. Fairly typical of me
  e. Very much typical of me

39) I can compose and send an email message.
  a. Not at all typical of me
  b. Not very typical of me
  c. Somewhat typical of me
  d. Fairly typical of me
  e. Very much typical of me

40) My supervisor or instructor will keep me up-to-date on the latest technologies.
  a. Not at all typical of me
  b. Not very typical of me
  c. Somewhat typical of me
  d. Fairly typical of me
  e. Very much typical of me

41) I have a good understanding of the effects of technology on the environment, society, and individuals.
  a. Not at all typical of me
  b. Not very typical of me
  c. Somewhat typical of me
  d. Fairly typical of me
  e. Very much typical of me

42) I have a good understanding of the rules of plagiarism when using information from electronic sources.
   a. Not at all typical of me
   b. Not very typical of me
   c. Somewhat typical of me
   d. Fairly typical of me
   e. Very much typical of me

43) I understand how to use electronic bulletin boards.
   a. Not at all typical of me
   b. Not very typical of me
   c. Somewhat typical of me
   d. Fairly typical of me
   e. Very much typical of me

44) I can use a database program to organize data into a printed report.
   a. Not at all typical of me
   b. Not very typical of me
   c. Somewhat typical of me
   d. Fairly typical of me
   e. Very much typical of me

45) When I misplace or forget where a file is on my computer, I know how to find it.
   a. Not at all typical of me
   b. Not very typical of me
   c. Somewhat typical of me
   d. Fairly typical of me
   e. Very much typical of me

46) I am able to discriminate between information that is meant to inform and educate for the public good and information to persuade me to a certain point of view or perspective.
   a. Not at all typical of me
   b. Not very typical of me
   c. Somewhat typical of me
   d. Fairly typical of me
   e. Very much typical of me

47) I would look for another job if my current employer told me to use a computer.
   a. Not at all typical of me
   b. Not very typical of me
   c. Somewhat typical of me
   d. Fairly typical of me
   e. Very much typical of me

48) I am comfortable with the idea of using a computer to work at home.

a. Not at all typical of me
b. Not very typical of me
c. Somewhat typical of me
d. Fairly typical of me
e. Very much typical of me

49) I can organize my computer files into meaningful folders/directories.
a. Not at all typical of me
b. Not very typical of me
c. Somewhat typical of me
d. Fairly typical of me
e. Very much typical of me

50) I would rather use a typewriter to compose a document than a computer.
a. Not at all typical of me
b. Not very typical of me
c. Somewhat typical of me
d. Fairly typical of me
e. Very much typical of me

51) If I have a problem using the computer, printer, fax, etc., I know where to seek help.
a. Not at all typical of me
b. Not very typical of me
c. Somewhat typical of me
d. Fairly typical of me
e. Very much typical of me

52) I use the Internet to gather information in my job, school, or personal life.
a. Not at all typical of me
b. Not very typical of me
c. Somewhat typical of me
d. Fairly typical of me
e. Very much typical of me

53) I understand why it is important not to copy copyrighted files or programs.
a. Not at all typical of me
b. Not very typical of me
c. Somewhat typical of me
d. Fairly typical of me
e. Very much typical of me

54) I would have trouble copying a file to a disk.
a. Not at all typical of me
b. Not very typical of me
c. Somewhat typical of me

d. Fairly typical of me
e. Very much typical of me

55) I can identify an author's bias in a work, whether it is in print or from an electronic source such as the Internet.
    a. Not at all typical of me
    b. Not very typical of me
    c. Somewhat typical of me
    d. Fairly typical of me
    e. Very much typical of me

56) I have a fear of losing my job or failing a course because I am not good at learning new technologies.
    a. Not at all typical of me
    b. Not very typical of me
    c. Somewhat typical of me
    d. Fairly typical of me
    e. Very much typical of me

57) I feel that there will always be a job for me using the computer even if I do not work to update my computer skills.
    a. Not at all typical of me
    b. Not very typical of me
    c. Somewhat typical of me
    d. Fairly typical of me
    e. Very much typical of me

58) I use the "help" feature included with programs to help me learn how they work.
    a. Not at all typical of me
    b. Not very typical of me
    c. Somewhat typical of me
    d. Fairly typical of me
    e. Very much typical of me

59) I know how to use Web browser programs such as Netscape and Internet Explorer.
    a. Not at all typical of me
    b. Not very typical of me
    c. Somewhat typical of me
    d. Fairly typical of me
    e. Very much typical of me

60) I would have difficulty using a spreadsheet program to organize data into a printed report.
    a. Not at all typical of me
    b. Not very typical of me

c. Somewhat typical of me
d. Fairly typical of me
e. Very much typical of me

61) I know the difference between “Save” and “Save As.”
a. Not at all typical of me
b. Not very typical of me
c. Somewhat typical of me
d. Fairly typical of me
e. Very much typical of me

Appendix J

Intermediate Algebra Competency Exam (IACE)

Name: ___________________________

Multiple Choice: *Identify the choice that best completes the statement or answers the question.*

1) Factor the greatest common factor from the expression. Write the greatest common factor with a positive coefficient. $20x^3 + 28x^5$
   a. $4x^3(5 + 7x)$
   b. $4x^2\left(7x + 5x^3\right)$
   c. $4x^3\left(5 + 7x^2\right)$
   d. $4x^3\left(7 + 5x^2\right)$
   e. $5x^3\left(4 + 7x^2\right)$

2) Factor the trinomial: $y^2 + y - 6$
   a. $(y-1)(y+5)$
   b. $(y+3)(y-2)$
   c. $(y+3)(y+2)$
   d. $(y-3)(y+2)$
   e. $y(y-6)$

3) Factor completely. Be sure to factor out the greatest common factor first if it is other than 1. $6x^2 - 7x - 10$
   a. $6(x-5)(x+2)$
   b. $(x+5)(6x-2)$
   c. $6(x+5)(x-2)$
   d. $(6x+5)(x-2)$
   e. The trinomial is prime.

4) Factor the difference of two squares. Be sure to factor completely. $x^2 - 81$
   a. $(x + 8)(x + 9)$
   b. $(x - 9)(x + 9)$
   c. $(x - 9)(x + 8)$
   d. $(x + 9)(x + 9)$
   e. $(x - 9)(x - 9)$

5) Factor the sum of cubes. $x^3 + 8$

a. $(x + 2)(x^2 + 2x - 4)$

b. $(x - 2)(x^2 - 2x - 4)$

c. $(x - 2)(x^2 - 2x + 4)$

d. $(x + 2)(x^2 - 2x + 4)$

e. $(x - 2)(x^2 + 2x + 4)$

6) Factor completely. $x^2 - 12x + 36$

a. $(x - 6)(x + 2)$
b. $(x - 6)^2$
c. $(x - 1)(x + 36)$
d. $(x - 6)(x + 6)$
e. the polynomial is prime

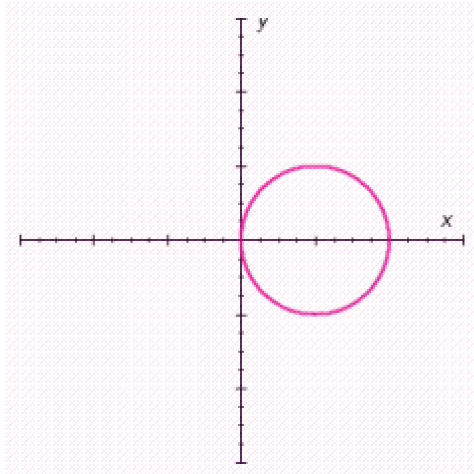
7) Solve the equation. $x^2 + 2x - 3 = 0$

a. $x = 1$, $x = -1$, $x = -3$
b. $x = 3$
c. $x = 1$, $x = -3$
d. $x = 1$, $x = 3$
e. $x = -2$, $x = 3$

8) For the following, give the domain and range and indicate whether it is a function. {(5, 1), (6, 7), (3, 5)}

a. Domain = {3, 7, 5}; Range = {1, 6, 3}; a function
b. Domain = {5, 6, 3}; Range = {1, 7, 5}; a function
c. Domain = {5, 6, 3}; Range = {1, 7, 5}; not a function
d. Domain = {1, 7, 5}; Range = {5, 6, 3}; not a function
e. Domain = {1, 6, 3}; Range = {3, 7, 5}; not a function

9) Does the graph represent a function?



a. No
b. Yes

10) Let $g(x) = x^2 + 3x + 6$. Evaluate $g(-2)$.

a. $g(-2) = -4$
b. $g(-2) = -8$
c. $g(-2) = -13$
d. $g(-2) = -2$
e. $g(-2) = 4$

11) Given $f(x) = x^2 - 6x - 7$ and $g(x) = x - 3$, find the following. $(f - g)(2)$

a. $(f - g)(2) = -14$
b. $(f - g)(2) = -18$
c. $(f - g)(2) = -15$
d. $(f - g)(2) = 1$
e. Undefined

12) Let $f(x) = 5x + 1$ and $g(x) = x - 4$. Find the function $f \cdot g$.

a. $5x^2 + 20x - 4$
b. $5x^2 - 19x - 4$
c. $4x^2 - 20x - 5$
d. $5x^2 - 20x - 4$
e. $5x^2 + 19x - 4$

13) Let $f(x) = 10x + 5$ and $g(x) = x^2 - 5$. Find the value $(f \circ g)(x)$.

a. $100x^2 + 100 + 20$
b. $10x^2 + 45$
c. $100x^2 - 50 + 20$
d. $10x^2 - 45$

14) State the domain for the rational function. $h(t) = \frac{t-6}{t^2-36}$

15) Reduce the rational expression to lowest terms. $\frac{8x+64}{x^2-64}$

a. $\frac{8}{x+8}$
b. $\frac{x}{x+8}$
c. $\frac{8x}{x-8}$
d. $\frac{8}{x-8}$
e. $\frac{8}{x}$

16) If $g(x) = \frac{x+3}{x-2}$, find $g(-3)$.

a. $g(-3) = 1$
b. $g(-3) = 2$
c. $g(-3) = 0$
d. $g(-3) = -3$
e. $g(-3) = -2$

17) Perform the indicated operations. Reduce your answer to lowest terms.

$\frac{x^2-25}{x^2-16} \cdot \frac{x-4}{x-5}$

a. $\frac{x-5}{x+4}$
b. $\frac{x+4}{x-5}$
c. $\frac{x+25}{x+16}$
d. $\frac{x+5}{x+4}$
e. $\frac{x-4}{x-5}$

18) Perform the indicated operations. Reduce your answer to lowest terms.

$\frac{5ab^3}{6a^2b} \div \frac{10a^8b^2}{12ab^9}$

a. $\frac{2b^2}{a}$

b. $\frac{b^9}{a^8}$
c. $\frac{2b^9}{a^8}$
d. $\frac{b}{2a^3}$
e. $\frac{b^8}{a^9}$

19) Combine the rational expressions. Reduce your answer to lowest terms.

$\frac{40}{y-5} - \frac{8y}{y-5}$

a. $5y$
b. $y - 5$
c. -5
d. -8
e. $-8y$

20) Combine the rational expressions. Reduce your answer to lowest terms.

$\frac{x+8}{2x + 14} + \frac{7}{x^2 - 49}$

a. $\frac{x-6}{(x-7)}$
b. $\frac{x}{x^2 - 49}$
c. $\frac{x-6}{2(x-7)}$
d. $\frac{x+8}{x^2 - 49}$
e. $\frac{x-8}{2(x-7)}$

21) Simplify as much as possible. $\dfrac{1-\dfrac{9}{t}}{\dfrac{1}{t}}$

a. $t+9$
b. $\dfrac{t}{t+9}$
c. $2t-9$
d. $\dfrac{1}{t-9}$
e. $t-9$

22) Solve the equation. $\dfrac{4}{a-3}=\dfrac{3}{a-4}$

a. $a=1$
b. $a=7$
c. $a=6,-8$
d. $a=7,-7$
e. $\varnothing$

23) Use the rational exponent theorem to simplify the following as much as possible. $8^{\frac{4}{3}}$

a. 8
b. $\dfrac{32}{3}$
c. 14
d. 32
e. 16

24) Write the expression in simplified form. (Assume the variables are nonnegative numbers.) $\sqrt[3]{162a^2b^3c^4}$

a. $3bc\sqrt[3]{5ac}$
b. $4b\sqrt[3]{6a^2c}$
c. $4b\sqrt[3]{5ac}$
d. $9bc\sqrt[3]{6a^2c}$
e. $3bc\sqrt[3]{6a^2c}$

25) Combine the following expressions. $2\sqrt{32x^2} - 8x\sqrt{8} - 3\sqrt{18x^2}$

a. $-10x\sqrt{3}$
b. $19x\sqrt{2}$
c. $-14x\sqrt{2}$
d. $-28x\sqrt{2}$
e. $-17x\sqrt{2}$

26) Multiply. $\left(\sqrt{3} - 5\sqrt{5}\right)\left(8\sqrt{3} - 6\sqrt{5}\right)$

a. $174\sqrt{15}$
b. $174 - 46\sqrt{15}$
c. $54 - 46\sqrt{15}$
d. -6
e. 15

27) Simplify the expression. $\sqrt[3]{\dfrac{27x^6y^3}{5z^2}}$

a. $\dfrac{9x^2y\sqrt[3]{25z}}{5z}$
b. $\dfrac{3x^2\sqrt[3]{25z}}{5z}$
c. $\dfrac{3x^2y\sqrt[3]{25z^2}}{5z}$
d. $\dfrac{3x^2y\sqrt[3]{25z}}{5z}$
e. $\dfrac{3xy\sqrt[3]{25z}}{5z}$

28) Rationalize the denominator in the following: $\dfrac{\sqrt{2}}{\sqrt{10} - \sqrt{2}}$

a. $\dfrac{\sqrt{20} + 1}{4}$
b. $\sqrt{10} - \sqrt{2}$
c. $\dfrac{4}{\sqrt{5} + 1}$
d. $\dfrac{1}{\sqrt{10} - \sqrt{2}}$
e. $\dfrac{\sqrt{5} + 1}{4}$

29) Solve the equation. $x + 5 = \sqrt{11x + 25}$

a. $x = 0, -1$
b. $x = 0, 1$
c. $x = -1, 1$
d. $x = 0$
e. $\varnothing$

30) Write the number in terms of *i*, and simplify as much as possible. $-\sqrt{-32}$

a. $-4\sqrt{2}$
b. $16i\sqrt{2}$
c. $-4i\sqrt{2}$
d. $4i\sqrt{2}$
e. $-16i\sqrt{2}$

31) Simplify as much as possible. i^{11}

a. $11i$
b. $-i$
c. 11
d. 1^{i}
e. 0

32) Combine the complex numbers. $(9 + 5i) - (5 + 7i)$

a. $14i - 2$
b. $4 + 2i$
c. $4 - 2i$
d. $9 + 5i$
e. $4 + 12i$

33) Find the product. $(2 - 7i)(2 + i)$

a. $12 + 14i$
b. $11 - 12i$
c. $11i$
d. $12 - 12i$
e. $11 + 12i$

34) Find the quotient. Write the answer in standard form for complex numbers. $\frac{1}{6-4i}$

a. $\frac{1}{13}+\frac{3}{26}i$
b. $\frac{3}{26}-\frac{1}{13}i$
c. $\frac{3}{26}+\frac{1}{13}i$
d. $39i$
e. $\frac{1-4i}{3}$

35) Solve the equation. $x^2=81$

a. $x=9$
b. $x=\pm 81$
c. $x=\pm 40.5$
d. $x=\pm 9$
e. $x=83$

36) Solve the following quadratic equation by completing the square.
$a^2-10a+29=0$

a. $a=-5\pm 2i$
b. $a=5\pm 2i$
c. $a=\pm 2i$
d. $a=-5,3$
e. $a=2\pm 2i$

37) Solve the equation using the quadratic formula. $x^2-4x+5=0$

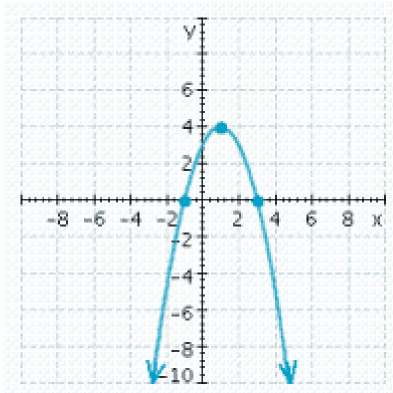
a. $-2\pm i$
b. $2-i$
c. $-2+i$
d. $2+i$
e. $2\pm i$

38) A company finds that it can make a profit of P dollars each month by selling x patterns, according to the formula $P(x)=-0.001x^2+5.5x-4{,}000$. How many patterns must it sell each month to have a maximum profit?

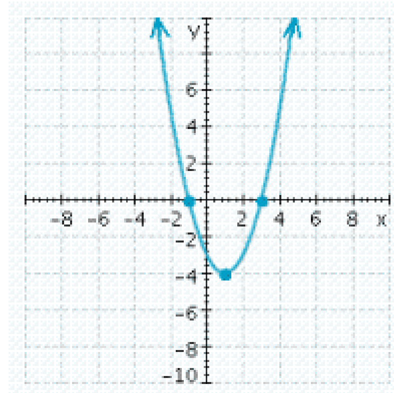
Number of patterns = _____ Maximum Profit = $_____

39) For the following equation, find the x-intercepts and the coordinates of the vertex, and choose the corresponding graph. $y = x^2 - 2x - 3$

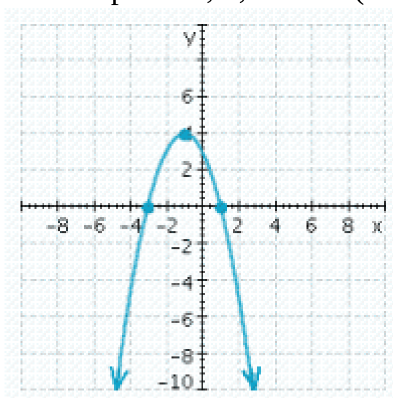
a. x-intercepts= –1, 3; vertex=(1, 4)



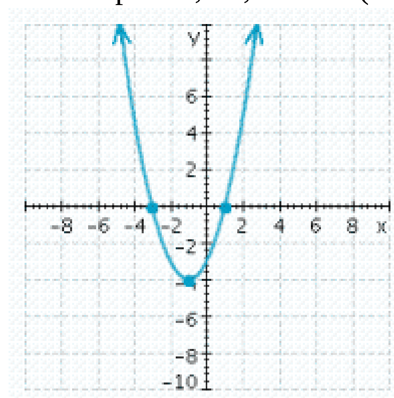
c. x-intercepts= –1, 3; vertex=(1, –4)



b. x-intercepts= –3, 1; vertex=(–1, 4)



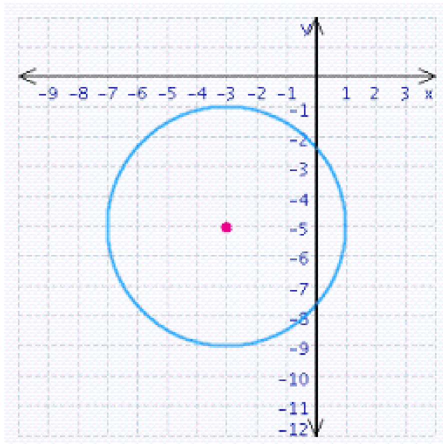
d. x-intercepts= 1, –3; vertex=(–1, –4)



40) Find the center and radius, and choose the graph of the following circle.

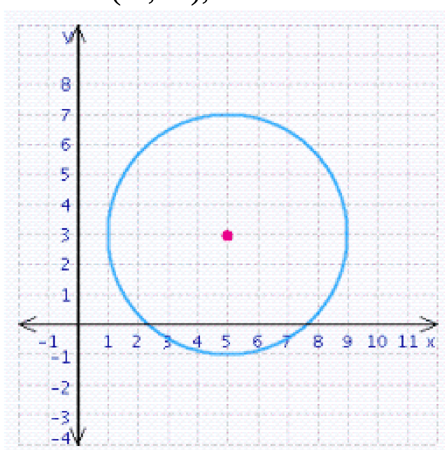
$(x - 5)^2 + (y - 3)^2 = 16$

a.



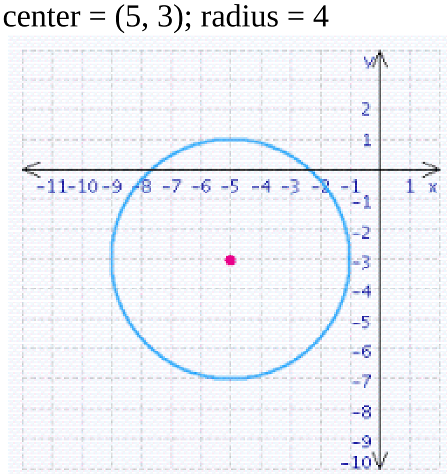
center = (-3, -5); radius = 4

b.



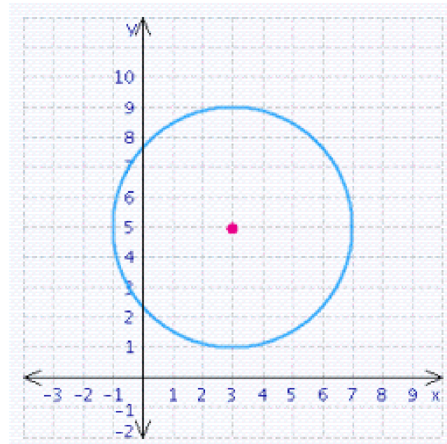
center = (5, 3); radius = 4

c.



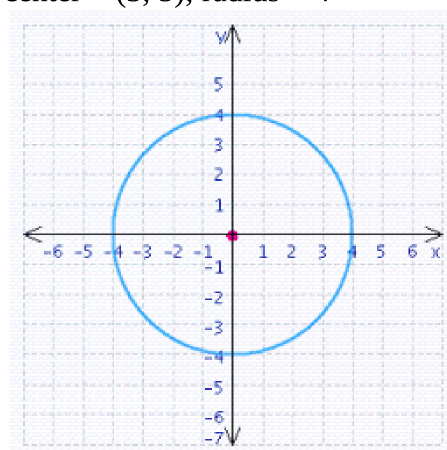
center = (-5, -3); radius = 4

d.



center = (3, 5); radius = 4

e.

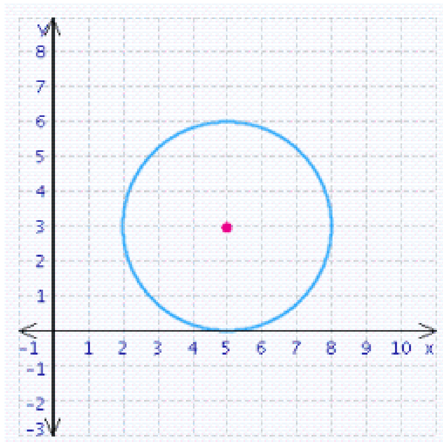


center = (0, 0); radius = 4

41) Write the equation of the circle with the given center and radius. Center (4, 9); $r = 5$

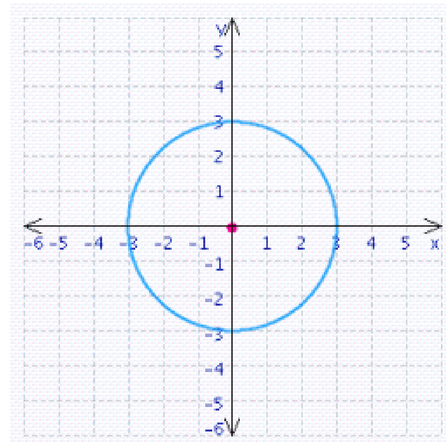
42) Find the center and radius, and choose the graph of the following circle.
$x^2 + y^2 - 10x - 6y = -25$

a.



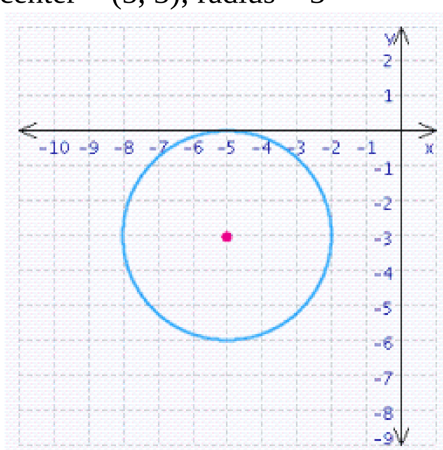
center = (5, 3); radius = 3

d.



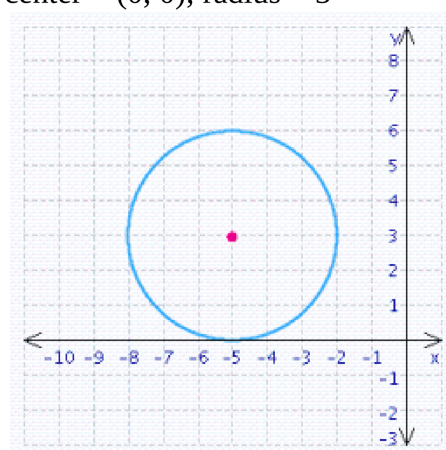
center = (0, 0); radius = 3

b.



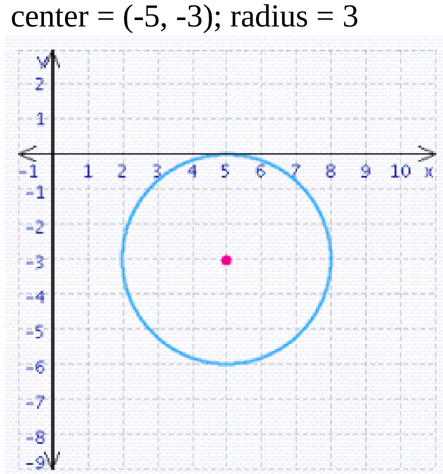
center = (-5, -3); radius = 3

e.



center = (-5, 3); radius = 3

c.



center = (5, -3); radius = 3

43) Let $g(x) = \left(\frac{1}{4}\right)^x$. Evaluate $g(-2)$

a. $g(-2) = 16$

b. $g(-2) = \frac{1}{8}$

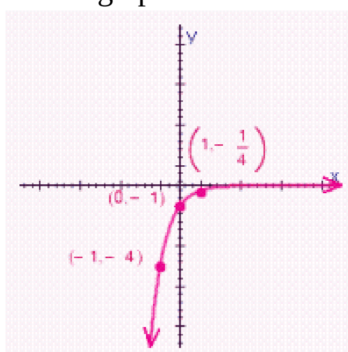
c. $g(-2) = \frac{1}{16}$

d. $g(-2) = \frac{1}{4}$

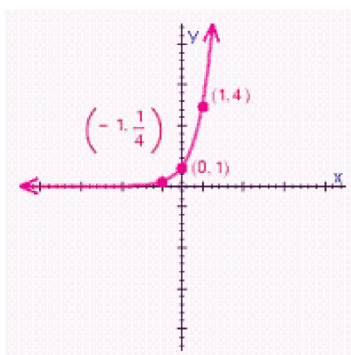
e. $g(-2) = 4$

44) Choose the graph of the function below. $y = 4^x$

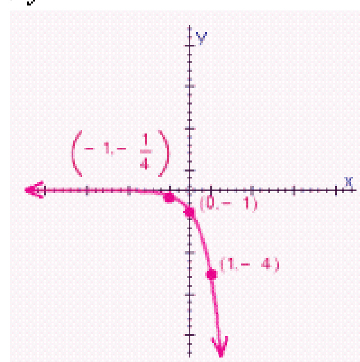
a.



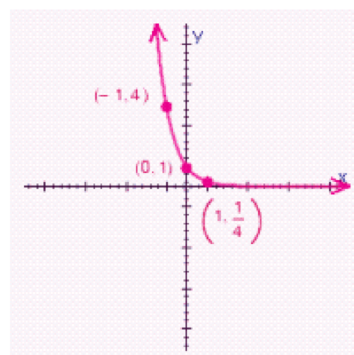
b.



c.



d.



45) Choose the answer that shows the equation in logarithmic form. $4^2 = 16$

a. $\log_4 16 = 2$

b. $\log_4 16 = -2$

c. $\log_{16} 4 = 2$

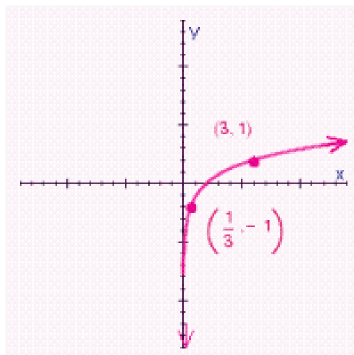
d. $\log_4 16 = 4$

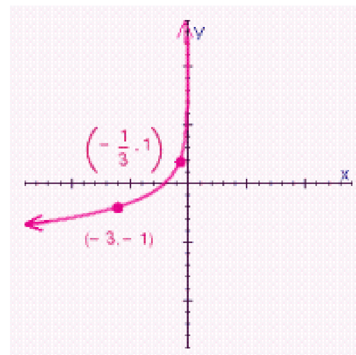
e. $\log_2 4 = 16$

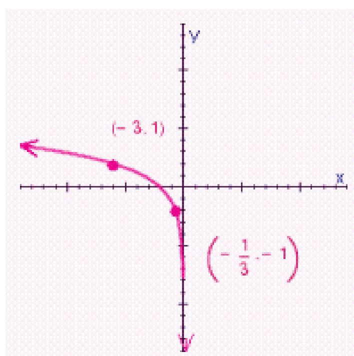
46) Choose the answer that shows the equation in exponential form.
$\log_4 16 = 2$

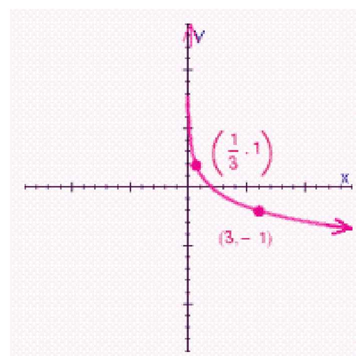
a. $2^4 = 16$
b. $4^{16} = 2$
c. $4^2 = 16$
d. $16^{-2} = 4$
e. $16^2 = 4$

47) Choose the graph of the following logarithmic equation. $y = \log_3 x$

a.


c.


b.


d.


48) Solve the equation for *x*. $\log_3 x = -4$

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Education

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Academic Experience

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Associate Professor of Mathematics, June 2005 – present
Coordinator of Developmental Mathematics, 2000 – 2006, 2007 – 2008
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Presentations

Ashby, J. & Loeffler, D. (2009). Nursing in the online environment. CCBC Nursing Professional Development Meeting, Baltimore, MD, June 8.

Ashby, J. (2008). Online and hybrid learning for developmental students. Developmental Education Association of Maryland (DEAM), Baltimore, MD, October 17.

Ashby, J. (2008). How to evaluate distance education courses: Perspectives from the literature. Paper presented at the Maryland Distance Learning Association Conference, Baltimore, MD, March 4-5.

Ashby, J. (2004). Individualized classes for repeating students. Developmental Education Symposium, Baltimore, MD, August

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Ashby, J., & Loeffler, D. (2007). Do hybrids work?. CCBC Teaching Learning Fair, Baltimore, MD, January.

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