FACTORS INFLUENCING SUCCESS IN ONLINE HIGH SCHOOL ALGEBRA

By

FENG LIU

A DISSERTATION PRESENTED TO THE GRADUATE SCHOOL
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To my family

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FACTORS INFLUENCING SUCCESS IN ONLINE HIGH SCHOOL ALGEBRA

By

Feng Liu

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At present, an increasing number of students at the K-12 level in the U.S. are taking courses online via virtual schools, which have been in existence since the end of the 20th century. Virtual schooling is becoming a mainstream option alongside traditional face-to-face learning environments. Even with its increasing popularity, very few empirical studies have been conducted to provide practical guidance for teaching, learning, research, and policy making in K-12 virtual schooling. Some leading virtual school organizations, such as the Southern Regional Educational Board and the International Association for K-12 Online Learning, have produced standards in these fields. However, many of the standards lack empirical support based on research conducted in virtual learning environments.

Math has been identified as a very important force to push a society forward since it is considered a foundational subject. Many countries emphasize the improvement of math knowledge and they develop policies to attract more people to the field. The examination of success factors in the math field in general and Algebra in specific in virtual learning environments can provide better implementation strategies in

virtual schools to improve student math and science achievement and increase the Science, Technology, Engineering, and Mathematics (STEM) workforce in U.S.

The purpose of this study is to examine the factors including LMS utilization, teacher comment/feedback and student demographic information that can influence the success of Algebra courses in K-12 virtual learning environments. Students who completed Algebra and took the end-of-course (EOC) test and students who took one state standardized mathematics test at grade 6-8 level in a state virtual school in the Midwestern U.S region during 2008-2009 participated in this study. Student scores on these tests were collected by this virtual school. Hierarchical linear modeling (HLM) technique was used for data analysis to account for the influence of school characteristics on student scores. The results show these factors have different influences on student performance on the state standardized mathematics test and the Algebra EOC test. These findings have implications for quality online teaching, instructional design, and the policy-making process in virtual learning environments. Further research is proposed based on the results and limitations of this study.

CHAPTER 1
INTRODUCTION

Background

The United States has experienced an extraordinary growth in online education at the K-12 level since its emergence in the late 1990s: from single online course offerings to large virtual schools today. Thousands of students were attracted to online education because of the advantages it brings such as flexible and longer school time, more educational opportunities, and increased access to resources (Cavanaugh, et al., 2004). Several surveys have showed that at least one third of high school students had online learning experience (Allen & Seaman, 2006; Setzer & Lewis, 2005). Figure 1-1 shows the dramatic increase of K-12 online enrollment between 2001 and 2008 (Clark 2001; Glass, 2009; Newman, Stein, & Trask, 2003; Peak Group 2002; Picciano & Seaman, 2009; Picciano & Seaman, 2007; Setzer & Lewis, 2005; Tucker 2007; Zandberg, Lewis, & Greene, 2008). By 2016, this number is anticipated to reach 5-6 million and will keep growing in the future (Picciano & Seaman, 2009). Only public school students were included in this figure; the number will be higher if all other students are included, such as those in private schools and home-schools (Picciano & Seaman, 2009).

The virtual school movement in the US is the outgrowth of independent study high schools in many ways (Clark 2003). The first two virtual schools in the US, the Virtual High School (VHS) and Florida Virtual School (FLVS), were both created in 1997 (Barbour & Reeves, 2009). By 2001, about 14 states had established state-wide virtual schools and 40,000 to 50,000 students enrolled in courses offered by these schools (Clark, 2001). In July 2005, 21 states offered statewide online programs (Watson & Kalmon, 2005). By September 2006, 38 states have either state-led online learning

programs or online education policies, and 24 states have state-led online learning programs (Watson & Ryan, 2006). As of September 2007, 42 states offered significant hybrid learning programs (students in physical schools taking some courses online), pure online programs (students in physical schools or at home taking most or all of course online) or both (Watson & Ryan 2007). By fall, 2008, 44 states have online offering for students and 34 states offer state-led online programs or initiatives (Watson, Gemin, & Ryan, 2008). Response to a survey administered during 2007-08 showed about 75% of public K-12 school districts were offering full or partial online courses (Glass, 2009; Picciano & Seaman, 2009), approximately 10% increase since 2005-06 academic year (Picciano & Seaman, 2009). Additionally, another 15% were planning to have online offerings within the next three years (Picciano & Seaman, 2009). Currently all states offer online courses at school or district level (Cavanaugh 2007). Online education is not seen as separate entity any more but one kind of educational approach which can strengthen the public education and benefit the society at large (Watson & Ryan, 2006). There is a need for deeper understanding of the success in virtual learning environments for the better utilization of this education format to help improve student academic achievement.

Problem Statement

Along with the extraordinary growth of online education in the US., some research has been conducted to examine success factors in online learning environments. According to Roblyer et al., (2008), there are two lines of research emerged to address success factors in online learning: studies focusing on learner characteristics and studies focusing on learning environment characteristics. Learner characteristics include student cognitive factors such as locus of control and learning styles; prior technology

skills and attitudes; and experience and prior knowledge about course content. Learning environment characteristics include technology support, course content area, and accessibility to Internet. At present, no clear set of characteristics have been identified to predict success in virtual learning environments, and no conclusive model has been created to apply in online learning practice (Roblyer & Davis, 2008; Tallent-Runnels et al., 2006). There is a gap regarding the establishment of one online success model to help improve student academic achievement considering the quick development of virtual schooling in the US. Learner characteristic variables including personal effort/participation in academic activities, student learning ability/whether has individual educational plan, race/ethnicity, and family background/participation in free or reduced lunch programs, and learning environment variables including teacher comment /instructor-student interaction and school type (private or public school) have been proved in some studies to correlate to student academic achievement. However, these variables have not been investigated systematically in one model regarding their effects on student success in K-12 virtual learning environments.

Math knowledge is important for a citizen to fully participate in society. Math is the most widely used subject among all the fields and almost every career uses math at different levels (Saint Paul Public Schools, 2007). During the May 2003 commencement address, the president of Society for Industrial and Applied Mathematics (SIAM), Professor Doug Arnold mentioned math is the foundation to understand the world around us and math knowledge can influence other sciences as well such as economics, business, and sociology. He predicted that math will have huge impacts in the 21st century, the digitalized and data-enriched century.

Math has been considered a very important force to push a society forward. Many countries emphasize the improvement of math knowledge and they develop policies to attract more people into this field. The underachievement of students in math subjects at the K-12 level could lead to the lack of preparation for students to pursue advanced degrees in these fields. This will cause a shortage in the workforce in math and other sciences fields, which, in turn, could weaken the momentum for a country to move forward in many aspects. The National Association of Manufacturers (NAM) believed the shortage of workforce in Science, Technology, Engineering, and Mathematics (STEM) fields can weaken manufacturers' abilities to ensure quality, productivity efficiency, and customers' satisfaction (D'Amico, 2008). The quality of Algebra courses is essential in building the number of students who are ready for advanced degrees in STEM and career success in these fields. Growing number of students take math courses online at K-12 level so there is a need to examine the quality of online math courses and build one online success model to help improve student academic achievement in general and Algebra/mathematics in specific. The present study was designed to fill this gap.

Purpose Statement

Based on the lack of models for predicting success in high school Algebra courses and the clear need for increased Algebra achievement, this study examines the problem of identifying factors that influence online high school Algebra performance.

Research Questions

The research questions in this study are:

- Does the level of LMS utilization influence Algebra/mathematics performance in online education?

- Does teacher comment or feedback influence Algebra/mathematics performance in online education?
- Do student demographic information such as race/ethnicity, grade level, status in virtual school, whether have individual educational plan (IEP), and participation in free/reduced lunch programs influence Algebra/mathematics performance in online education?

Significance of the Study

Even after more than 10 years of extraordinary growth in K-12 online learning, little research has been done as compared to post-secondary education (Cavanaugh 2007; Cooze & Barbour, 2005; Means et al., 2009; Picciano & Seaman, 2007; Picciano & Seaman, 2009; Ronsisvalle & Watkins, 2005). The amount of evidence-based research or empirical study applicable to guide educators' instruction and policy makers' decision relevancies is slight (O'Dwyer, Carey, & Kleiman 2007). The dearth of studies on academic achievement in K-12 virtual learning environments in comparison with that in traditional learning environments (Cooze & Barbour, 2005; Means et al., 2009; Picciano & Seaman, 2007; Picciano & Seaman, 2009; Smith, Clark, & Blomeyer, 2005; Watson, 2007) form the rationale for this study. This study can help discover certain characteristics and good practices in online learning and incorporate them into the instructional model of the K-12 virtual learning environment. This study could add to the knowledge of effectiveness of online/distance education in helping improve student academic achievement in the K-12 virtual learning environment. This will provide valuable guidance for the better implementation and practice of K-12 virtual schooling.

Given the dearth of research on the factors of academic success in K-12 virtual learning environments, this study could be beneficial to educators, course designers, researchers, online program leaders, policy makers, and society at large. The investigation of success factors in this study will provide a deeper understanding of

success in online learning in general and in the K-12 virtual learning environment in specific. It has implications for the decision making process for virtual schools with respect to the development of more efficient online courses in general and online mathematics courses in specific. It also could help identify the success factors that should be considered in the virtual learning process and guide management of virtual schools to maximize their effectiveness to provide better assistance and supplement to the traditional learning environment.

Delimitations

The study was conducted from Oct 2009 to June 2010. One state virtual school in the Midwestern US region was chosen as the location in which the data were collected. This virtual school has a big student population and large Algebra course enrollment from which the researcher can draw the sample. This virtual school also has a comprehensive data system enabling the use of advanced statistic model during data analysis. This virtual school can represent the virtual school as a whole in US in many respects such as the design of courses according to state and national standards, the utilization of one single LMS to deliver the course materials, and the flexible timeline for students to finish courses. However, this virtual also has its own characteristics that may not be common in other virtual schools such as it recruits both full-time and part-time students and it moves paced courses all along. Students statewide from bricks-and-mortar public and private schools as well as home school students were eligible to enroll in this virtual school. Students in this virtual school who completed Algebra courses during 2008-09 and took the EOC test and students who took one state standardized mathematics test at grade level 6-8 during 2008-2009 participated in this study.

Definition of the Terms

Distance education has been practiced in various forms since its emergence in the early 1900s, evolving from correspondence to broadcasting including radio and television, to online education today (Moore & Kearsley, 1996). It has experienced an extraordinary development in the 20th century and its practice will continue to grow in the 21st century. Many distance education related terms have appeared: cybershool, distance education, distance learning, e-learning, online education, online learning, virtual school, and web-based learning. There are also multiple definitions for each of these terms. In this study, the authors are using the definitions that have been broadly cited though by no means are they the most accurate ones.

Distance education, defined by Keegan (1996), has four main components: (1) quasi-permanent separation of teacher and learner, (2) the use of technical support to bridge the distance, (3) two-way communication during the process, and (4) possible non presence of learning groups. It is probably the most cited definition of DE in the literature. Another very comprehensive definition of distance education is in a published monograph by The Association for Education Communications and Technology (Schlosser & Simonson, 2002): “Institution-based, formal education where the learning group is separated, and where interactive telecommunications systems are used to connect learners, resources, and instructors” (p. 1). Distance learning, defined by Allen et al. (2004), is a course where the students and instructor will not be physically in the same location during the teaching/learning process. Distance learning can be conducted asynchronously using communication techniques such as e-mail, audio/video recording, mail correspondence, and synchronously using techniques such as television, radio, internet chat room, and telephone (Allen et al, 2004).

Allen and Seaman (2006) defined three types of online courses. Online is the course where most or all of the content is delivered online. At least 80% of the traditional face to face (f2f) classroom meeting time is replaced by online activity. Blended/Hybrid is the course that combines online and traditional f2f delivery methods. A considerable proportion (30 to 79%) of the content is delivered online. Web-facilitated is the course where web-based technologies are used to facilitate learning. A proportion (1 to 29%) of the content is delivered online.

Virtual school, defined by Clark (2000), is “a state approved and/or regionally accredited school that offers secondary credit courses through distance learning methods that include Internet-based delivery” (p. i). Russell (2004) defined virtual school as ‘‘a form of schooling that uses online computers to provide some or all of a student’s education” (p. 2). Greenway and Vanourek (2006) described virtual schools as “a hybrid of public, charter, and home schooling, with ample dashes of tutoring and independent study thrown in, all turbocharged by Internet technology” (p. 36). A more recent study conducted by Barbour and Reeves (2009), defined virtual school as “an entity, which has been approved or accredited by a state or governing body within the state, that offers secondary-level courses through distance delivery – most commonly using the Internet.” (p. 412). This study examined the practice of virtual school following Clark’s and Barbour and Reeves’ definition.

Organization of the Study

The remainder of the study is organized into five chapters and appendices including some released test items and national and state Algebra and mathematics standards. Chapter two is the review of the related literature regarding mathematics courses specifically Algebra success factors and online learning success factors.

Chapter three presents the research design and methodology of the study. The population and sampling technique, instruments that were used for data collection, and the procedure of data analysis are described. Chapter four presents the results of the data analysis and the findings based on the analysis. Chapter five contains the summary, discussions and implications of the results, recommendations based on the results, and conclusions. The study concludes with a bibliography and appendices.

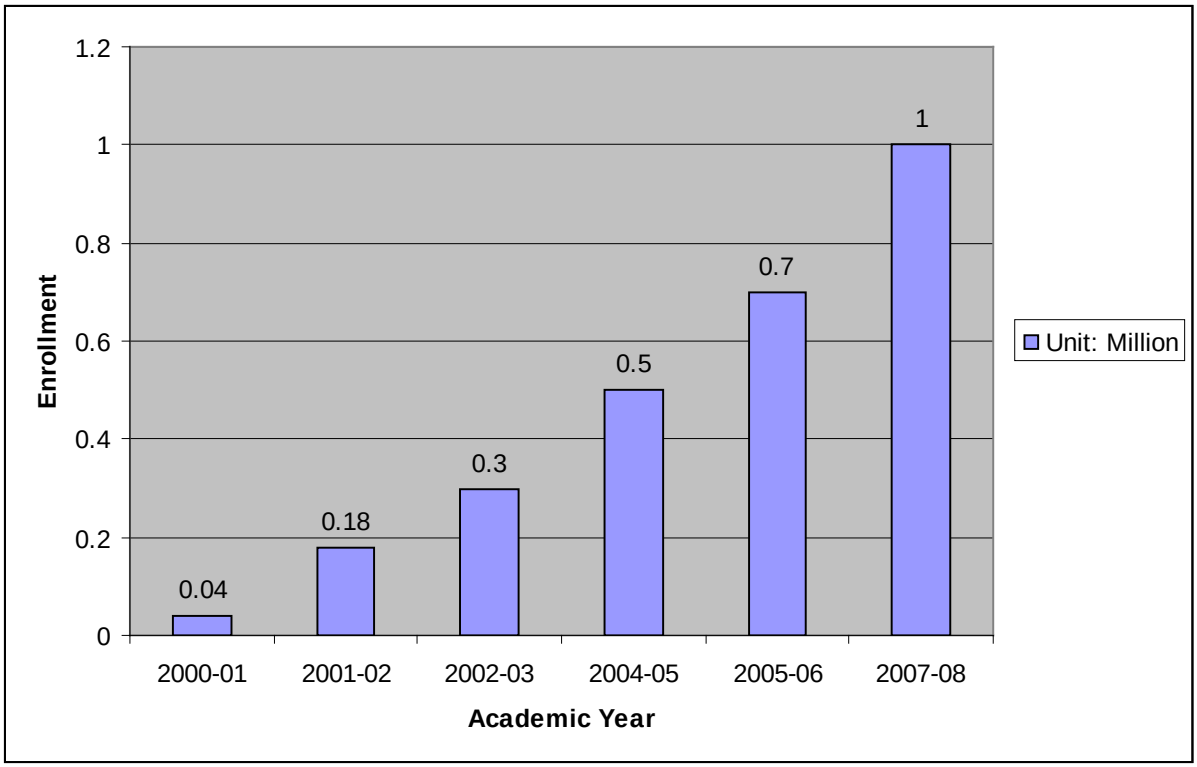


Figure 1-1. Online Students at K-12 Level

CHAPTER 2
REVIEW OF LITERATURE

Introduction

Online/distance education has greatly contributed to the American education system with its broad advantages covering a variety of aspects including economic, political, demographic, and pedagogical (Dede, 1990). Distance learning, especially online learning, can decrease instructor and student travel costs and possibly increase instructors' productivity (Bartley & Golek, 2004; Cavanaugh, 2001; Cornford & Pollock, 2003; Evans & Haase, 2001; Gallagher & McCormick, 1999; Glenn, 2001; Paulsen et al., 1998). The communities benefit from online/distance learning because it can increase educational opportunities that otherwise might be restricted by geographic barriers or resource restriction and provide the flexibility for students at different levels (Bogden, 2003; Helphinstine, 1995; Kerka, 1996; Parsad & Lewis, 2008; Patrick, 2004; Shachar & Neumann, 2003). The online delivery method via learning management systems can help the decision making process in regard to instruction and administration issues to improve teaching and learning effectiveness through providing data-enriched environments (NACOL & Partnership for 21st Century Skills, 2006). Well designed online instruction can promote collaboration among peers and between learners and instructors and co-construct their knowledge structure (Bartley & Golek, 2004; Blomeyer, 2002; Hassell & Terrell, 2004; Hill, 1997; Summers, Waigandt, & Whittaker, 2005; Webster & Hackey, 1997), leading to the enhancement of higher-order thinking skills and cognitive abilities (Blomeyer, 2002; Garrison, 2003) as well as motivation for students with different learning styles (Butz, 2004; Hassell & Terrell, 2004). Online courses have worked well with a variety of learners including at-risk

students, students with some disabilities, and students with limited English proficiency (Keeler et al., 2007; NACOL, 2009; Watson, Gemin, & Ryan, 2008). The advocates of online learning believe it will transform teaching, learning, and schooling as a whole (Cox, 2005).

As a comparatively new form of online education, virtual schooling has experienced significant development since its emergence in the late 1990s and has been accepted by more and more educators and students because of its great benefits. With its help, small schools and rural schools especially can offer a wide range of high quality courses that otherwise they can't offer (Donlevy, 2003). Virtual schooling gives students more options for obtaining education (Butz, 2004; Clark & Berge, 2005; Newman, Stein, & Trask, 2003; NACOL & the Partnership for 21st Century Skills, 2006). Virtual school could help solve the inequality of educational opportunities caused by a variety of reasons such as family income, geographical location, and school resources (Blaylock & Newman, 2005; Cavanaugh, 2001; Clark & Berge, 2005; Hernandez, 2005; Kellogg & Politoski, 2002; Newman, Stein, & Trask, 2003; Roblyer et al., 2007; Rose & Blomeyer, 2007; Setzer & Lewis, 2005; Watson & Ryan, 2007). Virtual school can help improve student learning outcomes and skills (Clark & Berge, 2005) through offering individual instruction and flexibility to meet the specific needs of students (Keeler et al., 2007; Kellogg & Politoski, 2002; Newman, Stein, & Trask, 2003).

With the support of advanced technologies and rigorous curriculum, virtual schooling can help students master 21st century skills including global awareness, self-directed learning, information and communications technology literacy, problem solving, and time management and responsibility (NACOL & the Partnership for 21st Century

Skills, 2006; Watson & Ryan, 2006). Virtual school gives students who failed a course in a traditional classroom the chance for remediation (Barker & Wendel, 2001; Freedman et al., 2002; Glass, 2009; Newman, Stein, & Trask, 2003) and students who want advanced courses an enriched curriculum such as advanced placement courses in different fields including mathematics and science (Barker & Wendel, 2001; Butz, 2004; Newman, Stein, & Trask, 2003; Watson, Gemin, & Ryan, 2008). Virtual school also can benefit home school students through offering more educational opportunities that they otherwise wouldn't have due to reasons such as their parents' lack of knowledge or family resource limitation (Butz, 2004; Watson, Gemin, & Ryan, 2008).

Research in Online/Distance Education and Significance of This Study

Along with the growth of online education in the US, considerable research has been conducted on online/distance education effectiveness with respect to improved student academic performance and most of the studies have confirmed its effectiveness. However, little research has been done to examine success factors in K-12 online learning environments. In recent years, two lines of research emerged to address online success factors: one focuses on learner characteristics and another one focuses on learning environment characteristics (Roblyer et al., 2008). However, no clear set of characteristics have been identified as online success factors and no conclusive model has been created to apply in online learning practice (Roblyer & Davis, 2008; Tallent-Runnels et al., 2006). Learner characteristics including participation in academic activities, whether have IEP and learning environment characteristics including teacher comment and school type (private or public school) have been proved to correlate to student academic achievement. However, these variables have not been

investigated systematically in one model regarding their effects on student success in K-12 virtual learning environments.

In a document about nation wide college student transcripts, Adelman (1995) reported that math courses detained the top 7 places in the percentage of grades that were withdrawals, incompletes, or no credit repeats. The first six were pre-college math courses and the seventh was college Algebra. Clearly, math is a difficult subject for many students including secondary level and higher education level. School Algebra is therefore a key subject during the school reform discussion (Chazon & Yerushalmy, 2003). It has been critical for filtering the educational opportunities for high school students to further study in college (Moses, 1994; Moses et al., 1989).

Algebra/mathematics is also a very important momentum to push a society to move forward. Many career options are only open to students with advanced mathematics skills in the job market (House, 1993). Stanic and Hart (1995) believe mastering mathematics knowledge and being able to apply mathematics ideas are critical for each member in a society to participate in the democratic processes and have more career opportunities. The possession of more mathematical literacy for everyone in the society is also the need for full participation in military service and shifts in US and the worlds' economic systems (Secada, 1992).

The purpose of this study is to examine the factors including LMS utilization, teacher comment/feedback and student demographic information that can influence the success of Algebra courses in K-12 virtual learning environments. This study can help discover certain characteristics and good practices in online learning and help incorporate them into the instructional model of the K-12 virtual learning environment. It

also will add to the knowledge of the effectiveness of online/distance education in helping improve student academic achievement in K-12 virtual schooling and provide valuable guidance for better implementation and practice. The investigation of success factors will provide a deeper understanding of success in the K-12 virtual learning environment specifically in online Algebra/math courses to guide management of virtual schools for maximizing their effectiveness to provide better assistance and supplementation to the traditional learning environment.

Review of Literature

The review of literature in this chapter covers the effectiveness of online/distance education, Algebra/mathematics education, and online success factors. The review of literature on effectiveness of online/distance education presents the evidence for the conduct of increasing research in online/distance education. It also provides the rationale for the investigation of online success factors in this study. The review of Algebra/mathematics education can grant the support for the selection of specific courses in which the present study is conducted and demonstrates the relationships between a traditional teaching format and online education. The review of online success factors grounds the present work in the related studies and provides the support for the selection of factors in the present study.

Effectiveness of Online/Distance Education

Well designed distance education courses/programs can provide effective learning with innovative pedagogy, rich experience, and deep understanding of knowledge (Cavanaugh, 2001). Many studies have been done to examine the effectiveness of distance education. Research on distance education effectiveness has mainly focused on several aspects: student learning outcomes, student-instructor interaction during the

learning process, and student and faculty attitude and satisfaction with the learning experience (Gallagher & McCormick, 1999).

Cavanaugh (2001) conducted one meta-analysis study to examine the effectiveness of interactive distance education in the K-12 learning environment. She reviewed 19 experimental and quasi-experimental studies selected with strict criteria including the focus of study, publication date, research design, and calculated effect sizes to assess the effects of some technologies including video-conferencing and online telecommunications on student achievement and to investigate the success factors for effective distance education. All these studies covered a wide range of subject areas and grade levels. The overall effect size for the 19 studies, 0.147, indicated the small positive effect of distance education over traditional education. No significant differences were found in grade levels, ability levels, content areas, technology use, and achievement measure. The author concluded distance education can be at least as effective as traditional education to help students achieve academic goals and that offering distance courses at the secondary level could enrich the course curriculum and students' knowledge structure.

Sherry, Jess, and Billig (2002) conducted one action research study to evaluate the effectiveness of online learning in improving student media literacy and multimedia techniques. They collected data quantitatively using surveys and qualitatively using interview and focus groups from students and instructor. The results showed technologies that are integrated into online learning can help students acquire a variety of skills such as creating multimedia projects, editing digital artifacts, designing web pages, and promoting student learning motivation. They concluded that the technology-

enriched learning environment in general and online education in specific has a positive influence on student achievement.

Allen et al. (2002) reviewed 25 empirical studies comparing student satisfaction between distance education and traditional classrooms. The criteria used to select the studies included the presence of comparison group and sufficient statistical information that effect sizes can be calculated. The results showed overall there was no significant difference in satisfaction level though students showed a slight preference toward traditional education over distance education. The researchers also examined the effects of communication and interaction on student satisfaction level and found that there was virtually no effect on communication methods (video, audio, written). They supported the implementation of distance education by providing the evidence that distance education will not reduce student satisfaction with the learning experience.

Aragon, Johnson, and Shaik (2002) examined the impact of learning style preference on student academic success between online and traditional learning environments to investigate the effectiveness of online learning. Thirty-eight students taking a graduate-level instructional design course, with nineteen in a traditional classroom and nineteen in an online course, taught by the same instructor in a Midwestern university participated in this study. The two groups of students were equivalent with respect to their demographic information such as age, undergraduate GPA, and year of baccalaureate graduation. The researchers found that there were differences in learning style between these two groups, though these differences were not significant when student success was controlled. It indicated online education can be as effective as traditional f2f education in helping students succeed academically

even though they have different learning style preferences. The researchers advocated for the development of online education based on the results.

Swan (2003) looked beyond the no significant differences phenomena and reviewed the literature on the effectiveness of online learning focusing on the three types of interaction: student-instructor, student-student, and student-content. She believed online education is effective as compared to traditional education, and some unique characteristics of the online technology can be further utilized to improve the online learning effectiveness. Based on the literature review, she gave some suggestions for the improvement of online learning environments such as providing timely and constructive feedback to students, integrating activities to establish online community, encouraging students to share experiences and thoughts during their learning process, and ensuring the clarity and consistency of the course materials.

Zhao et al. (2004) employed a meta-analytical approach to investigate the effectiveness of distance education. The researchers found many individual studies reporting significant differences between distance education and traditional education; some found distance education more effective while others found traditional more effective. They selected 51 out of thousands of articles for review with some criterion such as that they needed to be journal articles, they must possess empirical data, and they needed enough statistical information to calculate effect size. The researchers analyzed several variables in this meta-analysis including study related variables such as design of study, measurement employed, instruction related variables such as instructor (status, involvement level), learner (status, background), curriculum (content area, degree), and milieu (interaction, media, setting). Effect size was calculated for the

estimation of difference between distance education and traditional education. The results showed overall there is no significant difference between distance education and traditional education. However, the wide range of effect size (-1.43, 1.48) indicated distance education was much more effective in some studies while was much less effective in other studies. Interestingly, the researchers found publication time was a factor for the effectiveness: studies published before 1998 are more likely to find no significant difference while studies published after 1998 are more likely to find significant effectiveness favoring distance education. The researchers believed that distance education is getting better with the advance of technologies and design principles. The instructor involvement was found to influence the effectiveness: traditional education was more effective when involvement was low and distance education was more effective when it was high. This confirmed the importance of instructor involvement in the form of teacher feedback, and student-teacher discussion for successful distance learning. The researchers also found the content area can predict the difference between distance education and traditional education: distance education was more effective in fields such as Business, Computer Science, and Medical Science; no significant difference was detected in Social Science and Science fields; distance education was slightly effective over traditional education in Military, Mathematics and Specific Skills. Though the researchers did not examine the learner variables such as gender, or learning styles, they believed groups with certain characteristics are more likely to succeed in distance learning. This study also found a blended learning environment mixing distance education and a certain amount of f2f meeting was most effective and called for more comprehensive studies in the distance education field.

Cavanaugh et al. (2004) reviewed 14 studies to examine the effectiveness of K-12 distance education. The studies selected were related to distance education published between 1999 and 2004 under the following criteria: type of publication, K-12 focus, quantitative experimental or quasi-experimental studies, and enough statistical information for the calculation of effect size. They specifically looked at the effects of distance education on student academic achievement and the effects of different features of distance education including content area, duration and frequency of distance education, student grade level, school type, interaction, and instructor role on academic achievement. The overall effect size, zero, showed distance education is as effective as traditional education. The wide range of effect size (-1.158, 0.597) indicated some distance education courses/programs were much better than traditional education while others were much worse. Publication and methodological variables such as year and type of publication, measurement employed in the study and statistical power, and distance education experience variables such as duration and frequency of distance education, instructor role, and type of interactions had no significant influence on effect sizes. However, instructional and program variables such as student grade level, school type, and content area did influence effect sizes significantly. The researchers concluded with the promotion of implementation of K-12 distance education with close collaboration among different stakeholders including teachers, researchers, policymakers, developers, and parents, and more rigorous research in this field to guide the practice and implementation of K-12 distance education.

Stewart et al. (2005) evaluated the effectiveness of one online case-based continuing education program for family physicians in improving their knowledge and

skills. They randomly assigned the participants into experimental groups with the implementation of intervention: online learning and control group without the intervention. They analyzed the knowledge and skill growth measured by two knowledge questionnaires and charts quantitatively and the posts and emails qualitatively. The results showed the intervention had positive effects on knowledge growth and the quality of practice for these physicians. The researchers confirmed the promise of the broad implementation of online education in general.

Williams (2006) reviewed 25 comparative studies from 1990 to 2003 on distance education in allied health science education to examine the learning effectiveness on student achievement and the instructional design (ID) components contributing to the effectiveness. The overall effect size, 0.15, with confidence interval from 0.07 to 0.23, showed distance education was slightly more effective than traditional education with respect to improved student achievement. The results also showed the integration of ID components in distance courses had a positive effect on achievement. The researcher suggested the effective distance education courses should incorporate various ID components. The study was concluded with the promotion of distance education courses/programs and a call for more research on the effect of different aspects such as educational level on the effectiveness of distance education.

In 2009 US Department of Education (DOE) released a report about a meta-analysis of empirical studies from 1996 to 2008 to evaluate the effectiveness of online learning practice. The studies included in this meta-analysis were selected based on the criteria: rigorous research design including random assignment or controlled quasi-experimental design to contrast online to traditional education, objective learning

outcome was measured and enough information to calculate effect size. The researchers found overall online students outperformed traditional students with respect to their learning outcomes with effect size of 0.24 favoring online students. Hybrid learning students had a larger gain over traditional students relative to purely online students over traditional students with effect size of 0.35 favoring hybrid learning students when comparing hybrid learning and traditional learning and effect size of 0.14 favoring online students when comparing purely online learning and traditional learning. Some methodological variables including sample size, content knowledge, research design, and equivalence of instructional approach were evaluated whether they accounted for the results and equivalence of instructional approach was found to be a significant moderator variable. This report confirmed that the combination of a variety of elements in online learning such as instructional strategies, integrated technologies, and students' effort rather than the delivery medium per se is what results in better learning outcomes. The researchers also found that very few rigorous research studies of K-12 online learning effectiveness have been published. Only 7 out of 99 studies included in this meta-analysis focused on K-12 level, and the effect size comparing online learning and traditional learning at K-12 levels was not significant. Therefore, the researchers caution the application of the results to K-12 virtual learning environments and more rigorous research is needed to guide the practice and implementation of K-12 online education.

The proved effectiveness of online/distance education in the literature provides the support for the present study. Many effectiveness studies have focused on the student outcome. This lends the relevance to the selection of student academic achievement as

the dependent variable in the present study. Another focus in many effective studies, student-teacher interaction, presents the rationale for the investigation of teacher comments which could be the indicator of student-teacher interaction in the present study.

Algebra/Mathematics Education

Considerable educational and psychological research has been conducted to identify the success factors in mathematics fields (Grouws, 1992). In the literature on mathematics education, many researchers have focused on a variety of factors that associated with mathematics learning including student attitude and background, family background-socioeconomic, peer environment, instructor factors, and curriculum and instruction (Beaton & Dwyer, 2002; Kifer, 2002; Wilkins, Zembylas, & Travers, 2002). These factors have been categorized into three major topics by Schiefele and Csikszentmihalyi (1995): learner characteristics such as learning styles, learning strategies, and locus of control, home environment such as socioeconomic status (SES) and family size, and school environment such as instructor experience, instruction quality, technique support and resources. However, in other studies, these factors have been grouped into two categories: learner characteristics and learning environment characteristics which include home learning environment and school learning environment (Catsambis, 1995; Ercikan, McCreith, & Lapointe, 2005; Ho et al., 2000). To be consistent with Roblyer et al., (2008)'s study of K-12 distance education, we used two groups of factors in the present study.

Learner characteristics variables

Research has shown learner' personal characteristics variables such as prior knowledge and background, motivation or self-concept are strongly associated with

student mathematics achievement (Catsambis, 1995; Ercikan, McCreith, & Lapointe, 2005; Ho et al., 2000). Some affective variables such as self-concepts, attitudes toward mathematics, self-confidence mathematics learning ability, motivation, locus of control, and perceptions of the usefulness of mathematics have been found to relate to student academic achievement in mathematics (Bassarear, 1991; Duranczyk, 1997; House, 1995; House, 1993; Marsh & Yeung, 1997; Reyes, 1984). Increased study time and the taking of advanced coursework also can positively affect students' mathematics achievement (Secada, 1992). Student English language proficiency is another factor for student mathematics achievement in U.S. (Jacobson, 2000; Secada, 1992). Bilingual students whose native language is not English will be likely to achieve higher performance in mathematics if they receive the instruction in their native language (Secada, 1992).

Ercikan et al. (2005) conducted one exploratory research study examining factors that might affect students' achievement in mathematics and their participation in advanced mathematics courses in three countries: Canada, Norway, and the US. They found students' personal and home environment variables strongly affect their achievement in mathematics and participation in advanced mathematics courses in these three countries. These researchers specifically confirmed the relationship between attitude toward mathematics and participation in advanced mathematics courses in these countries and the relationship between SES related variables and achievement in mathematics in the US.

Higbee and Tomas (1999) conducted one research study to examine the relationship between non-cognitive variables including math anxiety, perceived

usefulness of mathematics, self control ability, and self confidence in one's ability to learn mathematics and academic achievement in mathematics. The participants were 23 college freshmen and student score in their math courses was collected as the indicator of academic achievement. The researchers found student attitudes toward mathematics, motivation, self-management skills and self-confidence are related to academic achievement. Jacobson (2000) examined success factors in high school mathematics using a variety of statistical techniques: multiple regressions, ANOVA, and path analysis with a sample size of 1205 high school students. She found student beliefs/confidence in their mathematics learning ability and family background/SES have strong effect on academic achievement in mathematics courses. Interestingly, she also found student's primary language and writing ability are significant success factors in mathematics learning.

Based on the review of literature on mathematics education, Reyes (1984) asserted the affective variables including students' confidence in their mathematics learning ability, attitude toward mathematics, and mathematics anxiety are related to mathematics learning. Reyes believed students' confidence in mathematics learning or self-concept about mathematics learning has a positive relationship with mathematics achievement. Mathematics anxiety can negatively affect student mathematics achievement. Reyes believed students' attitude toward mathematics and their perceived usefulness of mathematics can affect their decision about the mathematics course they will take. Students who valued mathematics more tended to take more mathematics courses, which, in turn, could contribute to their higher achievement.

Edge and Friedberg (1984) conducted one study to evaluate the effect of student ACT scores, high school prior knowledge in calculus, gender, family size, and high school size on student academic achievement in the first college calculus course. They found the long-term perseverance/self-control ability and student pre experience/knowledge in Algebra can significantly affect student achievement in the first semester of calculus for freshman. Schiefele and Csikzentmihalyi (1995) conducted one research study using 108 high school freshmen and sophomores to examine the relationships between interest, learning motivation, prior mathematics knowledge/mathematic ability, student mathematics learning experience, and academic achievement in mathematics. The researchers found mathematics ability is a significant predictor of academic achievement, and the predictability of interest for achievement is different for students at different grade levels. At 9th or 10th grade level, interest is a good predictor of achievement.

Belcheir (2002) reported a research study on the exploration of variables that can predict success in math courses. The sample of participants was 734 college students enrolled in one intermediate Math course. This study included learner variables such as student math learning attitude and dispositions, study skills, and student commitments. This study did not find time on task as a good predictor of course success as expected. However, the researcher further explained that some valuable information could be missing in this study because the researcher did not collect information about how students spent time studying and whether students felt the amount of time they could use on the course was sufficient. Student motivation and commitment were found to be the most significant predictors of success for the Algebra courses. The researcher also

emphasized that the instructors should let students know early on how they are performing in order for them to succeed in the courses.

Learning environment variables

Research has shown learning environment characteristics variables including family background and support, school or classroom resources, teacher/classroom are strongly associated with student mathematics achievement (Catsambis, 1995; Ercikan, McCreith, & Lapointe, 2005; Ho et al., 2000). High parent expectations (Cohen, 1987; Marjoribanks, 1988; Scott-Jones, 1984; Seginer, 1986; Thompson, Alexander, & Entwisle, 1988) can positively affect students' mathematics achievement. Instructional strategies including the implementation of computer Algebra software (Elington, 2003; Lawson, 1995; Mayes, 1995; Stephens & Konvalina, 2001), the use of other technologies such as calculators in general and graphing calculators in specific (Elington, 2003), and collaborative problem solving strategy and visual technique support (Higbee & Thomas, 1999) can positively affect student mathematics achievement. Teacher variables such as teaching behaviors are another type of factor that related to student academic achievement (Schoen et al., 2003).

House and Telese (2008) investigated the relationships between instructional strategies and self confidence in mathematics learning ability and Algebra academic achievement in the US and Japan using 2003 TIMSS assessment data. The sample includes 4244 students from Japan and 7862 students from the US. They found the teaching and learning strategies and students' self confidence/beliefs in mathematics learning ability are significantly associated with student Algebra academic achievement in these two countries. Interestingly, they found the instructional strategy of cooperative learning activities (working in small groups) negatively affected student achievement

and students who worked on problems on their own (active learning strategy) more often tended to achieve higher performance. Students who can associate their mathematics knowledge with their daily lives tended to achieve lower test score. More research is needed on the effect of learning strategies (group work or independent study) and the triangulation of a variety of academic measurements during the study of Algebra learning factors.

Elington (2003) investigated the effects of calculators including basic, scientific, and graphing on students' achievement and attitude levels through the examination of 54 studies, 26 of which targeted high school students. She found the use of calculators in the testing system and instruction can increase students’ strategic skills, computational and conceptual skills, and problem-solving skills and promote students’ positive attitude toward learning mathematics. Based on the empirical studies, Hollar and Norwood (1999) and Shoaf-Grubbs (1993) found the use of graphing calculators can increase students’ overall mathematics ability including the understanding of function, the ability for modeling, interpreting, and translating. In additional to students’ increased ability in mathematics problem solving, the integration of technology during the mathematics learning process can also promote collaboration among students during group interactions and class discussions (Goos et al., 2003).

Wheland et al. (2003) examined two types of factors that affect student academic performance in an intermediate Algebra course: instructor characteristics- English speaking status (non-native English speaker), teaching assistant or adjunct faculty, and student characteristics: attendance. The effect size was also calculated in the study. The researchers found the instructor characteristics variables: English speaking status,

teaching assistant or adjunct faculties do not have significant effect on student performance while student attendance can significantly affect academic performance. Schoen et al. (2003) also analyzed teacher variables related to student achievement within one reform-based project, the *Core-Plus Mathematics Project* involving 40 teachers and their 1466 students in 2 schools. They found teaching behaviors such as following the guidance and recommendations of standards and aligning the instruction with the high mathematics expectations are related to higher academic achievement.

Algebra teaching and learning

A significant amount of research has been conducted on Algebra teaching and learning considering its importance as the momentum to push society to move forward. The focus of Algebra teaching and learning research has been shifted from students' understanding of Algebra activities to the way students construct meaning of Algebra procedures and objects (Kieran, 2007). Based on these studies, recommendations and suggestions have been provided to help improve Algebra teaching and learning quality. Smith, diSessa, and Roschelle (1993) believe school Algebra instruction should build upon the strengths and the resources within the perceptions students have based on their own experience in relation to Algebra concepts. Students should grasp the ability to solve ill-defined tasks that are more closely connected with the questions they may have in the real life rather than the well-defined ones within the school settings (Resnick, 1987). Based on the review of literature on Algebra teaching and learning for students with different backgrounds, Secada (1992) recommended some instructional strategies including increased school time, more mathematics course taking, use of students' native language for instruction, direct instruction for structured curriculum and

basic mathematics skills, and divide of whole class activities into group and individual work.

Considerable research has been conducted on the approaches to Algebra learning. Bednarz, Kieran, and Lee (1996) reported the four approaches that have been focused on at an international colloquium on Algebra in early 1990, including generalization of numerical and geometric patterns and laws regarding Algebraic relationships, functional situations, modeling of mathematical phenomena, and problem solving. Drijvers (2003) described the similar approaches for Algebra learning in more detail:

- Problem-solving approach: view Algebra as a way to solve problems that can be expressed in equations.
- Functional approach: view Algebra as a way to investigate the functions and relations among different variables.
- Generalization approach: mainly focus on the examination of patterns or models and configurations, and focus on the generalization of relations among different variables.
- Language approach: view Algebra as a way to convey mathematics ideas in which Algebra is merely a representation structure composed of symbols without specific context attached meaning.

Drijvers also identified some aspects that make learning Algebra difficult. These include:

1. The difficulty for students to relate the formal algorithmic procedures with informal while meaningful methods
2. The abstract characters of Algebra problem solving approaches that students can’t connect them with the concrete situations
3. The Algebraic language includes particular symbols and rules that are difficult for students to grasp

Drijvers pointed out the importance of reification of expressions and formulas during the Algebra learning process. Students need to possess the ability to comprehend the structure and meaning of formulas and expressions, which as he called "symbol sense" (p.49). Furthermore, Drijvers explained some key elements of one theory for mathematics education: Realistic Mathematics Education (RME) and their meaning and relations to Algebra learning:

- Guided reinvention and progressive mathematization: with the guidance from the teacher, students are given the opportunities to develop formalized mathematics knowledge by employing the informal strategies and apply the knowledge in the concrete life situations.
- Didactical phenomenology: design activities that encourage students to develop their own mathematics learning strategies
- Horizontal and vertical mathematization:
- Horizontal: by employing empirical methods for example observation and experimentation, students can structure and solve the problem with mathematics formulas or conventions.
- Vertical: based on these problem-solving experiences and beyond, students can develop mathematical framework in regarding with the relations among symbol.

The review of Algebra/mathematics education demonstrates the relationships between f2f learning environments and online education with respect to the factors of academic achievement. It lends the support for the selection of success factors in the present study. For example, many Algebra/mathematics education studies have focused on a variety of factors that associated with mathematics learning outcome. These factors include learner characteristics such as learning styles and learning strategies, and learning environment characteristics such as family background and school learning resources. This supports the categorization of factors in the present study.

Success Factors in Online Learning

Given the fact of extraordinary development of online education in the last two decades, little research has been conducted to examine success factors in the online learning environment as compared to the traditional learning environment. With the high early dropout and failure rates in the online learning environment (Carr, 2000a; Roblyer & Elbaum, 2000), there is an urgent need for more research on success factors to prevent students from dropping out of virtual or physical school and ensure their success in this learning environment (Barbour & Reeves, 2009; Bernard et al., 2004a; Butz, 2004; Dickson, 2005; McLeod et al., 2005). At the K-12 level, there is great concern about the readiness for students to take online courses and succeed academically because they are not socially and emotionally mature as compared to students in higher education (Picciano & Seaman, 2007). The review of studies examining success factors in online learning environments as well as traditional learning environments can better guide the practice of K-12 online education.

Schrum and Hong (2001) administered a survey with 70 institutions and found several factors can influence student success in e-learning environment: learning styles, prior technology experience, personal disposition, study habits, and tools accessibility. Brown and Liedholm (2002) conducted a comparative study between online education and traditional education and found student's personal effort on learning tasks could make a difference in academic performance. Swan (2002) investigated the correlation between 22 course design factors and student academic achievement and satisfaction with learning experience. She found three factors: transparent interface/clarity and consistency in course design, instructor feedback/instructor-student interaction, and dynamic online discussion are associated with the success of online learning. These

three factors could be three necessary steps for the establishment of an online learning community (Swan et al., 2000), which can affect students' learning outcomes in online education.

Roblyer and Marshall (2003) evaluated one instrument, the Educational Success Prediction Instrument (ESPRI) which was created to predict success in Virtual High School (VHS) courses. The constructs measured by this instrument related to success in VHS courses included time management, achievement, motivation, self-responsibility, prior technology skills, self-regulation, and self-confidence. They evaluated ESPRI with 135 students in 13 virtual high schools and found ESPRI is a reliable instrument (Cronbach α=0.92) to predict student success in the online learning environment, and certain personality characteristics and attitude were associated with online learning success. Roblyer et al. (2008) created the instrument: ESPRI-V2 based on ESPRI and reevaluated it with a bigger sample size: 4110 students from VHS. They found the four factors measured by ESPRI-V2: technology use/self-efficacy, achievement beliefs, instructional risk-taking, and organization strategies can predict student success in VHS courses though it's harder to predict failure, and the Cronbach α, 0.92, indicated ESPRI-V2 is a reliable instrument. The researchers concluded the combination of prior knowledge, cognitive characteristics such as self-efficacy and achievement beliefs, and environment variables such as Internet accessibility and technical support can predict student online success.

According to Roblyer et al. (2008), two lines of research emerged to address success factors in online learning: studies focusing on learner characteristics and studies focusing on learning environment characteristics. Learner characteristics include

student cognitive factors such as locus of control and learning styles; prior technology skills and attitudes; and experience and prior knowledge about course content while learning environment characteristics include technology support, course content area, and accessibility to the Internet. At present, no clear set of characteristics have been identified to predict the success of the virtual learning environment, and no conclusive model has been created to apply in online learning practice (Roblyer & Davis, 2008; Tallent-Runnels et al., 2006). Other learner characteristics including personal effort/participation in academic activities, whether has individual educational plan, race/ethnicity, and family background/participation in free/reduced lunch programs, and learning environment characteristics including teacher comment/feedback/instructor-student interaction and school type (private or public school) also have been proved in some studies to correlate to student academic achievement. However, these factors' influences have not been investigated systematically. The review of these factors in light of the relationship with student academic achievement in other studies can provide deeper understanding of success in online learning in general and the K-12 virtual school environment in specific and shed light on the establishment of a model to predict online learning success in general and online Algebra/mathematics learning in specific.

Teacher comments/teacher-student interaction

Teacher comments and student-teacher interaction is a critical component in academic learning (Boaz, 1999; Laurillard, 1997; Parker, 1999; Schaffer & Hannafin, 1993; Summer, 1991; Swan, 2003; Williams, 2006). It can affect learning in traditional f2f learning environments (Christophel, 1990; Kelly & Gorham, 1988; Rodriguez, Plax & Kearney, 1996) and online learning environments (Blomeyer, 2002; Jiang & Ting, 2000; Johnson et al., 2000; Swan, et. al., 2000; Swan, 2002; Swan, 2003; Tallent-Runnels et

al., 2006). Interaction, well described by Cavanaugh, is the "core of teaching" (2001, p. 3) and “at the heart of online learning” (2007, p. 6). The presence of interactivity is vital for the quality education in distance learning (Blomeyer, 2002; Flottemesch, 2000; NACOL, 2006; Parker, 1999; Zhao et al., 2004). It can help students evaluate their learning progress and adjust the instructional strategies if necessary to improve the learning outcome which will lead to a deeper understanding of knowledge (Hiebert & Grouws, 2007; Parker, 1999; Schoenfeld-Tacher, McConnell, & Graham, 2001). Student-instructor interaction can provide the social support for students during the learning process, which is conducive to higher academic achievement and the development of social skills (Parker, 1999). It also has a positive relationship with students’ satisfaction with their learning experience (Liaw & Huang, 2000; Swan, 2002; Usun, 2004).

The educators’ active facilitation in the form of teacher comment and feedback in online learning is an important factor that influences students’ academic performance (Cavanaugh et al., 2005; Dickson, 2005; Ferdig, Papanastasiou, & DiPietro, 2005; Hughes et al., 2005; Karp & Woods, 2003; Lin 2001; Peters 1999; Phipps & Merisotis, 2000; Smouse, 2005; Zucker, 2005). Jiang and Ting (2000) conducted one study to examine instructor activity in online learning and found the student’s perceived learning is correlated with the number of feedback comments per student that the instructor made. This relationship also has been confirmed by Swan et al. (2000) and Swan (2002). Anderson and Kuskis (2007) argued many of the pedagogical benefits brought by instructor feedback/student-teacher interaction such as those related to motivation are relevant to distance education as well as the conventional classroom education.

Hughes et al. (2005) believed that teachers' individual feedback can increase communication opportunities for students who are shy and may not participate in academic activities, and these opportunities are helpful to develop closer relationships between the instructor and students. Constructive and timely feedback from instructor is one of the success factors for the practice of an effective virtual learning course/program (Cavanaugh, 2004).

Frequent and open communication between students and instructor is identified as an important component to build a virtual community during online learning (Lin 2001; Murphy, Mahoney & Harvell, 2000). The development of a learning community in an online K-12 course is considered an important factor for students' better academic performance (Lin 2001; Oren, et al., 2002; Ronsisvalle & Watkins 2005; Wang & Newlin, 2000). Wang and Newlin (2000) argued the social support provided by the learning community could improve students' academic achievement as well as their involvement and interest in online academic activities. Oren, et al. (2002) believed teachers should act as a moderator to facilitate and scaffold students learning and encourage various interactions especially peer-to-peer interaction to let students learn from each other. They emphasized teachers' supportive feedback to encourage student-to-student social interactions for the formation of the social groups during the leaning process and beyond. O'Dwyer et al. (2007) conducted a quasi-experimental study to examine the impact of one Algebra I online initiative on students' learning outcomes and found that online students themselves also highly value the student-instructor interaction during the learning process.

Participation in online academic activities

The number of times students logged into the LMS and how long they stayed in the LMS could be considered as the indicators of participation in online academic activities. The time spent in academic activities has been identified as a very important factor that has a strong effect on success in online education (Cavanaugh, 2007), face-to-face instruction (Rocha, 2007), and blended programs (Cavanaugh, 2009). The activities students engaged in during online study is a predictor of final scores, with students who participate in academic activities at high level performing better than those who do not in online learning (Wang & Newlin, 2000). Dietz (2002) believed one of the most significant predictors of success is attendance which could be reflected by the number of times students log into an LMS. These findings were confirmed by Dickson (2005) that participation in online academic activities, which is measured by clicks in the LMS, is a strong predictor of final scores in online learning.

Race/ethnicity

Considerable studies have been conducted on the relationship between race/ethnicity and academic achievement in traditional learning environment. Racial gaps in student test score are undeniable facts (Bali & Alvarez, 2004; Hall et al., 2000). The student body in online K-12 schools often represents the community that is served by the traditional school system (Ronsisvalle & Watkins, 2005). The findings in the literature of the relationship between race/ethnicity and student academic achievement in traditional learning environments could shed light on success factors studied in K-12 online learning environments.

Through a meta-analysis of 16 studies of race differences in mathematics performance from grades 4 to 8, Lockhead et al. (1985) found Asian Americans usually

perform at the highest level in math, followed by Caucasian students, and then Hispanic. All the three groups perform better than African American students. Hall et al. (2000) also found significant differences in student math achievement among different ethnicities in a study on gender and racial differences in mathematics performance among 5th and 8th grade students in the United States. These differences continue at the higher level. The math skills of most African American in 12th grade, as Barth (2001) described, are only equivalent to the skills of Caucasian students in the eighth grade. U.S. DOE released a report in 2004 about the gaps in academic achievement in different content areas such as reading, math, and science among different racial and ethnic groups based on the data collected since the mid-1980s. At 4th grade level, 41% of whites and 38% of Asians were proficient readers while the number for African Americans, Hispanics, and Native Americans was 13%, 15%, and 16%, respectively. In mathematics, 48% of Asians and 43% of Whites achieved at proficient level while only 10% of African Americans, 16% of Hispanics, and 17% of Native Americans achieved at this level.

Participation in school free lunch/family SES

Participation in school free or reduced programs has a correlation with student academic achievement, and the magnitude of correlation is weaker as grade level rises (McLoyd, 1998). Klein et al. (2000) conducted a research study on the relationship between students' participation in free or reduced lunch programs and school test score using the data about 2000 Texas 5th graders in reading and math. They found the percentage of students participating in the free or reduced lunch program in a school can affect the school's mean test score. The researchers believed participation in these programs could be considered a sign of the level of poverty which has a strong

relationship with student academic performance at the school level. Participation in a school lunch program was also frequently used as the measurement of student's family Social Economics Status (SES) in the literature on student academic achievement (Sirin, 2005). The level of the family support including the resources provided for students and education values can influence student academic achievement (Hiebert & Grouws, 2007). Higher SES families provide students more resources at home and social capital, both of which can improve chances for their academic success (Coleman, 1988). A considerable body of research has been done on the relationship between SES and student academic performance. The magnitude of this relationship was found to be strong in two meta-analytic studies conducted more than twenty years apart from each other: 0.343 in White's (1982) meta-analysis and 0.299 in Sirin's (2005) meta-analysis. In K-12 online learning environment, participation in school reduced lunch program/family SES could also be associated with student academic success.

Learning ability/presence of individual educational plan

Student learning ability is a factor that can influence student academic success during the learning process (Keeler & Horney, 2007). The virtual school student body is a diverse population including students with different learning disabilities (Dickson, 2005; Ferdig, Papanastasiou, & DiPietro, 2005). Virtual school offers individual education plans for these students during the learning process. Therefore, whether or not a student has an individual education plan could be a sign of the level of learning abilities. The review of studies on the relationship between learning ability and academic achievement could shed light on the decision making process to provide more opportunities for students with special needs to succeed in the K-12 online learning environment.

According to Keeler et al. (2007), students may bring some characteristics that could physically or psychologically inhibit their access to the information or tools on the Internet, preventing their success in the online learning environment. The virtual school learning environment has the potential to bridge gaps between disabled students and other students without learning disabilities with respect to the success opportunities in online learning. For example, for students with different levels of learning disabilities, technologies such as computer, internet, audio, video, animation, gaming and simulation could help reduce their disadvantages as compared to students without disabilities (Coombs & Banks, 2000; Richardson et al., 2004). Some instructional design strategies have been recommended to ensure online courses meet the special needs of students with disabilities (Keeler et al., 2007; Rose & Blomeyer, 2007). These include assurance of accessibility to the information for students with disabilities and the support in course materials and learning activities for these students. Virtual courses need to be designed with accommodations specifically for students with disabilities to access course materials and should benefit all learners under the framework of Universal Design for Learning principals (Rose & Blomeyer, 2007). Since the emergence of universal design technology and the requirement for the development of Learning Management System (LMS) to integrate components to meet the special needs of disabled students to align with the American with Disabilities Act (ADA) (Watson, 2007), the opportunities to achieve higher performance for disabled online students has been greatly increased. The proposition of early adoption of technology-infused education for disabled online students (O'Connor, 2000) also will benefit their

online learning. Over a decade virtual school programs have successfully provided quality education to students with special needs (Rose & Blomeyer, 2007).

However, even with the bridging gaps with regard to online success opportunities for disabled online students, they are still underrepresented in online education (Kinash & Crichton, 2007). For example, even though different learning management systems such as WebCT and Blackboard are generally accessible to disabled students, there are still inherent problems limiting them from fully utilizing the functions in their courses therefore limiting their chances of success in online learning (Asuncion et al., 2006). Many online courses still have barriers preventing students with disabilities from fully accessing materials as other students do (Edmonds, 2004; Keeler & Horney, 2007), which will affect their success in online learning.

Keeler and Horney (2007) conducted one study to evaluate the elements of online course design that address students' special needs. They found some problems still existed in the five categories of design elements: accessibility, website design, technologies used, instructional methodologies, and support systems, which can prevent students' special needs being fully addressed. According to National Center for Education Statistics (NCES, 2000), though computer and communication technologies may be especially beneficial for disabled students (Johnson, 1986), providing them the access to these technologies could be more expensive than regular students because they may need special equipment to use these technologies. The lack of accommodations for students with special needs may exclude them from fully participating in online learning (Keeler & Horney, 2007). Disabled students lack the opportunities to use these communication technologies for a variety of reasons

including insufficiently trained special education teachers and inadequate support services for them to use these technologies (NCES, 2000). This could lead to the academic gap between students with disabilities and students without these disabilities in online learning.

Students' learning ability could affect other academic performance in addition to achievement such as academic engagement. Kersting (1997) interviewed 10 deaf students to examine their learning experience and found these students had lower academic engagement in learning activities unless they got sufficient support during their learning process. Richardson, Long, and Foster (2004) compared deaf students and their peers without hearing loss regarding academic engagement in distance learning. There were 267 students with a hearing loss and 178 students without this disability in an open university who participated in this study. The results showed students with hearing loss could not perform well on communication and some other tasks in comparison to students without this disability, which could affect the academic achievement negatively for these disabled students.

School type

The gap in student achievement between private and public schools has been documented in many studies (Chubb & Moe, 1990; Coleman & Hoffer, 1987; Coleman, Hoffer, & Kilgore, 1982). In 2006, the US Department of Education's National Center for Education Statistics (NCES) released a report about the academic achievement differences in reading and math at grade levels 4 and 8 between private and public schools (Braun, Jenkins, & Grigg, 2006). This report showed on average the private school mean score was higher than the public school's. Students in private schools achieved at higher levels academically than those in public schools. However, many

studies did not control other important variables such as student SES, or grade level when examining the difference between public and private schools and many of them have been done more than two decades ago, so the data could be already outdated. Therefore, more studies with new data and new methodology are encouraged to be conducted. A study (Lubienski & Lubienski, 2005) supported by the National Assessment of Educational Progress (NAEP) compared student achievement in mathematics between public and private schools using a student sample of 4th and 8th graders. There were over 13000 4th grade students from 607 schools, 385 of which were public schools and 222 were private schools, and over 15000 8th grade students from 740 schools, 383 of which were public schools and 357 were private schools, who participated in this study. The results showed overall students in private schools outperformed their counterparts in public schools; however, after controlling for student's SES, public schools outperformed private schools. The larger proportion of high-SES students in private schools accounted for their overall outperformance. The researchers called for more research on the examination of effectiveness of public and private schools.

The review of success factors grounds the present work in the related literature. It helps the establishment of the model in the present study with respect to the selection of independent variables. For example, the family SES has been proved to relate to student academic performance in many studies, which provides the support for the inclusion of the participation in school reduced or free lunch programs which could be the indicator of family SES in the model. Many studies in this literature are quantitative

studies. This can shed lights on the quantitative research method utilized in the present study.

Conclusion

The review of literature on effectiveness of online/distance education demonstrates well designed online/distance course can be as effective as its traditional counterpart with respect to helping improve student academic achievement. This presents the evidence for the increasing research in online/distance education and provides the rationale for the present study. The review of literature on Algebra/mathematics education illustrates that several issues such as learner prior knowledge and learning ability, study time, and instructional strategies need to be addressed during the process of Algebra/mathematics teaching and learning. It also indicates a variety of approaches such as problem-solving, generalization of geometric patterns and Algebraic relationships, and functional situations should be utilized to improve learning efficiency. This section builds the connections between traditional education and online education. Both of these two education formats share success factors though the effect could be different in these two environments. The review of success factors confirmed the relationship between student demographic information, participation level in academic activities, and teacher comments and student academic achievement. These are also the variables of interest in the present study.

Even after more than 10 years of extraordinary growth in K-12 online learning, little research has been done as compared to post-secondary education (Cavanaugh, 2007; Cooze & Barbour, 2005; Means et al., 2009; Picciano & Seaman, 2007; Picciano & Seaman, 2009; Ronsisvalle & Watkins, 2005). The amount of evidence-based research or empirical study applicable to guide educators' instruction and policy makers' decision

relevancies is slight (O'Dwyer, Carey, & Kleiman, 2007). Many states have no data on the current practice of K-12 online education such as the number of students taking courses online, the number of online programs existing, and how these programs are managed (Watson, 2007). After review of 99 comparative studies regarding online education versus traditional education published between 1996 and 2008, the U.S. Department of Education found that only 7 of them involved K-12 learners (Means et al., 2009). The development of K-12 online education is advancing differently from the development of postsecondary online education (Picciano & Seaman, 2009). Therefore, the practice of online education in higher education may not be applied to the K-12 environment. The dearth of studies on academic achievement in K-12 virtual learning environment in comparison with that in traditional learning environments form the rationale for more quantitative research in this field to guide the implementation and practice of online learning at this level (Cooze & Barbour, 2005; Means et al., 2009; Picciano & Seaman, 2007; Picciano & Seaman, 2009; Smith, Clark, & Blomeyer 2005; Watson, 2007). Quantitative data collection is the required research methodology to support the understanding of the efficacy in K-12 virtual school (Smith, Clark, & Blomeyer, 2005).

Currently the lack of new data regarding K-12 online learning is attributed to a variety of reasons including lack of requirement in many states for data collection on online students and the significant growth of K-12 online education practice causing the difficulty of data collection (Picciano & Seaman, 2007). Research conducted in virtual schools is rare because of its comparatively new practice, and currently available data can't provide enough information for accurate estimation of its practice (Glass, 2009).

More research has been called for that focuses on students' academic performance, particularly on the factors influencing the success of students in K-12 virtual learning environments (Smith, Clark, & Blomeyer, 2005). The question of whether the factors that affect students' achievement in the traditional school learning environment play the same role in the virtual school learning environment remain to be answered. Academic performance is considered as the single greatest indicator of school completion (Battin-Pearson, Newcomb, & Abbott, 2000), and lowering the school dropout rate is a national priority. The investigation of the factors that influence student academic performance in virtual schools is of critical interest to educators, researchers, virtual school program administrators, and policy makers.

CHAPTER 3
METHODOLOGY

Introduction

There are five sections in the methodology chapter: research design, population and sample, instrumentation, data collection and analysis, and limitations. What type of design employed in this study is explained in research design section. Then the population that this study is targeting, sample that has been selected and sampling techniques employed are described. Instruments utilized in this study are detailed in the section of instrumentation. The process of data collection and analysis are then explained. And limitations if any are pointed out at the end.

The purpose of this study is to examine the factors including LMS utilization, teacher comment/feedback and student demographic information that can influence the success of Algebra courses in K-12 virtual learning environments. The research questions in this study are:

- Does the level of LMS utilization influence Algebra/mathematics performance in online education?
- Does teacher comment or feedback influence Algebra/mathematics performance in online education?
- Do student demographic information such as race/ethnicity, grade level, status in virtual school, whether have individual educational plan (IEP), and participation in free/reduced lunch programs influence Algebra/mathematics performance in online education?

Research Design

The present study is descriptive in nature. The researcher described some factors' predictability of Algebra learning outcome without intervening. The researcher collected the data at the end of 2008-09 academic year. These data include student demographic

information, their participation level in online academic activities, teacher comments, student EOC test score, and the score on one state standardized mathematics test.

The variables of interest in this study include: teacher comments (TEACHERCOM), student participation level of online academic activities - the number of times students logged into the LMS (TOTALLOG), the time they stayed in the LMS (TOTALMIN), and student demographic information - whether students have IEP, students' grade levels in their physical schools (GRADE), race/ethnicity (RACE), students' status in the virtual school (full time or part time students, PT/FT), and the participation in free or reduced lunch (FRL) programs. They are independent variables in the study. Student EOC test score and the score on one state standardized mathematics test are dependent variables in this study.

Participants and Data Collection

The data were collected during the 2008-09 academic year from one state virtual school in the Midwestern US region. This virtual school was implemented in 2007. A similar pilot project was conducted in spring, 2009, based on its first year (2007-08) data. This dissertation builds on the results of the pilot project. However, the present study is different from the pilot project in many respects. For example, the present study investigated the success factors not only for Algebra EOC test but also for one state standardized mathematics test which was missed in the pilot project. The present study was conducted with different sample from the pilot project. Students statewide from bricks-and-mortar public and private schools as well as home school students were eligible to enroll in this virtual school. Enrolled students resided in most of the state's school districts. The school hired content area teachers who met state certification and

other requirements. A single LMS was utilized by this virtual school to manage course content and deliver instruction at the secondary level.

The students needed to take the EOC test at the end of each semester during 2008-09 academic year after they completed the course. Some students also took one state standardized mathematics test at the end of academic year. Students who completed the four Algebra courses: Algebra I (1st half), Algebra I (2nd half), Algebra II (1st half), and Algebra II (2nd half) and took the EOC tests and the students who took the state standardized mathematics test grade 6, 7, or 8 participated in this study (Due to lack of information about students who took the standardized test grade 3, 4, or 5, they were dropped from the study). The number of students who took the four Algebra EOC tests was: 101, 75, 26, and 36 respectively. Due to the insufficient power for data analysis caused by the small sample size of Algebra II (1st half) and Algebra II (2nd half), 26 and 36, these two groups were dropped from the study. Within the two Algebra I groups, 64 out of 101 students in Algebra I (1st half) (63.4%) and 59 out of 75 students in Algebra I (2nd half) (78.7%) were second year students in this virtual school. Students who took the two Algebra EOC tests were from grades 8 to 12. Students who took the standardized mathematics test grade 6, 7, or 8 were from grade 6 to 10 and the number was: 74 (grade 6), 73 (grade 7), and 107 (grade 8). All of these participants were first year students in this virtual school.

Instrument

Success in an online course can be measured by academic achievement including the grades students earn and their performance on advanced placement exams (Ronsisvalle & Watkins, 2005; Tallent-Runnels et al, 2006). Dickson (2005) used student final score as the measure of student performance in online courses during the

data analysis in a study conducted to investigate the variability of student performance in online courses. Full-time online schools assessed student achievement in the same way as all public schools (Watson, Gemin & Ryan, 2008). Student achievement in many supplemental online programs is also assessed by course grade or EOC test score (Watson, Gemin, & Ryan, 2008). Indeed, some virtual schools and their teachers are paid on the basis of successful students, defined as those passing their courses.

Algebra EOC Test

Students who took the Algebra I EOC test in the virtual school participated in this study. The Algebra EOC tests were tests administered at the end of each semester in this virtual school. According to the virtual school administration, they have high correspondence to the state's Algebra and mathematics content standards. The purpose of the EOC test, as described by the state's department of education (2009), is to:

- Measuring student achievement and progress toward postsecondary readiness
- Identifying students' strengths and weaknesses
- Communicating expectations for all students
- Meeting state and national accountability requirements
- Evaluating programs

The Algebra I EOC test includes one session of multiple choice items and one session of performance events (Missouri Department of Elementary and Secondary Education (MDESE), 2009a). The items in the multiple choice session are developed specifically for students in this state (see Appendix A for some released samples). The items in the performance events session are longer, and focusing on more challenging

tasks that require students to work through different problems, arguments, or require extended writing (see Appendix B for some released samples). These EOC tests are intended to measure students' skills in number and operations, Algebraic relationships, and data and probability. This state has its standards for Algebra (see Appendix C for the state Algebra standards). The Appendices A-E provide the evidence of alignment between the Algebra I EOC test and state Algebra standards.

State Standardized Test

Students who took one state standardized mathematics test grade 6, 7, or 8 after they finished one year of study in this virtual school during 2008-09 academic year participated in this study. This standardized mathematics test is aligned with the state **Show-Me Standards** which are the educational standards of this state. For mathematics, the **Show-Me standards** require students in state public schools to obtain knowledge of (MDESE, 2008)

1. Addition, subtraction, multiplication and division; other number sense, including numeration and estimation; and the application of these operations and concepts in the workplace and other situations
2. Geometric and spatial sense involving measurement (including length, area, volume), trigonometry, and similarity and transformations of shapes
3. Data analysis, probability and statistics
4. Patterns and relationships within and among functions and Algebraic, geometric and trigonometric concepts
5. Mathematical systems (including real numbers, whole numbers, integers, fractions), geometry, and number theory (including primes, factors, multiples)
6. Discrete mathematics (such as graph theory, counting techniques, matrices)

This grade level state standardized mathematics test is a standards-based test designed to measure the skills for each grade of students in the state where this virtual

school is located (MDESE, c). It also has a national norm-referenced test that can be used to compare students in this state with students across the country. This component helps align the state standardized test with the National Council of Teachers of Mathematics (NCTM) standards. See Appendix D for NCTM mathematics standards for grades 6-8.

There are three types of questions in this grade level standardized mathematics test: 1. multiple choice items that are developed specifically for students in this state or the questions in the national norm-referenced survey; 2. constructed response items that require students to provide the response rather than selecting the options among different choices; 3. performance events items as described above in EOC test that are longer, and focusing on more challenging tasks that require students to work through different problems, arguments, or require extended writing (MDESE, c). See Appendix E for released items of this standardized test (spring 2006) at grade level 6. This state has standards for mathematics at different grade levels. See Appendix F for the state standards for mathematics at grade level 6 (due to the space limit, the author did not attach released items of this standardized test (spring 2006) at grade 7 and 8 and state standards for mathematics at grade level 7 and 8). The Appendices D-F provide the evidence of alignment between this state standardized mathematics test and NCTM mathematics standards and state mathematics standards.

Data Analysis

Due to the very small sample size of minority groups including Asian American, Hispanic American, Indian American, and African American in this study, these four groups were combined as one category during data analysis in this study: Minority. There are only two categories in the categorical variable: Racial/Ethnicity, Caucasian

American Students and Minority Students. Other categorical variables were coded accordingly during data analysis. Table 3-1 shows the coding information.

Students who took the two Algebra EOC tests were from grades 8 to 12. Students who took the standardized mathematics test grade 6, 7, or 8 were from grade 6 to 10. These two sets of groups were overlap to some degree. Therefore, the analysis was conducted for these two sets of groups separately. Some of the participants in state standardized test groups will take Algebra course in this virtual school. The analysis of these groups can add to the knowledge of success factors in Algebra.

This virtual school student body included students statewide from bricks-and-mortar public and private schools as well as home school students. The physical schools as well as the home schools that students attend could affect student academic performance through school culture, technical support, and resources available for students. Student test scores within the same physical school are not independent of one another. Therefore, any evaluation of the influence of student level factors such as grade level, race, and teacher comment on these scores must account for the influence of school characteristics. To investigate the Algebra/mathematics success factors in the K-12 online learning environment, Hierarchical Linear Modeling (HLM) technique was used to account for the clustering of student score within one school caused by school characteristics. HLM was carried out by the software program HLM 6.06 for data analysis in this study. The fully unconditional or Random ANOVA (RA) model was estimated at the beginning in order to partition the variance into within-school (Sigma Square) and between-school (Tau) components. After that, all independent variables

were added into the model. Generalized estimating equation was applied for the estimation of correlation coefficients.

Limitations

Limitations of this study include:

1. The small sample size could affect the power for statistic claims.
2. The coding strategy for race/ethnicity variable could mask influential information.
3. Many home school students and the very small number of students from many different physical schools (some only had one student) may cause data analysis difficulty.

Table 3-1. Coding of the independent variables

Variable	Categories
Student status (part-time or full-time)	0: part time
	1: full time
IEP (individual educational plan)	0: without individual educational plan
	1: with individual educational plan
FRL (free or reduced lunch)	0: not in free or reduced lunch programs
	1: in free or reduced lunch program
RACE	0: Caucasian American student
	1: minority student

CHAPTER 4
RESULTS

Introduction

As stated in Chapter 1, the study reported here examined the success factors including student demographic information, teacher comments, and student participation level in online academic activities in K-12 virtual learning environments. This chapter is organized based on the three research questions posed in Chapter 1. It first describes the sample of this study. It then reports the effects of LMS utilization, teacher comment, and student demographic information such as race/ethnicity and whether have IEP on Algebra/mathematic achievement in virtual learning environments.

Sample

The data were collected during the 2008-09 academic year by a consulting company that works with one state-led virtual school in the Midwestern US region. This consulting company collected student demographic information and their performance on two types of tests: EOC test and state standardized test. The researcher obtained the data from this consulting company. The criteria for the participation in this study were: (1). students who completed Algebra online courses during the 2008-09 year and took the EOC test at the end of each semester; or (2)students in this virtual school who took one state standardized mathematics test at the end of the 2008-09 academic year.

EOC Tests Taker

This virtual school offered four Algebra courses: Algebra I (1st half), Algebra I (2nd half), Algebra II (1st half), and Algebra II (2nd half) during the 2008-09 academic year. The number of students who completed these four Algebra courses and took the EOC tests at the end of each semester during that academic year was: 101, 75, 26, and 36

respectively. These four groups participated in this study. However, due to the insufficient power for data analysis caused by the small sample size of Algebra II (1st half) and Algebra II (2nd half), 26 and 36, these two groups were dropped from the study. Within the two Algebra I groups, 64 out of 101 students in Algebra I (1st half) (63.4.2%) and 59 out of 75 students in Algebra I (2nd half) (78.7%) were second year students in this virtual school. See table 4-1 for student demographic information. The sample can be described as primarily white, not participating in school free or reduced lunch programs, and part time virtual school students without individual educational plans.

State Standardized Test Taker

There were 487 students in this virtual school during 2008-09 academic year who took a state standardized mathematics test at the end of academic year. This standardized mathematics test has different grade levels from 3 to 8. Due to lack of information about students who took the state standardized mathematics test grade level 3, 4 and 5, only students who took the state standardized mathematics test grade level 6, 7, and 8 participated in this study. The number of students in these three groups is 74, 73, and 107 respectively. All of these participants were first year students in this virtual school. See table 4-2 for student demographic information. The sample can be described as primarily white, participating in school free or reduced lunch programs, and part time virtual school students with individual educational plans.

As stated in Chapter 3, the physical schools students attended could affect student academic performance via the resources the school provided for students, technical support, and school culture. Students' test scores within one school are not independent of one another. Any evaluation of the variables at student level such as teacher

comments, grade level, and race on student test score must account for the influence of school characteristics on this dependent variable. The Hierarchical linear modeling (HLM) technique was carried out by the software program HLM 6.06 for data analysis to account for the clustering of students' scores within one school caused by the school characteristics. The fully unconditional or Random ANOVA (RA) model was utilized to partition the total variance of student test score into within-school (Sigma Square) and between-school (Tau) components at the beginning during the analysis. After that, all the independent variables were added into the model. Generalized estimating equation was then applied for the estimation of coefficients of the different variables.

RA Model

The RA model was estimated for each dataset to partition the variance of student test score into within-school (Sigma Square) and between-school (Tau) components.

Level-1 Model

$Y = B0 + R$

Level-2 Model

$B0 = G00 + U0$

The Intra-Class Correlation (ICC) was calculated according to the formula: Tau/ (Tau+ Sigma Square) for each dataset. Results for the RA model are presented in Table 4-1.

Table 4-1 demonstrates the ICC for all the five datasets is equal to or above 0.7. This finding shows the between-school variance was large in comparison with the within-school variance for the five groups of students. This tells us the students within the same school are similar with respect to their academic achievement in mathematics and in Algebra particularly in comparison with the students from different schools.

Coefficients for the Variables

After estimating the RA model, all the independent variables were added into the model at the level 1 (student level). With the exception of the data on the standardized test in grade 6, the generalized estimating equation (GEE) procedure was then used to estimate the coefficients of these variables. For the data on the standardized test in grade 6, ordinary least square was used. The results are presented in Tables 4-2 to 4-4. Summarization of the results is presented following Table 4-4.

Level-1 Model

Y = Y = B0 + B1*(GRADE) + B2*(RACE) + B3*(FRL) + B4*(IEP) + B5*(PT/FT) + B6*(TEACHERCOM) + B7*(TOTALLOG) + B8*(TOTALMIN) + R

Level-2 Model

B0 = G00 + U0

B1 = G10

B2 = G20

B3 = G30

B4 = G40

B5 = G50

B6 = G60

B7 = G70

B8 = G80

The results of the GEE are presented in Tables.

EOC Test

Table 4-2 shows the estimate of the variable effect coefficients for the two Algebra EOC tests: Algebra I (1) and Algebra I (2). The variables that have significant effects on student final score on these two tests are highlighted in grey.

State Standardized Mathematics Test

Table 4-3 shows the estimate of the variable effect coefficients for the two state standardized mathematics tests - grade 7 and grade 8. The variables that have significant effects on student final score on these two tests are highlighted in grey.

Ordinary Least Square (OLS) was applied for the dataset: mathematics standardize test grade 6 for the estimate of effect coefficient. There are 74 students in this group. Five of them are from the same school and all other 69 students are from different schools. There is almost no clustering for student scores due to the small sample size at student level (74) and comparatively large sample size at school level (70). Thus, least-squares estimates with robust standard errors can't be applied to correct the errors associated with the clustering of student scores within one same school. Instead, OLS was applied for the estimates of coefficients of the independent variables. Table 4-6 shows the results.

Descriptive Statistics, Standardized Coefficient, and Reduction of Variance

Descriptive statistics analysis was conducted for each group to demonstrate the mean and variance of the factors (independent variables) and student score (dependent variable). See table 4-7 and 4-8 for this information for these two sets of participants.

To compare among different factors with respect to the importance in determining student score, standardized coefficient (β) was calculated according to the formula: $\beta_k = b_k * S_{xk} * S_y$ (b_k is the unstandardized coefficient, S_{xk} is the standard deviation of the

corresponding independent variable, and S_y is the standard deviation of the dependent variable). See table 4-9 and 4-10 for standardized coefficients for these two sets of participants. Standardized coefficient demonstrates that how increases in the independent variables affect relative position within the group. For example, the standardized coefficient of TEACHERCOM was 0.56 for Algebra I (2). It means with 1 standard deviation increase in TEACHERCOM, student test score increased 0.56 standard deviation.

The adjusted R-square (R_c^2) was calculated according to the formula: R_c^2= 1- VAR $_e$/VAR $_t$ (VAR $_e$ is the least squares estimates of the model with all the predicators, VAR $_t$ is the least squares estimates of the RA model) to show the reduction of test score variance from the RA model with the addition of the factors. See table 4-11 for adjusted R-square for the five groups. The adjusted R-square also shows the variance that is accounted for by these factors. For example, R_c^2 is 0.15 for Algebra I (2). It means the eight factors accounted for 15 percent of test score variance.

Research Question 1

Does the level of student participation in academic activities predict Algebra/mathematics performance in online education?

The participation in online academic activities can be reflected through the number of times students logged into the Learning Management System (LMS) and how long they stayed in the LMS. This study used these two variables as the indicators of the level of student participation. Other indicators of participation not collected by the virtual school's data system, such as the time students spent online on academic tasks and the time they spent on non academic tasks, will not be part of this study. Time on task has been identified as a critical factor in relation to the improvement of understanding level

of subject matter (Bransford et al., 1999). As Bransford et al. mentioned, students need to take time to make meaning of the concepts in the subject areas and build the connections to their preexisting knowledge. Based on one study on the effect of one Algebra I online learning model on students' academic outcome, O'Dwyer et al. (2007) concluded online students spent more time on interacting with one another on academic topics than their counterparts in traditional classroom. Peer-to-peer interaction could help improve online students' learning outcome. The time spent in academic activities has a strong effect on success in online education (Cavanaugh, 2007), face-to-face instruction (Rocha, 2007), and blended programs (Cavanaugh, 2009). It can predict student final grade in online learning (Wang & Newlin, 2000). To investigate the effects of student participation in online academic activities on student achievement in mathematics and Algebra in particular in online learning environments, the number of times students logged into the LMS and how long they stayed in the LMS were analyzed using HLM along with other factors in one single equation. Other student time on task outside the LMS was not measured in the school data system.

EOC Test

Table 4-2 shows TOTALLOG (number of times student log into the LMS) had a non significant effect (-0.03, p=0.230) on student final score for Algebra I (1) and the direction shows students who logged into the LMS less tending to perform better than those students who logged into the LMS more. The effect of TOTALLOG is significant for Algebra I (2) (-0.02, p=0.006), with students who logged into the LMS less achieved higher scores. There is a weak and non significant effect of TOTALMIN (total minutes students stay in LMS) on final score for Algebra I (1) (0.0005, p=0.304), with students who stayed in the LMS longer tending to achieve higher scores. The effect of

TOTALMIN is significant for Algebra I (2) (0.0004, p=0.008). The direction of the effect tells us students who stayed in the LMS longer performed better.

State Standardized Test

Table 4-3 shows TOTALLOG has no significant effect (0.02, p=0.725) on student score in the grade 7 mathematics standardized test. The direction shows students who logged into the LMS more tending to perform better than those students who logged into the LMS less. The effect of TOTALLOG is also not significant (-0.07, p=0.117) for the grade 8 mathematics standardized test, with students who logged into the LMS less achieving higher scores. Table 4-4 shows TOTALLOG also has no significant effect (-0.04, p=0.414) for the grade 6 mathematics standardized test, with the same direction as it in grade 8. Table 4-3 shows there is a weak and non significant effect of TOTALMIN (0.0004, p=0.680) on student score in the grade 7 mathematics standardized test, with students who stayed in the LMS longer tending to achieve higher scores. The effect of TOTALMIN is nearly significant (0.001, p=0.057) for grade 8. The direction of the effect tells us students who stayed in the LMS longer tended to perform better. Table 4-4 shows there is a weak and non significant effect (0.0005, p=0.544) of TOTALMIN for the grade 6 mathematics standardized test, with students who spent more time in the LMS tending to achieve higher scores.

Research Question 2

Does teacher comment or feedback predict Algebra/mathematics performance in online education?

Bransford et al. (1999) emphasized the importance of frequent feedback from the instructors for students to monitor their learning process and evaluate their understanding levels and the learning strategies during the learning process. Based on

the feedback, students could revise their thinking and enrich their knowledge structure as they move along. Teacher feedback or teacher comment on student assignments, papers, and projects has been identified as a critical factor that can influence student academic performance in online education (Cavanaugh et al., 2005; Dickson, 2005; Ferdig, Papanastasiou, & DiPietro, 2005; Hughes et al., 2005; Peters, 1999; Zucker, 2005). Phipps and Merisotis (2000) believed that student-teacher interaction and the timely and constructive teachers' feedback to students' assignments and questions are critical characteristics of the teaching/learning benchmarks for the quality of online learning. Watson and Ryan (2006) showed there are big differences in students' experiences between virtual classrooms with minimal teacher involvement and those with greater student-teacher interactions via different means such as e-mail, online message, online discussion forum, phone, etc. Based on a quasi-experimental study on the impact of one state-wide Algebra I online initiative on students' learning outcomes, O'Dwyer et al. (2007) found that online students highly value the student-instructor interaction during the learning process.

The critical value of teacher feedback and teacher comment for success in online learning is also applicable to students with special needs. Based on a study of students with learning disabilities (SLD) and students with attention deficit hyperactivity disorder (ADHD), Smouse (2005) found communication with and feedback from instructors was the most valuable aspect of online courses. To investigate the effect of teacher comment or teacher feedback on student achievement in mathematics and Algebra in particular in online learning environments, the number of teacher comments was analyzed using HLM along with other factors in one single equation.

EOC Test

Table 4-2 demonstrates the non significant effect of TEACHERCOM (teacher comments) for Algebra I (1) (-0.04, p=0.450). Interestingly, the direction shows students with fewer teacher comments tended to achieve higher scores than those with more teacher comments. This could be due to the lower need for corrective feedback from teachers for students with better performance during the learning process. The effect of TEACHERCOM for Algebra I (2) is also not significant (0.01, p= 0.912). Its direction is different from the one in Algebra I (1). In Algebra I (2), students who received more teacher comments tended to perform better than those students who received less teacher comments.

State Standardized Test

Table 4-3 demonstrates the significant effect of TEACHERCOM (0.46, p=0.041) for the grade 7 mathematics standardized test. The direction shows students with more teacher comments performed better in this test. The effect of TEACHERCOM for grade 8 is not significant (0.002, p=0.990), with the same direction as it is in the grade 7 mathematics standardized test. Table 4-4 shows there is no significant effect of TEACHERCOM (-0.02, p=0.949) on student score in the grade 6 mathematics standardized test. Interestingly, the direction shows students with more teacher comments tended to achieve lower scores in this test.

Research Question 3

Do student demographic information, such as race/ethnicity, grade level, status in virtual school, whether have IEP, and participation in free/reduced lunch programs, predict Algebra/mathematics performance in online education?

The virtual school student body is a diverse population of learners that includes students with different learning disabilities (Dickson, 2005; Ferdig, Papanastasiou, & DiPietro, 2005). In the present study, the virtual school follows individual education plans for students with special needs during the learning process. Therefore, whether or not a student has an individual education plan could be considered as a sign of student learning ability which can affect student academic achievement during the learning process (Keeler & Horney, 2007). Currently, many popular LMS, such as WebCT and Blackboard, still have different problems that can prevent students with disabilities from fully utilizing their functions even though they are generally accessible to these disabled online students (Asuncion et al., 2006). Students' learning ability may be related to their learning outcome through some other factors such as academic engagement (Richardson et al., 2003). Based on a study comparing online students with a hearing loss and those without this disability with respect to the relationship between students' academic engagement and their perceptions of the academic quality of the courses, Richardson et al. (2003) found the correlation between hearing status and students' academic engagement and their perceived academic quality of the courses. Students with hearing disability can't perform well on communication and some other tasks during online learning processes as compared to students without this disability. This, in turn, may negatively impact these disabled students' academic achievement.

Research shows that eligibility for school free or reduced lunch programs correlates with academic achievements, with students not participating in these programs achieving better performance (McLoyd, 1998). Participation in these programs could be considered as the indicator of the family poverty level, which has a

strong relationship with student academic achievement at school level (Klein et al., 2000). Considerable research has also found student academic achievement difference among different racial groups, with Hispanic and African American students lagging behind Caucasian and Asian American students (Bali, 2004; Barth, 2001; Hall et al., 2000; Lockhead et al., 1985). Though students' race/ethnicity and their participation in school free or reduced lunch programs have been proved to correlate with student academic achievement in traditional face-to-face education, their effects have not been examined systematically for virtual learning environments. In this study, student demographic information including race/ethnicity, participation in free/reduced lunch programs, learning ability, grade level, and status in virtual school were investigated with other factors in one single equation.

EOC Test

Table 4-2 shows the participation in free or reduced lunch programs has no significant effect (-0.04, p=0.992) on student EOC test score in Algebra I (1), with students who did not participate in these programs tending to achieve higher scores. The non significant effect (-4.36, p=0.172) of the participation in these programs was also observed for Algebra I (2), with the same direction as it for Algebra I (1). There is no significant difference (0.93, p=0.826) in student EOC test score between Caucasian American students and the minority students for Algebra I (1) (see Table 4-2). The direction shows minority students tend to perform better than Caucasian American students. No significant difference (-2.53, p=0.455) was also found for Algebra I (2). However, the direction is different from Algebra I (1), with Caucasian American students tending to perform better.

Student grade level has a significant effect (-3.89, p=0.030) on student EOC test score for Algebra I (1), with students in lower grade levels achieving better scores than their counterparts in higher grade levels. The significant effect (-3.36, p=0.005) of grade level has also been found for Algebra I (2), with the same direction as for Algebra I (1). Table 4-2 demonstrates the non significant effect (-1.37, p=0.825) of student learning ability on EOC test score for Algebra I (1). The direction shows the students who do not have individual educational plans tended to perform better. Similarly, the non significant effect (-2.26, p=0.557) of student learning ability is observed for Algebra I (2), with the same direction as for Algebra I (1). Table 4-2 shows student status in the virtual school (full-time or part-time) has no significant effect (1.78, p=0.733) on the EOC test score for Algebra I (1), with full-time students tending to achieve better performance than part-time students. The non significant effect of student status (6.49, p=0.096) has also been found for Algebra I (2), with the same direction as for Algebra I (1).

State Standardized Test

Table 4-3 shows the participation in free or reduced lunch programs has no significant effect (-0.89, p=0.936) on student score in the grade 7 mathematics standardized test, with students who participated in these programs tending to perform better. However, the strong and significant effect of participation in these programs (-61.40, p=0.000) has been found for the grade 8 standardized test, with the same direction as it is for the grade 7 standardized test. A significant difference (-21.28, p=0.046) in student score in the grade 7 mathematics standardized test between Caucasian American students and minority students is observed (see Table 4-3). The direction shows the Caucasian American students achieved higher scores than the minority students in this test. Table 4-3 demonstrates there is no significant difference (-

9.31, p=0.254) between these two ethnicity groups for the grade 8 standardized test, with the same direction as it for the grade 7 standardized test.

Student's grade level in his/her physical school has no significant effect (-0.17, p= 0.083) on score in the grade 7 mathematics standardized test, with students in lower grade levels tending to achieve higher scores (see Table4-3). The non significant effect of student grade level (1.71, p=0.623) has also been found for the grade 8 mathematics standardized test (see Table 4-3). However, the direction is different for the grade 7 standardized test. Table 4-3 shows there is a strong and significant effect of student learning ability (-41.90, p=0.001) on student test score in the grade 7 standardized test, with students without individual educational plans performing better than those students with educational plans in the virtual school. The significant effect of student learning ability (21.92, p=0.022) was also observed for the grade 8 mathematics standardized test. Interestingly, the direction tells us students with individual educational plans achieved better scores. Table 4-3 demonstrates the non significant effect of student status in virtual school on student score for the grade 7 standardized test (4.97, p=0.614), grade 8 standardized test (-11.98, p=0.146). However, the two directions are different, with the direction for the grade 7 test showing full-time students tending to perform better than part-time students and the direction for grade 8 test showing part-time students tending to perform better.

Shown in table 4-4, the participation in free or reduced lunch programs has no significant effect (-26.54, p=0.496) on student score in the grade 6 mathematics standardized test, with students who did not participate in these programs tending to achieve better scores than their counterparts who participated in these programs. There

is a nearly significant difference (-21.48, p=0.068) in student score between Caucasian American students and the minority students for the grade 6 standardized test. The direction shows Caucasian American students tended to perform better than the minority students. Student grade level has no significant effect (-8.13, p=0.106) on student score in the grade 6 standardized test, with students who are in the lower grade levels tending to achieve better performance. A non significant while strong effect was observed for student learning ability (-40.10, p=0.348) in the grade 6 mathematics standardized test (see Table 4-4). The direction tells us students without individual educational plans tended to perform better than their counterparts who had educational plans. Table 4-4 demonstrates the non significant effect (11.62, p=0.344) of student status in the virtual school for the grade 6 standardized test, with full-time students tending to achieve better scores than part-time students.

Summary of Findings

The purpose of this study is to examine the factors including LMS utilization, teacher comment/feedback and student demographic information that can influence the success of Algebra courses in K-12 virtual learning environments. The three research questions formulated sought to (1) discover the influence of student participation in online academic activities on student mathematics achievement in virtual learning environments; (2) explore whether teacher comment or feedback can predict student academic achievement in online mathematics courses; and (3) investigate the differences in online mathematics achievement among students with different demographic information.

The results of question one showed the influence of participation in online academic activities on achievement could be different based on mathematics levels.

The indicators of student participation in online academic achievements in this study include the number of times student logged into the LMS (TOTALLOG) and how long they stayed in the LMS (TOTALMIN). TOTALLOG has a significant influence on student performance in Algebra I (2) EOC test (-0.002, p=0.006) while not in Algebra I (1) EOC test. The direction of the significant influence showed students who logged into the LMS less performed better. Similarly, TOTALMIN also has a significant influence for Algebra I (2) EOC test (0.0004, p=0.008) while not for Algebra I (1) EOC test. The direction of the significant influence indicated students who spent more time in the LMS achieved better performance. For the state standardized mathematics test, TOTALLOG has no significant influence on student performance at all the three levels: grade 6 to 8. Similarly, TOTALMIN also has no significant influence at the three levels.

The results of question two provided the evidence that teacher comment can affect student mathematics performance at different levels depending on the type of mathematics tests. In this study, teacher comment has no significant effect on student achievement in the two Algebra courses: Algebra I (1) and Algebra I (2). For the state standardized mathematics test, teacher comment has a significant effect on student achievement at the grade 7 level (0.46, p=0.041) while not at grade 6 and grade 8 levels. The significant effect at the grade 7 level showed students with more teacher comments performed better in the test.

The results of question three showed some demographic information was predictive of student online mathematics achievement while others may not be and the predictability also depended on the type and the level of the mathematics test. The participation in free or reduced lunch programs, race/ethnicity (Caucasian American or

minority), student learning ability, and student status in the virtual school (full-time or part-time) were not predictive of student performance in Algebra I (1) and Algebra I (2) EOC tests. However, student grade level is predictive of student performance in Algebra I (1) (-3.89, p=0.030) and Algebra I (2) (-3.36, p=0.005) EOC tests, with students in lower grade levels achieved higher scores. For the state standardized mathematics test, the participation in free or reduced lunch programs, student grade level and status in the virtual school were not predictive of student performance at all three levels: grade 6 to 8. The participation in free or reduced lunch programs was a significant predictor only at the grade 8 level (-61.40, p=0.000). The direction showed students not participating in these programs performed better. Race/ethnicity was a significant predictor only for the grade 7 level test (-21.28, p=0.046), with Caucasian American students performing better than the minority students. Student learning ability was a significant predictor for the grade 7 level (-41.90, p=0.001) and the grade 8 level (21.92, p=0.022) tests. They have different directions. For the grade 7 level test, students without individual educational plans performed better than those with individual educational plans while for the grade 8 level test, students with individual educational plans performed better.

Table 4-1: EOC test takers demographics

Algebra I (1st half)	GRADE	8: 4(4.0%), 9: 35(34.7%), 10: 37(36.6%), 11: 15(14.9%), 12: 10(9.9%)
	RACE	White: 82(81.2%), Other Minority: 19(18.8%)
	FRL	0: 68(67.3%), 1: 33(32.7%)
	IEP	0: 94(93.1%), 1:7(6.9%)
	PT/FT	0: 87(86.1%), 1: 14(13.9%)
Algebra I (2nd half)	GRADE	7: 2(2.7%), 8: 13(17.3%), 9: 24(32.0%), 10: 24(32.0%), 11: 9(12.0%), 12: 3(4.0%)
	RACE	White: 62(82.7%), Other Minority: 13(17.3%)
	FRL	0: 53(70.7%), 1: 22(29.3%)
	IEP	0: 70(93.3%), 1: 5(6.7%)
	PT/FT	0: 62(82.7%), 1: 13(17.3%)

Table 4-2: Standardized test takers demographics

Standardized test Grade 6	GRADE	6: 35(47.3%), 7: 28(37.8%), 8: 6(8.1%), 9: 4(5.4%), 10: 1(1.4%)
	RACE	White: 60(81.1%), Other Minority: 14(18.9%)
	FRL	0: 6(8.1%), 1: 68(91.9%)
	IEP	0: 5(6.8%), 1:69(93.2%)
	PT/FT	0: 61(82.4%), 1: 13(17.6%)
Standardized test Grade 7	GRADE	7: 29(39.7%), 8: 32(43.8%), 9: 9(12.3%), 10: 2(2.7%), missing: 1(1.4%)
	RACE	White: 59(80.8%), Other Minority: 14(19.2%)
	FRL	0: 16(21.9%), 1: 57(78.1%)
	IEP	0: 19(26.0%), 1: 54(74.0%)
	PT/FT	0: 68(93.2%), 1: 5(6.8%)
Standardized test Grade 8	GRADE	8: 63(58.9%), 9: 39(36.4%), 10: 4(3.7%), missing: 1(0.9%)
	RACE	White: 83(77.6%), Other Minority: 24(22.4%)
	FRL	0: 20(18.7%), 1: 87(81.3%)
	IEP	0: 20(18.7%), 1: 87(81.3%)
	PT/FT	0: 89(83.2%), 1: 18(16.8%)

Table 4-3: Overview of RA model for different datasets

Test	Variables	df	Sigma Square	Tau	ICC
Algebra I (1)	None	79	41.79	225.26	0.84
Algebra II (2)	None	56	63.25	146.04	0.70
Standardized test Grade 6	None	69	43.33	1797.90	0.98
Standardized test Grade 7	None	63	468.66	1189.96	0.72
Standardized test Grade 8	None	93	401.44	1052.68	0.72

Table 4-4: Least-squares estimates of fixed effects (with robust standard errors)

Test	Fixed Effect	Coefficient	Standard Error	T-ratio	d.f.	P-value
Algebra I (1)	GRADE	-3.89	1.76	-2.21	92	0.030
	RACE	0.93	4.22	0.22	92	0.826
	FRL	-0.04	3.93	-0.01	92	0.992
	IEP	-1.37	6.19	-0.22	92	0.825
	PT/FT	1.78	5.20	0.34	92	0.733
	TEACHERCOM	-0.04	0.06	-0.76	92	0.450
	TOTALLOG	-0.03	0.03	-1.21	92	0.230
	TOTALMIN	0.0005	0.00	1.04	92	0.304
Algebra I (2)	GRADE	-3.36	1.14	-2.96	66	0.005
	RACE	-2.53	3.37	-0.75	66	0.455
	FRL	-4.36	3.15	-1.38	66	0.172
	IEP	-2.26	3.83	-0.59	66	0.557
	PTFT	6.49	3.85	1.69	66	0.096
	TEACHERCOM	0.01	0.09	0.11	66	0.912
	TOTALLOG	-0.02	0.01	-2.90	66	0.006
	TOTALMIN	0.0004	0.00	2.74	66	0.008

Table 4-5: Least-squares estimates of fixed effects (with robust standard errors)

Test	Fixed Effect	Coefficient	Standard Error	T-ratio	d.f.	P-value
Standardized test Grade 7	GRADE	-0.17	0.10	-1.76	64	0.083
	RACE	-21.28	10.50	-2.03	64	0.046
	FRL	-0.89	11.03	-0.08	64	0.936
	IEP	-41.90	11.93	-3.51	64	0.001
	PT/FT	4.97	9.81	0.51	64	0.614
	TEACHERCOM	0.46	0.22	2.09	64	0.041
	TOTALLOG	0.02	0.06	0.35	64	0.725
	TOTALMIN	0.0004	0.00	0.41	64	0.680
Standardized test Grade 8	GRADE	1.71	3.47	0.49	98	0.623
	RACE	-9.31	8.11	-1.15	98	0.254
	FRL	-61.40	9.57	-6.42	98	0.000
	IEP	21.92	9.39	2.33	98	0.022
	PT/FT	-11.98	8.17	-1.47	98	0.146
	TEACHERCOM	0.002	0.16	0.01	98	0.990
	TOTALLOG	-0.07	0.04	-1.58	98	0.117
	TOTALMIN	0.001	0.00	1.92	98	0.057

Table 4-6 Ordinary Least-squares estimates of fixed effects

Test	Fixed Effect	Coefficient	Standard Error	T-ratio	d.f.	P-value
Standardized test Grade 6	GRADE	-8.13	4.97	-1.64	65	0.106
	RACE	-21.48	11.59	-1.85	65	0.068
	FRL	-26.54	38.75	-0.69	65	0.496
	IEP	-40.10	42.42	-0.95	65	0.348
	PT/FT	11.62	12.18	0.95	65	0.344
	TEACHERCOM	-0.02	0.26	-0.06	65	0.949
	TOTALLOG	-0.04	0.05	-0.82	65	0.414
	TOTALMIN	0.0005	0.00	0.61	65	0.544

Table 4-7 Descriptive statistics for EOC test takers

Test	Variables	N	Mean	Std. Deviation
Algebra I (1)	FINAL GRADE	101	70.82	15.598
	GRADE	101	9.92	1.026
	RACE	101	.19	.393
	FRL	101	.33	.471
	IEP	101	.07	.255
	PT/FT	101	.14	.347
	TEACHERCOM	101	20.78	21.390
	TOTALLOG	101	215.36	125.476
	TOTALMIN	101	10783.93	6418.637
Algebra I (2)	FINAL GRADE	75	79.00	13.650
	GRADE	75	9.45	1.119
	RACE	75	.17	.381
	FRL	75	.29	.458
	IEP	75	.07	.251
	PT/FT	75	.17	.381
	TEACHERCOM	75	15.31	21.526
	TOTALLOG	75	461.04	288.174
	TOTALMIN	75	27425.76	17097.182

Table 4-8 Descriptive statistics for standardized test takers

Test	Variables	N	Mean	Std. Deviation
Standardized test Grade 6	MAP_SCALE_SCORE	74	664.07	41.827
	GRADE	74	6.76	.919
	RACE	74	.19	.394
	MAP_FRL	74	.92	.275
	IEP_STUDENT	74	.93	.253
	PTFT	74	.18	.383
	TEACHERCOM	74	11.32	18.144
	TOTALLOG	74	354.65	181.272
	TOTALMIN	74	23006.26	13370.676
Standardized test Grade 7	MAP_SCALE_SCORE	73	676.18	41.913
	GRADE	73	9.03	10.704
	RACE	73	.19	.396
	MAP_FRL	73	.78	.417
	IEP_STUDENT	73	.74	.442
	PTFT	73	.07	.254
	TEACHERCOM	73	11.15	19.715
	TOTALLOG	73	253.25	141.193
	TOTALMIN	73	16720.51	9324.034
Standardized test Grade 8	MAP_SCALE_SCORE	107	696.23	38.020
	GRADE	107	8.36	.994
	RACE	107	.22	.419
	MAP_FRL	107	.81	.392
	IEP_STUDENT	107	.81	.392
	PTFT	107	.17	.376
	TEACHERCOM	107	11.28	18.569
	TOTALLOG	107	293.93	202.395
	TOTALMIN	107	18067.10	14548.311

Table 4-9 Standardized coefficients for EOC test takers

Tests	Factors	Standardized Coefficients
Algebra I (1)	GRADE	-0.26
	RACE	0.36
	FRL	-0.05
	IEP	-0.74
	PT/FT	2.42
	TEACHERCOM	-2.47
	TOTALLOG	-0.18
	TOTALMIN	0.03
Algebra I (2)	GRADE	-0.28
	RACE	-0.86
	FRL	-5.24
	IEP	-1.24
	PT/FT	9.85
	TEACHERCOM	0.56
	TOTALLOG	-0.27
	TOTALMIN	0.02

Table 4-10 Standardized coefficients for standardized test takers

	Factors	Standardized Coefficients
Standardized test Grade 6	GRADE	-0.18
	RACE	-9.21
	MAP_FRL	-18.52
	IEP_STUDENT	-36.89
	PTFT	17.59
	TEACHERCOM	-0.95
	TOTALLOG	-0.40
	TOTALMIN	0.04
Standardized test Grade 7	GRADE	-0.04
	RACE	-0.79
	MAP_FRL	-0.93
	IEP_STUDENT	-44.41
	PTFT	2.86
	TEACHERCOM	35.70
	TOTALLOG	0.143
	TOTALMIN	0.03
Standardized test Grade 8	GRADE	0.04
	RACE	-3.92
	MAP_FRL	-57.44
	IEP_STUDENT	21.92
	PTFT	-11.49
	TEACHERCOM	0.10
	TOTALLOG	-0.76
	TOTALMIN	0.07

Table 4-11 Adjusted R-squares

Tests	VAR_e	VAR_t	R_c^2
Algebra I (1)	236.69	243.29	0.03
Algebra I (2)	159.04	186.32	0.15
Standardized test Grade 6	1412.24	1749.46	0.19
Standardized test Grade 7	1440.78	1756.73	0.18
Standardized test Grade 8	1146.03	1445.5	0.21

CHAPTER 5
DISCUSSION AND IMPLICATIONS

Introduction

This chapter summarizes the findings of the present study and presents the important conclusions drawn from the data shown in Chapter 4. It also addresses the implications for teaching, research, and policy making processes in the discussion of the findings. This chapter presents the implications based on the three research questions in the present study.

Summary of Study

To explore different success factors for online mathematics in general and online Algebra in specific, the present study investigated the effect of a variety of variables on student achievement on Algebra EOC tests and state standard mathematics tests. The present study used the secondary data collected from a state led virtual school in the Midwestern US region. The variables include learner characteristic variables such as student demographic information and participation level in online academic activities and learning environment characteristics variables such as teacher comment in the present study.

Overview of the Problem

The U.S has experienced an astonishing growth in online education at K-12 level during the past decade. The enrollment of K-12 virtual school students has increased from 40,000 in 2000-01 academic year to 1 million in 2007-08 academic year (Clark 2001; Glass, 2009; Newman, Stein & Trask, 2003; Peak Group, 2002; Picciano & Seaman, 2009; Picciano & Seaman, 2007; Setzer & Lewis, 2005; Tucker, 2007; Zandberg, Lewis, & Greene, 2008). With the large population of online learners, it’s

possible to evaluate the effectiveness of online courses. However, currently, there is no one single model being created to predict online success and no clear set of characteristics that have been identified in this regard (Roblyer & Davis, 2008; Tallent-Runnels et al., 2006).

Math has been considered a very important force to push a society forward. Many countries emphasize the improvement of math knowledge and they develop policies to attract more people into this field. Having good academic performance in math subjects at the K-12 level is important for students to pursue advanced degrees in this field. It will help prepare more students to have careers in Science, Technology, Engineering, and Mathematics (STEM) and increase workforce for U.S. in these fields, which could provide strong momentum for this country to move forward in many aspects. The quality of Algebra courses is essential in building the number of U.S. students who are ready for advanced degrees in STEM and career success in these fields.

Purpose Statement and Research Questions

The purpose of this study is to examine the factors including LMS utilization, teacher comment/feedback and student demographic information that can influence the success of Algebra courses in K-12 virtual learning environments. The research questions in this study are

- Does the level of LMS utilization influence Algebra/mathematics performance in online education?
- Does teacher comment or feedback influence Algebra/mathematics performance in online education?
- Do student demographic information such as race/ethnicity, grade level, status in virtual school, whether have individual educational plan (IEP), and participation in free/reduced lunch programs influence Algebra/mathematics performance in online education?

Review of the Methodology

The present study is descriptive in nature. The researcher described the relationship between some factors and student learning outcome without intervening. The researcher received the secondary data from one state led virtual school in the Midwestern US region that collected student demographic information, participation in online academic activities, teacher comments, and academic achievement on Algebra EOC tests and state standardized mathematics tests in the 2008-09 academic year. The present study builds on the results of Liu and Cavanaugh (2010)'s study. This virtual school was launched in 2007. Liu and Cavanaugh's study used the first year (2007-08) data collected by this virtual school and the present study used the second year data. The present study investigated success factors for both Algebra EOC tests and one state standardized mathematics test while Liu and Cavanaugh's study only investigated these factors for Algebra EOC tests. The data regarding student demographic information, participation in online academic activities and teacher comments were collected by the LMS utilized by this virtual school for course content delivery. Student academic achievement on (1) the Algebra I, II EOC tests administered at the end of semester designed based on the state Algebra standards and (2) one state standard mathematics test, designed based on the state mathematics standards, was collected. HLM was carried out by the software program HLM 6.06 for data analysis in this study to account for the clustering of academic scores of students recruited from the same physical school. The rest of chapter 5 will discuss the outcomes and review the implications associated with the three research questions designed to examine the impact of different success factors on student mathematics achievement. This chapter will close with the conclusions drawn from the findings shown in chapter 4.

Findings

In the present study, RA model was analyzed at the beginning to partition the total variance of student score into within-school and between-school components. The intra-class correlation coefficient was calculated for the five groups and it was Algebra I (1) - .84, Algebra II (2) - .70, Standardized test Grade 6 - .98, Standardized test Grade 7 - .72, and Standardized test Grade 8 - .72 respectively. This shows the between-school variance was big in comparison with the within-school variance for all these five groups especially for the Standardized test Grade 6 group. Partially, it could be attributed to the small number of students per school. The big ICC indicated students from different schools are different from each other with respect to their academic achievement. This finding confirmed the gap between private and public schools in student academic achievement found in other studies (Braun, Jenkins, Grigg, Tirre, Spellings, Whitehurst, & Schneider, 2006; Demircioglu & Norman, 1999; Lubienski & Lubienski, 2005). It also could indicate that it will take time for the standardized testing criterion to be well implemented in the school system of this state.

In the present study, standardized coefficient (β) was calculated according to the formula: $\beta_k = b_k * S_{xk} * S_y$ (b_k is the unstandardized coefficient, S_{xk} is the standard deviation of the corresponding independent variable, and S_y is the standard deviation of the dependent variable). It can be used to compare among different factors with respect to the importance in determining test score. Table 4-9 shows that for Algebra I (1) group, student status (β = 2.42) and teacher comment (β = -2.47) were most important factors, and for Algebra I (2) group, participation in school free or reduced lunch programs (β = -5.24) and student status (β = 9.85) were most important factors. Table 4-10 shows that for standardized test grade 6, participation in school free or reduced

lunch programs (β = -18.52), whether have IEP (β = -36.89) and student status (β = 17.59) were most important factors. For standardized test grade 7, whether have IEP (β = -44.41) and teacher comment (β = 35.70) were most important factors while for standardized test grade 8, participation in school free or reduced lunch programs (β = -57.44), whether have IEP (β = 21.92) and student status (β = -11.49) were most important factors. These findings show that the same factors can influence student test score differently for different online Algebra courses. The adjusted R-square (R_c^2) was also calculated according to the formula: $R_c^2 = 1 - VAR_e/VAR_t$ to show the reduction of test score variance from the RA model with the addition of the factors. Table 4-10 shows that the same set of factors accounted for student score variance at different degree for different tests. All these findings demonstrated the complexity of the investigation of factors influencing success in online Algebra.

The following Table 5-1 shows the summary of the significance and direction of the factor effect on student academic performance in the five tests. The "+" sign indicates the positive direction of the factor effect and the "-" sign indicates the negative direction of the factor effect. The "X" sign indicates the factor had a significant effect on student academic performance in the corresponding test.

Research Question 1

Does the level of LMS utilization influence Algebra/mathematics performance in online education?

The time spent in academic activities has been identified as a very important factor that has strong effect on success in online education (Cavanaugh, 2007), face-to-face instruction (Rocha, 2007), and blended programs (Cavanaugh, 2009). Based on a study for the investigation of the cognitive-motivational and demographic characteristics of

online students and the predictors for their success, Wang and Newlin (2000) found out students who participate in online activities at a high level tend to perform well in the online course. They concluded the total online course activity is a predictor of students' final grades. Compared to the students in traditional classrooms, online students spend more time in the virtual learning environments on interacting with one another on academic topics (O'Dwyer et al., 2007). The peer-to-peer interaction, in turn, could help improve online students' learning outcomes (Cavanaugh, 2007). In the present study, the numbers of times students logged into the LMS and how long they stayed in the LMS were considered the indication of student participation level on online academic activities. The number of times students logged into the LMS also has been identified as a strong predictor of student academic performance in online learning (Dietz, 2002; Dickson, 2005).

Compared to traditional classroom instructors, online instructors lack of the regular set of cues about students' confusion or frustration during the learning process such as their facial expression and body positions. The measure of time students spent in the online academic activities can provide online instructors the information about students' understanding of content materials. A lower level of involvement in online activities in the course at the beginning of the semester could be an early warning sign of failure later during the learning process. Therefore, online instructors should closely monitor these behaviors via LMS login data to prevent students who show warning signs at the beginning from failure.

The influence of time students spent in the LMS was found to be positive for the five groups and significant for Algebra I (2). These findings are aligned with the

statement Wang and Newlin (2000) made in their study mentioned above that students participating in online academic activities at a higher level achieve better performance in online learning. They echo the call for sustained time on task for cognitive learning (Gallagher, 2009) and provide support for the emphasis of expanded learning time, including with online courses, to improve academic achievement (Cavanaugh, 2009). These findings could be explained by the call for changes in instructional practices in mathematics education by many educational reformers such as the implementation of standards for mathematics instruction from the National Council of Teachers of Mathematics (NCTM, 1989, 1991) and the active involvement in academic activities is one of their arguments (Forman, 1996). This also confirmed the value of increased participation in learning activities in mathematics education emphasized in Forman's article. However, it's surprising to the researcher that this factor only had a significant effect for Algebra I (2) in this study considering many other studies already showed the importance of time on task for the improvement of student achievement. Many of the students taking Algebra I (2) course are from higher grade levels for credit recovery or to make up failing grades in their physical schools. The increased engaged time on task could be more effective with respect to the improvement of academic achievement than the other four groups. Nevertheless, the significant effect of time spent in the LMS for 1 out of 5 groups calls for more studies on activities that engage students during their stay in the LMS as an explanation for the findings.

The effect of the number of times students logged into the LMS on student academic achievement is negative for the 4 out 5 groups and negative and significant for Algebra I (2). To some degree, this is contradictory to the belief that the number of

times students login to the LMS is a strong and positive predictor of success in online learning (Dietz, 2002; Dickson, 2005). It is possible that if students are logging into the course environment more often, they are staying and working for shorter time periods, negatively impacting their concentration on their studies. This also calls for more research on the investigation of LMS utilization with bigger sample size and diversified mathematics tests.

Implications Related to Research Question 1

Several implications for research, policy and practice can be drawn from the outcomes associated with research question one even though the results found in this study are mixed. These implications provide guidance for future studies to investigate the effect of time on task and the form of activities students engaged in when they stay in the LMS on academic achievement in virtual learning environments. The positive and significant effect of the time spent in LMS for Algebra I (2) shows students who spent more time in the LMS performed better than students spending less time in the LMS. It is plausible that each log in session of high-performing students was longer than the session length for lower-performing students, showing that high-performing students may benefit from sustained time on task rather than more frequent but shorter time on task. This explanation would support flexible online courses that allow students to stay in the course for extended periods of time while working on complex and abstract content. The positive influence of time spent in the LMS provides the support for the improvement of many LMSs to make them more user-friendly with attractive interfaces that motivate students to spend more time in the system engaging in academic activities delivered during the learning process, as well as teaching practices that foster

connectedness among teachers and students and time management strategies for students who do not have high self-regulation abilities.

As mentioned above, the significant effect of time spent in the LMS on only 1 out of 5 groups and the contradictory directions of the effect of number of times student logged into the LMS calls for more research in this field. Future researchers should investigate the activities students engaged in each time they logged into the LMS and the distribution of the logged in times throughout the semester for deeper understanding of the effect of time on task on academic achievement in virtual learning environments. This information could be used to help teachers have better knowledge about the activities in which students are more interested and their engagement level in academic activities during the learning process. Online instructors and course designers could design and develop better online activities, specifically activities that are more individualized, diverse, and authentic to increase engaged learning time.

Research Question 2

Does teacher comment or feedback influence Algebra/mathematics performance in online education?

Educators' active facilitation of online learning and teachers' feedback are important factors that influence students' academic performance during the learning process (Dickson, 2005; Cavanaugh, Gillan, Bosnick, Hess, & Scott, 2005; Hughes, McLeod, Brown, Maeda, & Choi, 2005; Ferdig, Papanastasiou, & DiPietro, 2005; Zucker, 2005). Many of the pedagogical benefits brought by the student-teacher interaction such as those related to motivation and feedback are relevant to distance education as well as the conventional classroom education (Anderson & Kuskis, 2007). Teacher individual feedback and comments are especially helpful for students who are

shy and may not participate in academic activities to increase their communication opportunities (Hughes et al., 2005), which could help improve learning outcomes. Based on the results of a study of students with learning disabilities (SLD) and students with attention deficit hyperactivity disorder (ADHD), Smouse (2005) found communication with and feedback from instructors was the most valuable aspect of online courses. Timely and constructive teachers' feedback to students' assignments and questions have been identified as the critical characteristics of the teaching/learning benchmarks for the quality of online learning (Phipps & Merisotis, 2000).

The influence of teacher comments on student academic achievement is positive and significant for standard test grade 7. This provides the evidence of the importance of teacher comments and teacher-student interaction for the improvement of learning outcomes in online learning environments (Cavanaugh et al., 2005; Peters, 1999; Williams, 2006; Zucker, 2005). It confirmed the relationship between social interaction and mathematics learning (Cobb, Yackel & Wood, 1992; Vogit, 1996). This finding also align with the belief that in mathematics education, the interactions between adults (instructor) and children (students) have impacts on the quality of learning outcome via the psychological benefits brought to students such as critical thinking and self-reflection (Oers, 1996) and on students' cognitive development (Voigt, 1994). In the process of interaction or negotiation during mathematics learning, students can build the connections between materials and mathematics terms (Voigt, 1994), which can be proved, to some degree, by these this finding. However, it's surprising to the researcher that the influence of this factor is found to be positive and significant for 1 out of 5 groups considering many studies have shown the positive effect of this factor on

academic achievement. Variables other than teacher comments especially the number of teacher comments investigated in the present study such as teaching styles, quality of teacher comments, etc., could have more influence on student achievement. Due to the small sample size for each group in the present study, readers should be cautious about the interpretation of the findings.

Implications Related to Research Question 2

The positive and significant effect of teacher comment or feedback for standard test grade 7 provides the support for the statement about the importance of this factor in other studies. This finding could shed light on the development of online courses that integrate teacher feedback and teacher-student interaction as critical components during the course design. It also indicates the importance of timely and constructive feedback from online instructors for the success in online learning. However, the significant effect of this factor for only 1 out 5 groups in the present study showed more research is needed with a bigger sample size and on the form and content of teacher feedback for insightful explanation. It also supports the call for more study about the most effective interaction type, tools, and frequency for the participants in online learning (Cavanaugh, 2007) for online instructors to better facilitate the learners to achieve success. The integration of qualitative dimensions of interaction in future study also will assist in the triangulation of quantitative dimensions as shown in the present study to better understand the importance of teacher-student interaction in online learning (Weiner, 2003).

Research Question 3

Do student demographic information such as race/ethnicity, grade level, status in virtual school, whether have IEP, and participation in free/reduced lunch programs influence Algebra/mathematics performance in online education?

Students' demographic information such as participation in free or reduced lunch programs, race/ethnicity and whether have IEP has been proved to relate to students academic achievement in other studies. McLoyd (1998)'s study showed there is a correlation between student participation in school free or reduced lunch programs and student academic achievement: the magnitude is weaker as grade level rises. Student participation in these programs can be considered as the indicator of his/her family Social Economics Status (SES) (Sirin, 2005), which has already been proved to affect student academic performance in many studies (Coleman, 1988; Sirin, 2005; White, 1982). In the present study, the influence of participation in these programs on achievement is negative for all the five groups and significant for standard test grade 8. For standard test grade 8 group, students who did not participated in these lunch programs achieved higher scores than students who participate in these programs. This provides support for the findings regarding the correlation between this factor and achievement in other studies mentioned above. The negative influence of this factor found in the present study can add to the body of knowledge about the correlation between SES and academic achievement. Other studies about the relationship between participation in free/reduced lunch programs or SES and academic achievement are all conducted in traditional learning environments. The result in the present study demonstrates the possibility for the generalization of study findings between traditional learning environments and virtual learning environments. On the other hand, the

influence of participation in free or reduced lunch programs is only significant for 1 out of 5 groups in this study is surprising to the researcher considering the body of research demonstrating the correlation between this factor and student academic achievement.

The virtual school student body is a diverse population including students with different learning disabilities (Dickson, 2005; Ferdig, Papanastasiou & DiPietro, 2005). Virtual schools offer or support individual educational plans (IEP) for these students during the learning process. Therefore, whether a student has an individual educational plan could be a sign of the level of learning abilities. Many technologies utilized in virtual school learning environments could help bridge gaps between students with disabilities and students without these disabilities with respect to the success opportunities in online learning (Coombs & Banks, 2000). However, students with disabilities are still underrepresented in online education (Kinash & Crichton, 2007). The present study provides some evidence for this claim. For example, the influence of IEP on student achievement is negative and significant for standardized test grade 7 with students who did not have an IEP (usually students without learning disabilities) performed better than students who had an IEP (usually students with learning disabilities). However, for standard test grade 8, the influence of IEP is positive and significant favoring students with learning disabilities. This finding could indicate that the virtual school may be able to help improve academic achievement for students at risk for failure in their physical schools. It also could be a sign of bridging gaps between students with learning disabilities and others without these disabilities with respect to their academic performance possibly due to the academic support provided through the IEP.

Racial gaps in student test score have been proved in many other studies conducted in traditional learning environments (Bali & Alvarez, 2004; Barth, 2001; Hall et al., 2000; Lockhead et al., 1985). The student body in online K-12 schools represents the community that is served by traditional school system (Ronsisvalle & Watkins, 2005). The findings about the racial gaps in student achievement in other studies could apply to the present study as well. The significant racial difference for standardized test grade 7 and nearly significant difference for standardized test grade 6 provides the evidence for the findings in other studies. The directions of the difference in the two groups show white American students perform better than other minority groups as a whole. However, the finding that the significant racial difference was only found for 1 out 5 groups could be due to the coding system that combined different minority groups into one category potentially masking important information regarding the differences in student academic achievement among different racial groups. Future study could be conducted to investigate these differences with bigger sample size. The effect of student grade level in physical school was found to be negative and significant for two Algebra I groups, with students from lower grade levels performing better than those from higher grade levels. Students taking the standardized tests are from lower levels (grade 6-8) compared with the students who took the Algebra I courses and Algebra I EOC tests (most of them from grade 9-12). Algebra I is a required course for high school graduation. Many students in higher grades such as grade 11, 12 take Algebra I courses in this virtual school as credit recovery or remediation to make up failing grades in their physical schools to meet the graduation requirement. It could be the explanation for the negative and significant effect of this factor for the two Algebra I groups. The

effect of student status in the virtual school (part-time or full-time online students) was not significant for all the five groups.

Implications Related to Research Question 3

In the present study, the influence of participation in free or reduced lunch programs is negative for all the five groups and significant for standard test grade 8. For standard test grade 8 group, students who participated in these lunch programs achieved lower scores than students who did not participate in these programs. This echoes the belief that family SES could affect student academic achievement via its influence on parental involvement in virtual learning environments (Black, 2009). This finding can guide the decision making process in the virtual schools by encouraging them to be sensitive to the needs of students with low family SES background and to take measures to bridge the gap in access to resources that could influence student academic achievement. The effect of IEP on student achievement is negative for 4 out of 5 groups and significant for standard test grade 7 in the present study. For standard test grade 7 group, students with IEP (usually students with learning disabilities) achieved lower performance than others without IEP. This could provide support for the integration of instructional strategies such as hiring academic coaches or tutors or advanced technologies during the online learning process to help students with disabilities succeed.

The negative and significant effect of grade level for the two Algebra I groups could be explained by the situation that many students in higher grade levels take Algebra I courses in this virtual school to make up the credits lost in their physical schools to meet the graduation requirement. This has the implication for the virtual

school during online course design for the implementation of certain strategies such as peer support and online tutoring, or flexible timelines and multiple paths to help higher grade students in Algebra I courses to achieve better performance. Online teachers also should provide individual assistance based on the needs of different students.

Broad Implications for Online Course Design and Online Teaching

In September 2007, International Association for K-12 Online Learning (iNACOL) endorsed the *National Standards of Quality for Online Courses* based on the Southern Regional Education Board (SREB) *Standards for Quality Online Courses*. In February 2008, iNACOL released *National Standards for Quality Online Teaching* based on SREB's *Standards for Quality Online Teaching and Online Teaching Evaluation for State Virtual Schools*. The SREB's two sets of standards have been widely used by the 16 states in the southern United States. iNACOL' *National Standards of Quality for Online Courses* standards were designed to "provide states, districts, online programs, and other organizations with a set of quality guidelines for online course content, instructional design, technology, student assessment, and course management." (iNACOL, 2006, p.1). There are 6 categories in iNACOL standards:

1. Content
2. Instructional Design
3. Student Assessment
4. Technology
5. Course Evaluation and Management
6. 21st Century Skills.

Under each category there are a set of standards. *National Standards for Quality Online Teaching* is designed to "provide states, districts, online programs, and other organizations with a set of quality guidelines for online teaching and instructional design." (iNACOL, 2008, p.1). There are 13 categories in these standards:

A. The teacher meets the professional teaching standards established by a state-licensing agency or the teacher has academic credentials in the field in which he or she is teaching.

B. The teacher has the prerequisite technology skills to teach online.

C. The teacher plans, designs and incorporates strategies to encourage active learning, interaction, participation and collaboration in the online environment.

D. The teacher provides online leadership in a manner that promotes student success through regular feedback, prompt response and clear expectations.

E. The teacher models, guides and encourages legal, ethnical, safe and healthy behavior related to technology use.

F. The teacher has experienced online learning from the perspective of a student.

G. The teacher understands and is responsive to students with special needs in the online classroom.

H. The teacher demonstrates competencies in creating and implementing assessments in online learning environments in ways that assure validity and reliability of instruments and procedures.

I. The teacher develops and delivers assessments, projects, and assignments that meet standards-based learning goals and assesses learning progress by measuring student achievement of learning goals.

J. The teacher demonstrates competencies in using data and findings from assessments and other data sources to modify instructional methods and content and to guide student learning.

K. The teacher demonstrates frequent and effective strategies that enable both teacher and students to complete self- and pre- assessments.

L. The teacher collaborates with colleagues.

M. The teacher arranges media and content to help students and teachers transfer knowledge most effectively in the online environment. (Instructional Design)

Under each category there are a set of standards. Many of the findings, derivative outcomes, or implications in the present study align with the two sets of standards. The following two tables show these alignments.

Conclusions

This dissertation examined the impact of some variables including students' demographic information, teacher comments, and student utilization of the LMS on academic performance in Algebra EOC tests and state standard mathematics tests using a sample of students from a state led virtual school in the Midwestern U.S region. The results show different variables affect student Algebra/mathematics achievement in different ways. No single factor investigated in the present study has been found to be significant for all five groups. It could be due to the limitations mentioned in Chapter 3: Methodology. It also indicated that some other factors such as instructional strategies utilized, teacher experience and student prior subject knowledge could have been missed in the present study. They should be investigated in the future studies on success factors in the virtual schooling. Outcomes of this study have some specific implications for researchers, practitioners, and policy makers.

The results show the time student spent in the LMS has positive influence on student academic achievement. This provides the support for the online instructional designers or LMS developers to utilize more advanced technologies such as some educational games and refine the course delivery system to motivate students learn the content and spend more time engaging the academic activities. It also can lend relevance to online instructors for the implementation of instructional strategies to encourage students to focus on the learning tasks during their stay in the course delivery systems. The results of data analysis in this study show the influences of many factors are mixed. Some are positive, and others are negative. Even for the same factor, the influence could be in different directions for different tests. This indicates that the investigation of success factors of online learning is a complex process in which

quantitative methodology independently may not be able to effectively measure the influence of the factors on academic achievement. Therefore, future research seeking to investigate the success factors in online learning should utilize mixed methodology incorporating quantitative and qualitative methods.

This dissertation has implications for policy-making processes at state and national level regarding quality virtual schooling and research support. At state levels in which the virtual school is implemented, effective and well-designed LMS should be utilized for course delivery and management. The LMS interface should be user-friendly that can attract students' attentions in longer periods during the learning process. Components such as online forum, incorporation of social networking software, online synchronous audio/video conferencing should be integrated in the LMS to encourage more and diversified teacher-student and student-student interaction. To increase success opportunities for all students, virtual schools should take some measures to increase access of students from lower SES households the learning resources such as additional lab time, one on one computer/laptop, or extra instructional time. Virtual school should provide individualized assistance based on students' different needs such as

- for students with learning disabilities it could be individual education plans
- for students taking the online courses for credit recovery it could be peer-to-peer support or group projects

At national level, more support should be provided to help build better designed state led virtual schools to increase access to more effective learning resource for all students. More national standards regarding quality virtual schooling should be created to guide the practice and implementation of state level virtual schools. Both at state and

national level, policy makers should grant more resources to support more empirical study collecting quantitative and qualitative data to provide evidence for policies making process. More research is needed on student academic achievement, online success model, and longitudinal study on virtual school retention. One data system regarding virtual school practice should be built both at state and national level from which the researchers can draw the information they need to conduct the secondary research similar to the present study. These secondary research studies can supplement the first hand studies though they may have limitations such as missing information like the present study that lacks of qualitative data for some factors.

Since the establishment of the first virtual school at the end of 20th century, it has experienced an extraordinary development during the last one decade. However, with its short history, K-12 virtual schools are still a relatively new concept for many researchers and educators. Compared to online education at post-secondary level, little research has been done in K-12 virtual learning environments (Cavanaugh 2007; Cooze & Barbour, 2005; Means et al., 2009; Picciano & Seaman, 2007; Picciano & Seaman, 2009; Ronsisvalle & Watkins, 2005). The present study is the first research on success factors in K-12 virtual learning environments. At present, no clear set of characteristics have been identified to predict success in virtual learning environments, and no conclusive model has been created to apply in online learning practice (Roblyer & Davis, 2008; Tallent-Runnels et al., 2006). However, to help improve the practice and implementation of virtual schooling, Smith et al. (2005) emphasized the empirical studies on student academic achievement. Given the dearth of research on success factors in K-12 online learning environments, this dissertation should serve as the

starting point for more studies utilizing both qualitative and quantitative methods to help the development of one success model to improve student academic achievement in virtual schooling.

Table 5-1: Significance and Direction of the Effect of Factors

Course\Factor		Grade Level	Race	Free or Reduced Lunch	IEP	Student Status	Teacher Comment	Number of Times Logged into the LMS	Time Spent in the LMS
Algebra I	1st half	- X	+	-	-	+	-	-	+
	2nd half	- X	-	-	-	+	+	- X	+ X
MAP	Grade 6	-	-	-	-	+	-	-	+
	Grade 7	-	- X	-	- X	+	+ X	+	+
	Grade 8	+	-	- X	+ X	-	+	-	+
TOTAL of 5		2	1	1	2	0	1	1	1

Table 5-2: Alignment with National Standards in Quality Online Course

Findings, derivative outcomes, or implications of the present study	Aligned standards in iNACOL *National Standards of Quality for Online Courses*
Tests used in the present study align with state or national standards.	Course tasks and assessments align with the required local, state, and national assessments that are associated with the course. (A)
This virtual school hires the authorized course provider to implement the Learning Management System (LMS) and content area teachers who met state certification and other requirements as online instructors.	The course provider is authorized to operate in the state in which the course is offered. (E) The teacher meets the professional teaching standard established by a state licensing agency or the teacher has academic credentials in the field in which he or she is teaching and has been trained to teach online and to use the course. (E)
Flexible online courses that allow students to stay in the course for extended periods of time while working on complex and abstract content.	The course instruction includes activities that engage students in active learning. (B) The course provides opportunities for students to engage in higher-order thinking, critical-reasoning activities and thinking in increasingly complex ways. (B)
Improvement of many LMSs to integrate teaching practices that foster connectedness among teachers and students. Development of online courses that integrate teacher feedback and teacher-student interaction as critical components during the course design.	The course design provides opportunities for appropriate instructor-student interaction, including timely and frequent feedback about student progress. (B) The course provides opportunities for appropriate instructor-student and student-student interaction to foster mastery and application of the material and a plan for monitoring that interaction. (B)
Integration of instructional strategies or advanced technologies during the online learning process to help students with disabilities to succeed.	The course meets universal design principles, Section 508 standards and W3C guidelines to ensure access for all students. (D)

Table 5-3: Alignment with National Standards in Quality Online Teaching

Findings, derivative outcomes, or implications of the present study	Aligned standards in iNACOL *National Standards for Quality Online Teaching*
The importance of timely and constructive feedback from online instructors for the success in online learning.	Encourages interaction and cooperation among students, encourages active learning, provides prompt feedback, communicates high expectations, and respects diverse talents and learning styles. (D The teacher provides online leadership in a manner that promotes student success through regular feedback, prompt response and clear expectations.) Establishes and maintains ongoing and frequent teacher-student interaction, student-student interaction and teacher-parent interaction. (D) Provides timely, constructive feedback to students about assignments and questions. (D) Personalizes feedback (support, growth and encouragement). (D) Creates a warm and inviting atmosphere that promotes the development of a sense of community among participants. (C The teacher plans, designs and incorporates strategies to encourage active learning, interaction, participation and collaboration in the online environment)
The finding that students who participated in free or reduced lunch programs achieved lower scores than students who did not participate in these programs for state standardized test grade 8 group could guide the decision making process in the virtual schools by encouraging them to be sensitive to the needs of students with low family SES background and to take measures to bridge the gap in access to resources that could influence student academic achievement.	Provides activities, modified as necessary, that are relevant to the needs of all students. (G The teacher understands and is responsive to students with special needs in the online classroom.)

Table 5-3. Continued

Findings, derivative outcomes, or implications of the present study	Aligned standards in iNACOL *National Standards for Quality Online Teaching*
Online teachers should provide individual assistance based on the needs of different students.	Provides activities, modified as necessary, that are relevant to the needs of all students. (G) Personalizes feedback (support, growth and encouragement). (D) Provides evidence of effective learning strategies that worked for the individual student and details specific changes in future instruction based upon assessment results and research study (data-driven and research- based). (J The teacher demonstrates competencies in using data and findings from assessments and other data sources to modify instructional methods and content and to guide student learning.)

APPENDIX A
ALGEBRA I MULTIPLE CHOICE RELEASED SAMPLES

Directions to the Student

Today you will be taking Session I of the Missouri Algebra I Test. This is a test of how well you understand the course level expectations for Algebra I.

There are several important things to remember:

1. Read each question carefully and think about the answer. Then choose the one answer that you think is best.
2. Make sure you completely fill in the bubble for the answer on your answer sheet with a number 2 pencil.
3. If you do not know the answer to a question, skip it and go on. You may return to it later if you have time.
4. If you finish the test early, you may check over your work.
5. Do NOT write in your test booklet. Mark your answers directly on your answer sheet with a number 2 pencil.

Algebra I

1. If the first Now = $^{-}9$, which equation represents this sequence?

$$^{-}9, {}^{-}4, 1, 6, 11, \ldots$$

A. Next = Now − 5

B. Next = Now + 5

C. Next = 5 · Now − 1

D. Next = 5 · Now + 1

2. Which inequality statement is *true*?

A. $8 < \sqrt{78} < 9$

B. $38 < \sqrt{78} < 40$

C. $77 < \sqrt{78} < 79$

D. $6{,}083 < \sqrt{78} < 6{,}085$

3. Daniel made a box-and-whisker plot of the ages of his cousins.

What is the median age of his cousins?

A. 24

B. 25

C. 27

D. 28

4. Given $y = x^2$, how would the graph of $y = x^2 - 2$ differ?

A. It shifts 2 units up.

B. It shifts 2 units down.

C. It shifts 2 units left.

D. It shifts 2 units right.

Go On ►

5. Given the following fractions:

$$\frac{3}{4}, \frac{18}{29}, \frac{24}{39}, \frac{3}{5}, \frac{12}{18}$$

Which group below has the fractions in order from *least* to *greatest*?

A. $\frac{3}{5}, \frac{24}{39}, \frac{18}{29}, \frac{12}{18}, \frac{3}{4}$

B. $\frac{3}{4}, \frac{3}{5}, \frac{18}{29}, \frac{24}{39}, \frac{12}{18}$

C. $\frac{3}{5}, \frac{12}{18}, \frac{24}{39}, \frac{3}{4}, \frac{18}{29}$

D. $\frac{3}{4}, \frac{3}{5}, \frac{12}{18}, \frac{18}{29}, \frac{24}{39}$

6. The automobile repair shop uses the following chart to determine labor costs for each job.

Automobile Repair Shop Costs

Hours	Labor Cost
1	$25
2	$40
3	$55
4	$70

Which function should the automobile repair shop use to determine the labor cost, C, for a job that takes h hours?

A. $C = 15h$

B. $C = 15h + 10$

C. $C = 25 + 15h$

D. $C = 25h + 15h$

7. A survey was administered to 500 high school students to determine the type of music they prefer. The survey indicated that 22% prefer rock, 26% prefer hip hop, 29% prefer pop, and 23% selected "other." Which representation best illustrates the *number* of students preferring each type of music?

A.

Preferred Music

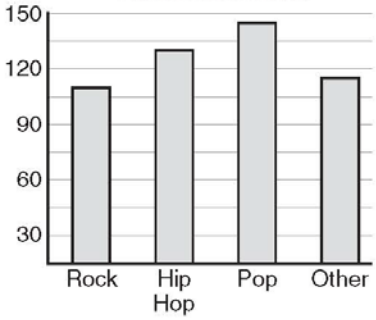
Type	Percent of Students
Rock	22
Hip Hop	26
Pop	29
Other	23

C.

Preferred Music

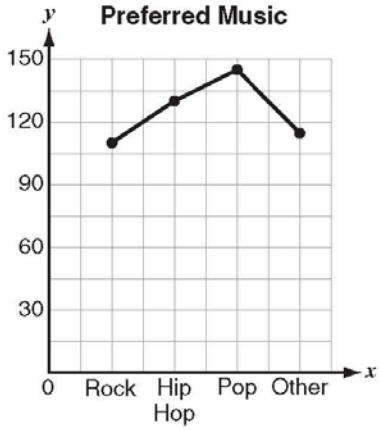
B.

Preferred Music



D.

Preferred Music



Go On ►

8. What is the value of the numerical expression below?

$$\sqrt{16} + \frac{24}{3} - 2^3$$

A. 4

B. 6

C. 8

D. 10

9. Aaron listed the ages of all of his family members as shown below.

10, 10, 10, 10, 10, 12, 14, 14, 15, 16, 50, 50, 51, 53, 80

What is the mean age of his family members?

A. 10

B. 14

C. 27

D. 70

10. What is the product of the following expression?

$$2x(x^2 + x - 5)$$

A. $2x^3 + x - 5$

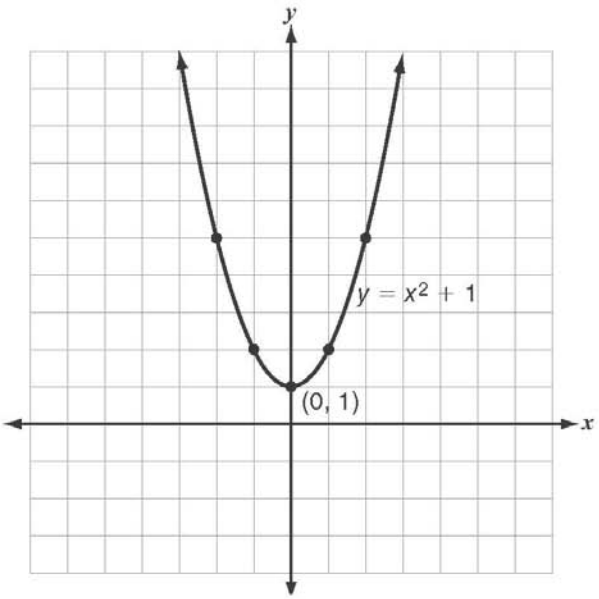
B. $2x^3 + 2x - 10$

C. $2x^3 + 2x^2 - 5x$

D. $2x^3 + 2x^2 - 10x$

Go On ►

11. Beth and Jacob are graphing two equations on a coordinate grid. Beth has graphed the equation $y = x^2 + 1$.



If Jacob graphs $y = x^2 + 3$, where will his graph be in relation to the graph Beth made?

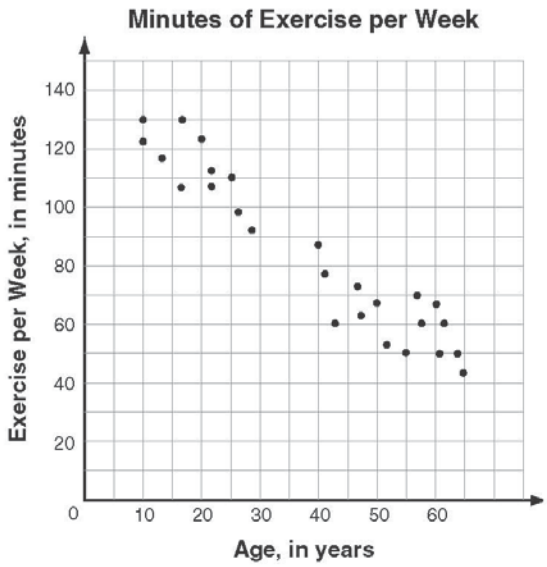
A. 2 units up

B. 3 units up

C. 2 units to the left

D. 3 units to the right

12. A survey was taken asking participants their age and the number of minutes they exercise per week. The results of the survey are shown in the scatterplot below.



The data for people who are 30 to 39 years of age are not displayed. Based on the scatterplot, how many minutes would a 30- to 39-year-old person be expected to exercise?

A. 40–60 minutes

B. 60–80 minutes

C. 80–100 minutes

D. 100–120 minutes

Go On ►

13. Ben bought 8 notebooks for \$24.50. Some of the notebooks were \$2.50 each, and the others were \$3.25 each. If x represents the number of least expensive notebooks, which equation can be used to find the number of least expensive notebooks purchased?

A. $\$5.75(8 - x) = \$24.50$

B. $\$2.50(x - 8) + \$3.25x = \$24.50$

C. $\$2.50x + \$3.25(8 - x) = \$24.50$

D. $\$2.50x + \$3.25(x - 8) = \$24.50$

14. The number 18 is 24% of which number?

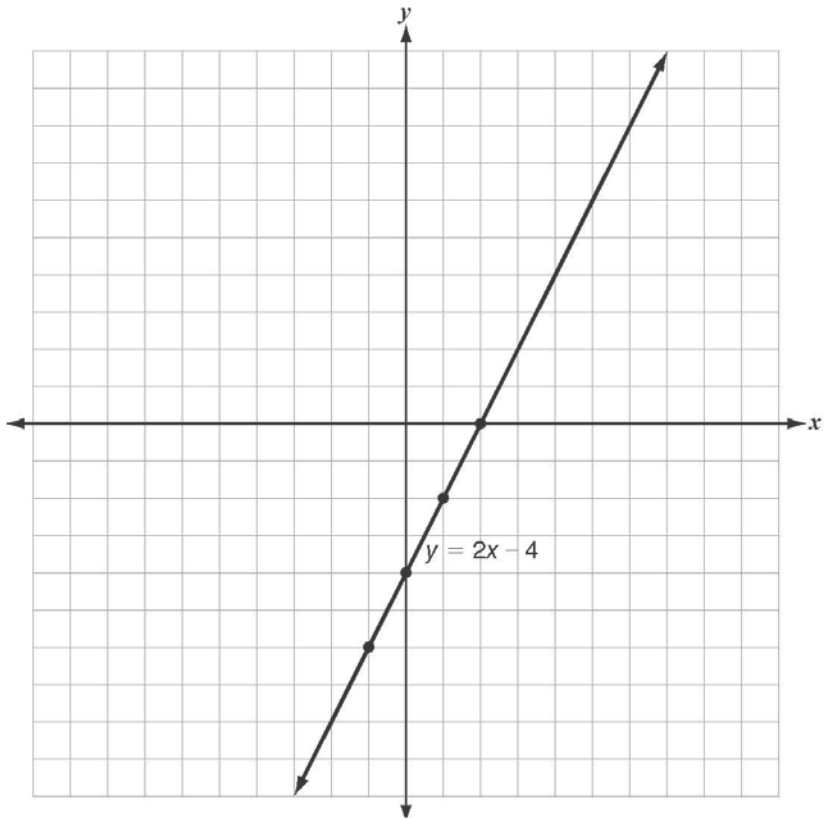
A. 4.32

B. 75

C. $133\frac{1}{3}$

D. 432

15. The graph of $y = 2x - 4$ is shown below.



If the slope of the line is doubled, the new equation is $y = 4x - 4$. Which of these is a correct comparison of the two lines?

A. The x-intercept and y-intercept change.

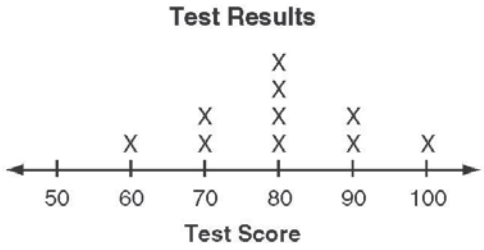
B. The x-intercept and y-intercept stay the same.

C. The x-intercept changes, and the y-intercept is the same.

D. The x-intercept is the same, and the y-intercept changes.

Go On ►

16. The following line graph shows the test scores for 10 students on a unit exam.



Which shape *most accurately* describes these data?

A. The data are skewed to the left.

B. The data are skewed to the right.

C. a bimodal or "U"-shaped curve

D. a normal or "bell"-shaped curve

17. Mary would like to plant grass in her backyard. Her backyard is a rectangle that measures 10 yd by 8 yd. In the middle of her backyard is a circular swimming pool that has a diameter of 5 yd. What is the area to be planted with grass, to the nearest tenth of a square yard?

A. 1.5 yd^2

B. 19.6 yd^2

C. 60.4 yd^2

D. 80 yd^2

18. Which expression represents the output of the nth term?

Input	1	2	3	4	5	n
Output	1	3	5	7	9	

A. $n + 2$

B. $n + 11$

C. $2n + 1$

D. $2n - 1$

19. What is the solution to the equation?

$$-12 = 6 + \frac{2}{3}y$$

A. -27

B. -24

C. -12

D. -9

Go On ►

20. What is the mode of the data set displayed below?

Stem	Leaf
1	0 0 3 4 4 4 4 4
2	2 2 4 9
3	1 1 2 3
4	6 7 8 8 8 8 8 9 9
5	0 0 1 2 5 7
19	8

Key
1 | 3 = 13

A. 14

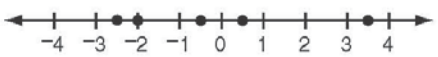
B. 48

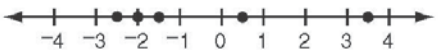
C. 4 and 8

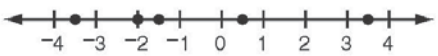
D. 14 and 48

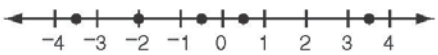
21. Which number line below shows the set of numbers graphed correctly?

$$\left\{3.5,\ \frac{-7}{2},\ \frac{1}{2},\ -2,\ -1\frac{1}{2}\right\}$$

A.


B.


C.


D.


22. What is true about the slope and y-intercept of the two equations below?

$$4x + 3y = 12$$
$$-8x + 6y = 6$$

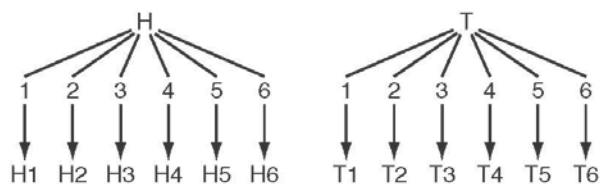
A. same slope, same y-intercept

B. same slope, different y-intercept

C. different slope, same y-intercept

D. different slope, different y-intercept

23. The diagram shows the outcomes of flipping a coin and rolling a die.



Which statement regarding the diagram is *false*?

A. The probability of obtaining "H6" is 2 out of 12.

B. There are 12 possible outcomes in the sample space.

C. The chance of flipping "heads" and rolling a "5" is 1 in 12.

D. Flipping "tails" and rolling a "2" represents about 8% of the possible outcomes of the sample space.

Go On ►

24. The population of a type of bacteria triples every minute. The chart below represents the population of bacteria after t minutes.

t	Bacteria Population
0	1
1	3
2	9
3	27
4	81
5	243

Which type of function represents the data?

A. linear

B. quadratic

C. exponential

D. absolute value

25. What are the slope, m, and the y-intercept, b, of a line that passes through the points $(-3, 1)$ and $(7, -5)$?

A. $m = \frac{-3}{5}$ and $b = \frac{-4}{5}$

B. $m = \frac{-5}{3}$ and $b = -4$

C. $m = \frac{-4}{5}$ and $b = \frac{-3}{5}$

D. $m = \frac{-3}{5}$ and $b = 4$

26. Given the following set of numbers:

$$-\sqrt{4},\ -2\tfrac{2}{3},\ -2.\overline{3},\ \frac{-5}{2},\ -2.7$$

Which set is in order from *least* **to** *greatest*?

A. $\left\{-2.7,\ -2.\overline{3},\ -2\frac{2}{3},\ \frac{-5}{2},\ -\sqrt{4}\right\}$

B. $\left\{-2.7,\ -2\frac{2}{3},\ \frac{-5}{2},\ -2.\overline{3},\ -\sqrt{4}\right\}$

C. $\left\{-\sqrt{4},\ \frac{-5}{2},\ -2\frac{2}{3},\ -2.\overline{3},\ -2.7\right\}$

D. $\left\{-\sqrt{4},\ -2.\overline{3},\ \frac{-5}{2},\ -2\frac{2}{3},\ -2.7\right\}$

27. Which of these shows the following expression factored completely?

$$6x^2 + 15x - 36$$

A. $(2x - 3)(x + 4)$

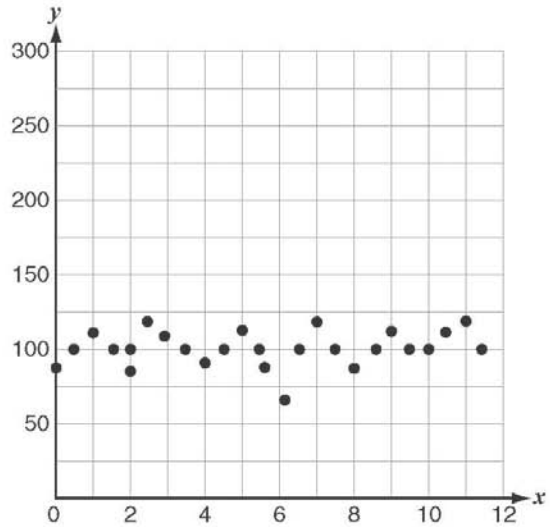
B. $(6x + 9)(x - 4)$

C. $3(2x - 3)(x + 4)$

D. $3(2x + 3)(x - 4)$

Go On ►

28. A scatterplot is shown on the graph below.



Which of these could be a line of best fit?

A. $y = x + 100$

B. $y = x - 100$

C. $x = 100$

D. $y = 100$

29. What is the equation of the function represented by this table of values?

x	-2	-1	0	1	2
y	$\frac{3}{25}$	$\frac{3}{5}$	3	15	75

A. $y = 5x + 3$

B. $y = 12x + 3$

C. $y = 3 \cdot 5^x$

D. $y = 5 \cdot 3^x$

30. The enrollment at High School R has been increasing by 20 students per year. Currently High School R has 200 students attending. High School T currently has 400 students, but its enrollment is decreasing in size by an average of 30 students per year. If the two schools continue their current enrollment trends over the next few years, how many years will it take the schools to have the same enrollment?

A. 4 years

B. 5 years

C. 10 years

D. 20 years

Go On ►

31. What is the solution to the following inequality?

$$\frac{1}{3}(6 - x) \geq -2$$

A. $x \geq 0$

B. $x \leq 0$

C. $x \geq 12$

D. $x \leq 12$

32. Which is a true statement about the data shown in the tables?

Table 1

x	y
1	4
2	5
3	6
9	12
10	13

Table 2

x	y
0	0
1	1
2	4
3	9
4	16

A. Both tables represent a linear relation.

B. Only Table 1 represents a linear relation.

C. Only Table 2 represents a linear relation.

D. Neither table represents a linear relation.

33. The length of a rectangle is 4 times its width. If the length of the rectangle is cut in half, the new perimeter is which percent of the original perimeter?

A. 25%

B. 50%

C. 60%

D. 100%

34. What is the simplified form of the expression?

$$\frac{4x^3y^3}{8x^5y^2}$$

A. $\frac{y}{2x^2}$

B. $\frac{2y}{x^2}$

C. $2x^2y$

D. $2x^8y^5$

35. What is the solution for the system of equations?

$$y = 2x - 3$$
$$4x - 3y = 31$$

A. $(-11, -25)$

B. $(-11, -19)$

C. $(11, 19)$

D. $(14, 25)$

STOP

APPENDIX B
ALGEBRA I PERFORMANCE EVENT RELEASED SAMPLES

Directions to the Student

Today you will be taking Session II of the Missouri Algebra I Test. This is a test of how well you understand the course level expectations for Algebra I.

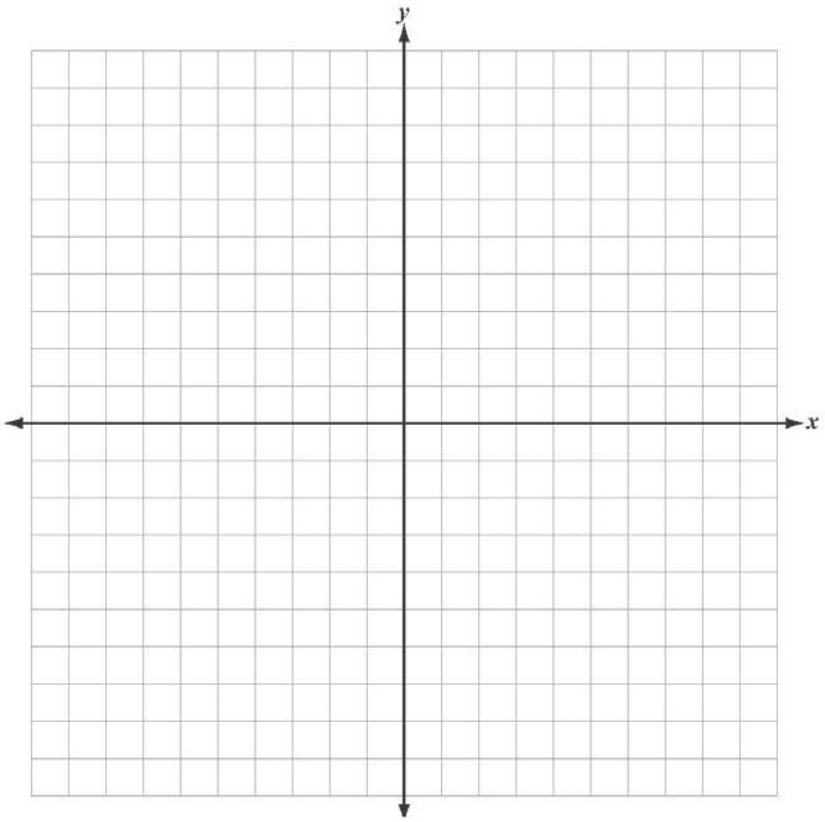
There are several important things to remember:

1. Read the performance event carefully and think about how to answer the questions.
2. Show all of the work that you did to answer the question with a number 2 pencil. If a box is provided, make sure all of your work is in the box. If a line is provided to write your answer on, be sure your answer is on the line.
3. If you do not know the answer to a question, skip it and go on. You may return to it later if you have time.
4. If you finish the test early, you may check over your work.
5. There is not an answer sheet for this session of the test. Write or mark your answers directly in your test book with a number 2 pencil.

1. A line passes through the points (3, 5) and (−2, 7).

- On the line below, write an equation of the line and graph it on the coordinate grid.

Equation:_____



- What is the y-intercept of the line? _____
- What is the slope of the line? _____
- Write a new equation with the same slope and a different y-intercept on the line below.

  Equation:_____

- On the lines below, explain how the graph of this line relates to the original line.

_____

_____

_____

- Write a new equation with the original y-intercept and a different slope on the line below.

  Equation:_____

- On the lines below, explain how the graph of this line relates to the original line.

_____

_____

_____

STOP

APPENDIX C
STATE ALGEBRA STANDARDS

Number and Operations

N.1.A.AI compare and order rational and irrational numbers, including finding their approximate locations on a number line

N.1.B.AI use real numbers and various models, drawing, etc. to solve problems

N.1.C.AI use a variety of representations to demonstrate an understanding of very large and very small numbers

N.2.B.AI describe the effects operations, such as multiplication, division, and computing powers and roots on the magnitude of quantities

N.2.D.AI apply operations to real numbers, using mental computation or paper-and-pencil calculations for simple cases and technology for more complicated cases

N.3.D.AI judge the reasonableness of numerical computations and their results

N.3.E.AI solve problems involving proportions

Algebraic Relationships

A.1.B.AI generalize patterns using explicitly or recursively defined functions

A.1.C.AI compare and contrast various forms of representations of patterns

A.1.D.AI understand and compare the properties of linear and nonlinear functions

A.1.E.AI describe the effects of parameter changes on linear, exponential growth/decay and quadratic functions including intercepts

A.2.A.AI use symbolic Algebra to represent and solve problems that involve linear and quadratic relationships including equations and inequalities

A.2.B.AI describe and use Algebraic manipulations, including factoring and rules of

integer exponents and apply properties of exponents (including order of operations) to simplify expressions

A.2.C.AI use and solve equivalent forms of equations (linear, absolute value, and quadratic)

A.2.D.AI use and solve systems of linear equations or inequalities with 2 variables

A.3.A.AI identify quantitative relationships and determine the type(s) of functions that might model the situation to solve the problem

A.4.A.AI analyze linear and quadratic functions by investigating rates of change, intercepts and zeros

Data and Probability

D.1.A.AI formulate questions and collect data about a characteristic which include sample spaces and distributions

D.1.C.AI select and use appropriate graphical representation of data and given one-variable quantitative data, display the distribution and describe its shape

D.2.A.AI apply statistical measures of center to solve problems

D.2.C.AI given a scatter plot, determine an equation for a line of best fit

D.3.A.AI make conjectures about possible relationships between 2 characteristics of a sample on the basis of scatter plots of the data

APPENDIX D
NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS MATHEMATICS STANDARDS FOR GRADES 6-8

Table A-1. Number and Operations Standard for Grades 6–8 Expectations

Instructional programs from prekindergarten through grade 12 should enable all students to—	In grades 6–8 all students should—
Understand numbers, ways of representing numbers, relationships among numbers, and number systems	• work flexibly with fractions, decimals, and percents to solve problems; • compare and order fractions, decimals, and percents efficiently and find their approximate locations on a number line; • develop meaning for percents greater than 100 and less than 1; • understand and use ratios and proportions to represent quantitative relationships; • develop an understanding of large numbers and recognize and appropriately use exponential, scientific, and calculator notation; • use factors, multiples, prime factorization, and relatively prime numbers to solve problems; • develop meaning for integers and represent and compare quantities with them.
Understand meanings of operations and how they relate to one another	• understand the meaning and effects of arithmetic operations with fractions, decimals, and integers; • use the associative and commutative properties of addition and multiplication and the distributive property of multiplication over addition to simplify computations with integers, fractions, and decimals; • understand and use the inverse relationships of addition and subtraction, multiplication and division, and squaring and finding square roots to simplify computations and solve problems.

Table A-1. Continued

Instructional programs from prekindergarten through grade 12 should enable all students to—	In grades 6–8 all students should—
Compute fluently and make reasonable estimates	• select appropriate methods and tools for computing with fractions and decimals from among mental computation, estimation, calculators or computers, and paper and pencil, depending on the situation, and apply the selected methods; • develop and analyze algorithms for computing with fractions, decimals, and integers and develop fluency in their use; • develop and use strategies to estimate the results of rational-number computations and judge the reasonableness of the results; • develop, analyze, and explain methods for solving problems involving proportions, such as scaling and finding equivalent ratios.

Table A-2. Geometry Standard for Grades 6–8 Expectations

Instructional programs from prekindergarten through grade 12 should enable all students to—	In grades 6–8 all students should—
Analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships	• precisely describe, classify, and understand relationships among types of two- and three-dimensional objects using their defining properties; • understand relationships among the angles, side lengths, perimeters, areas, and volumes of similar objects; • create and critique inductive and deductive arguments concerning geometric ideas and relationships, such as congruence, similarity, and the Pythagorean relationship.
Specify locations and describe spatial relationships using coordinate geometry and other representational systems	• use coordinate geometry to represent and examine the properties of geometric shapes; • use coordinate geometry to examine special geometric shapes, such as regular polygons or those with pairs of parallel or perpendicular sides.
Apply transformations and use symmetry to analyze mathematical situations	• describe sizes, positions, and orientations of shapes under informal transformations such as flips, turns, slides, and scaling; • examine the congruence, similarity, and line or rotational symmetry of objects using transformations.
Use visualization, spatial reasoning, and geometric modeling to solve problems	• draw geometric objects with specified properties, such as side lengths or angle measures; • use two-dimensional representations of three-dimensional objects to visualize and solve problems such as those involving surface area and volume; • use visual tools such as networks to represent and solve problems; • use geometric models to represent and explain numerical and Algebraic relationships; • recognize and apply geometric ideas and relationships in areas outside the mathematics classroom, such as art, science, and everyday life.

Table A-3. Measurement Standard for Grades 6–8 Expectations

Instructional programs from prekindergarten through grade 12 should enable all students to—	In grades 6–8 all students should—
Understand measurable attributes of objects and the units, systems, and processes of measurement	• understand both metric and customary systems of measurement; • understand relationships among units and convert from one unit to another within the same system; • understand, select, and use units of appropriate size and type to measure angles, perimeter, area, surface area, and volume.
Apply appropriate techniques, tools, and formulas to determine measurements	• use common benchmarks to select appropriate methods for estimating measurements; • select and apply techniques and tools to accurately find length, area, volume, and angle measures to appropriate levels of precision; • develop and use formulas to determine the circumference of circles and the area of triangles, parallelograms, trapezoids, and circles and develop strategies to find the area of more-complex shapes; • develop strategies to determine the surface area and volume of selected prisms, pyramids, and cylinders; • solve problems involving scale factors, using ratio and proportion; • solve simple problems involving rates and derived measurements for such attributes as velocity and density.

Table A-4. Data Analysis and Probability Standard for Grades 6–8 Expectations

Instructional programs from prekindergarten through grade 12 should enable all students to—	In grades 6–8 all students should—
Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them	• formulate questions, design studies, and collect data about a characteristic shared by two populations or different characteristics within one population; • select, create, and use appropriate graphical representations of data, including histograms, box plots, and scatterplots.
Select and use appropriate statistical methods to analyze data	• find, use, and interpret measures of center and spread, including mean and interquartile range; • discuss and understand the correspondence between data sets and their graphical representations, especially histograms, stem-and-leaf plots, box plots, and scatterplots.
Develop and evaluate inferences and predictions that are based on data	• use observations about differences between two or more samples to make conjectures about the populations from which the samples were taken; • make conjectures about possible relationships between two characteristics of a sample on the basis of scatterplots of the data and approximate lines of fit; • use conjectures to formulate new questions and plan new studies to answer them.
Understand and apply basic concepts of probability	• understand and use appropriate terminology to describe complementary and mutually exclusive events; • use proportionality and a basic understanding of probability to make and test conjectures about the results of experiments and simulations; • compute probabilities for simple compound events, using such methods as organized lists, tree diagrams, and area models.

Table A-5. Problem Solving Standard for Grades 6–8

Instructional programs from prekindergarten through grade 12 should enable all students to—
• build new mathematical knowledge through problem solving; • solve problems that arise in mathematics and in other contexts; • apply and adapt a variety of appropriate strategies to solve problems; • monitor and reflect on the process of mathematical problem solving.

Table A-6. Reasoning and Proof Standard for Grades 6–8

Instructional programs from prekindergarten through grade 12 should enable all students to—
• recognize reasoning and proof as fundamental aspects of mathematics; • make and investigate mathematical conjectures; • develop and evaluate mathematical arguments and proofs; • select and use various types of reasoning and methods of proof.

Table A-7. Communication Standard for Grades 6–8

Instructional programs from prekindergarten through grade 12 should enable all students to—
• organize and consolidate their mathematical thinking through communication; • communicate their mathematical thinking coherently and clearly to peers, teachers, and others; • analyze and evaluate the mathematical thinking and strategies of others; • use the language of mathematics to express mathematical ideas precisely.

Table A-8. Connections Standard for Grades 6–8

Instructional programs from prekindergarten through grade 12 should enable all students to—
• recognize and use connections among mathematical ideas; • understand how mathematical ideas interconnect and build on one another to produce a coherent whole; • recognize and apply mathematics in contexts outside of mathematics.

Table A-9. Representation Standard for Grades 6–8

Instructional programs from prekindergarten through grade 12 should enable all students to—
• create and use representations to organize, record, and communicate mathematical ideas; • select, apply, and translate among mathematical representations to solve problems; • use representations to model and interpret physical, social, and mathematical phenomena.

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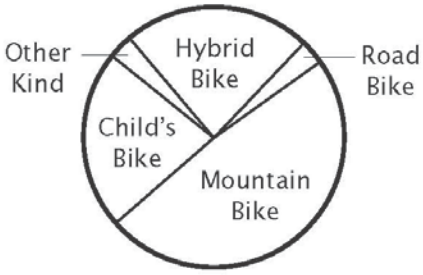
1 The circle graph below shows sales of different kinds of bikes at Bill's Bikes.

BILL'S BIKES



Which kind of bike had approximately twice the sales as hybrid bikes?

- ○ road bike
- ○ child's bike
- ○ mountain bike
- ○ other kind of bike

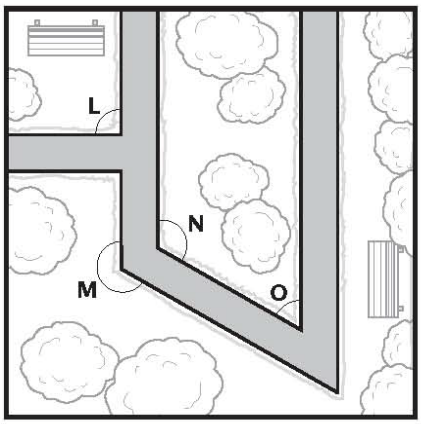
2 Ms. Williams is making a design using tiles, as shown below.

Which statement describes the pattern?

- ○ 1 large tile above and 2 small tiles below
- ○ 1 large tile above and 3 small tiles below
- ○ 2 large tiles above and 3 small tiles below
- ○ 2 large tiles above and 4 small tiles below

3 Use your protractor to help you solve this problem.

The picture below shows walking paths in a park.



Which angle is an acute angle?

- ○ angle L
- ○ angle N
- ○ angle M
- ○ angle O

4 A rectangular field measures 40 feet wide by 20 feet long. Which of these shows how to find the area of the field?

- ○ 40 feet + 20 feet
- ○ 40 feet × 2
- ○ 2(40 feet + 20 feet)
- ○ 40 feet × 20 feet

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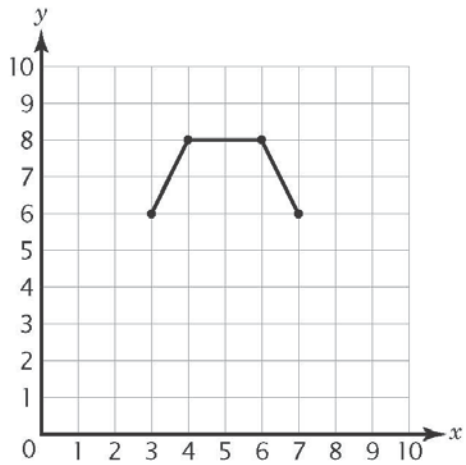
5 Study the grid below.



Which two pairs of coordinates can be used so that the figure on the grid, when completed, is a hexagon?

- ○ (2, 4) , (8, 4)
- ○ (4, 4) , (6, 4)
- ○ (4, 6) , (6, 6)
- ○ (3, 6) , (7, 6)

6 Each of the 3 sixth-grade classes at Jefferson School has 25 students. On picture day, a few students were absent. Which expression shows how many sixth-grade students had their pictures taken?

p = number of sixth-grade students who were absent on picture day

- ○ $(25 - p) \times 3$
- ○ $(25 - p) \div 3$
- ○ $(25 \times 3) - p$
- ○ $(25 \div 3) - p$

7 Study Figure A and Figure B below.

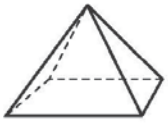


Figure A

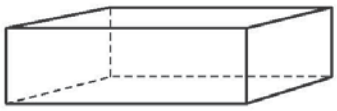


Figure B

In the table below, fill in the correct number of faces, vertices, and edges for Figure A and Figure B.

	Number of Faces	Number of Vertices	Number of Edges
Figure A			
Figure B			

8 Karen baked cookies for 2 hours and 25 minutes. She finished baking cookies at 4:15 P.M. What time did she begin baking cookies?

- ○ 1:50 P.M.
- ○ 2:40 P.M.
- ○ 2:50 P.M.
- ○ 6:40 P.M.

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12 Kyle is 3 years older than twice his sister's age. His sister is 5 years old. How old is Kyle?

- ○ 7
- ○ 8
- ○ 10
- ○ 13

14 Study the figures labeled A and B.

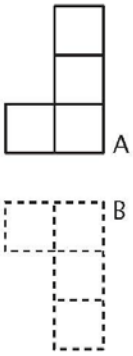

Figure B shows Figure A after 1 transformation. Which transformation was used—a flip, a slide, or a turn? Write your answer on the line.

_____

In the figures above, draw the flip line, slide arrow, or turn point on the figures for the transformation you chose.

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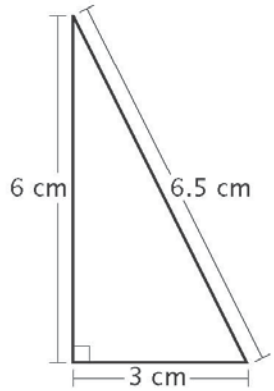
17 Jodi wants to rent sports equipment to people at the park. She needs to know the equipment that will rent most often. Which is the best method to gather the information?

- ○ observe the equipment that most people buy at a sports store
- ○ survey adults at the library on Saturday afternoon
- ○ survey elementary school students on the playground
- ○ observe the equipment that most people rent at different rental stands

18 Study the triangle below.



Area for a triangle = $\frac{1}{2} \times$ base $\times$ height

Which of these expressions can be used to find the area of the triangle?

- ○ $6 + 6.5 + 3$
- ○ $\frac{1}{2}(3 \times 6)$
- ○ $3 \times 6 + 6.5$
- ○ $\frac{1}{2}(3 \times 6.5)$

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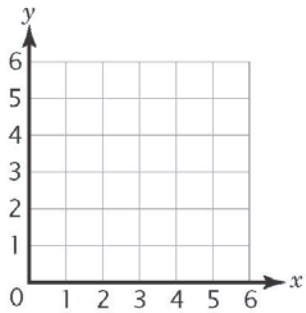
19 The table below shows the coordinates for points A, B, C, and D.

Point	A	B	C	D
Coordinates	(1,5)	(1,3)	(4,3)	(4,5)

Locate and label the points A, B, C, and D on the grid below.



Connect the points to create a polygon. On the line below, write the name of the polygon.

_____

20 Which expression shows the same value as $3(40 + n)$?

- ○ $(3 + 40) + (3 + n)$
- ○ $(3 \times 40) + (3 \times n)$
- ○ $(3 + 40) \times (3 + n)$
- ○ $(3 \times 40) \times (3 \times n)$

21 Study the table below. The table shows the information about 4 accounts that were opened at the same time.

SAVINGS ACCOUNTS INFORMATION

Name	Amount When Opened	Monthly Deposit
Linda	$25	$15
Michael	$40	$10
Nelson	$30	$14
Olivia	$20	$20

Who will be the first to have $100 in his or her savings account?

- ○ Linda
- ○ Michael
- ○ Nelson
- ○ Olivia

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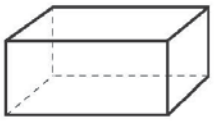
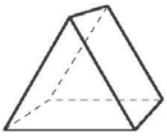
22 Which 3-dimensional figure has 7 faces, 15 edges, and 10 vertices?

○ 

○ 

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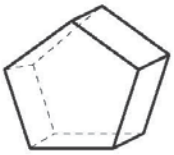
○ 

23 Study the table below.

MEASUREMENT CONVERSIONS

1 foot = 12 inches
1 yard = 3 feet
1 mile = 1,760 yards

What is the best estimate for the number of inches in a mile?

○ 40,000 inches

○ 60,000 inches

○ 90,000 inches

○ 120,000 inches

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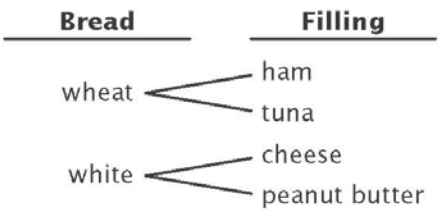
25 Sela uses one type of bread and one type of filling to make each sandwich.

Bread	Filling
wheat	ham
white	tuna
	cheese
	peanut butter

Which diagram shows all the possible types of sandwiches Sela can make?



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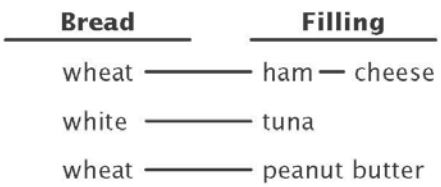

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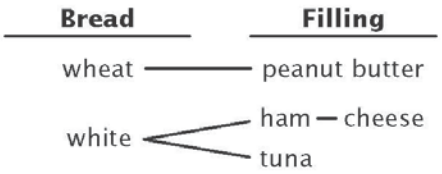

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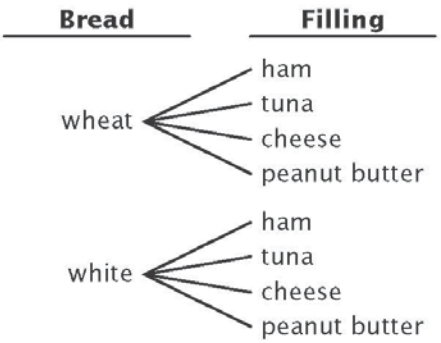

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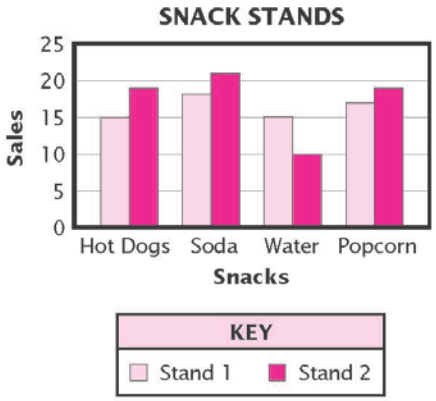
26 Each of two snack stands at the soccer field collected data to compare sales. Which of these does ***not*** show the number of hot dogs sold at each stand?

○



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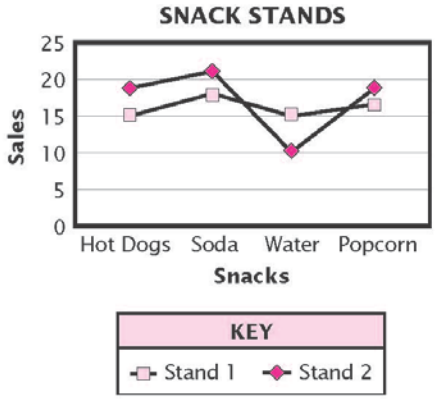

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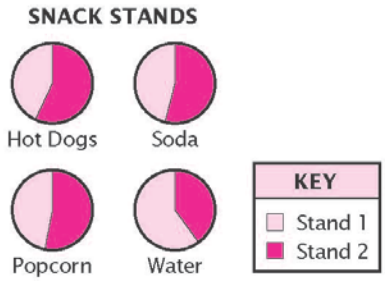

○

SNACK STANDS

Snacks	Stand 1	Stand 2
Hot Dogs	15	19
Soda	18	21
Water	15	10
Popcorn	16	19

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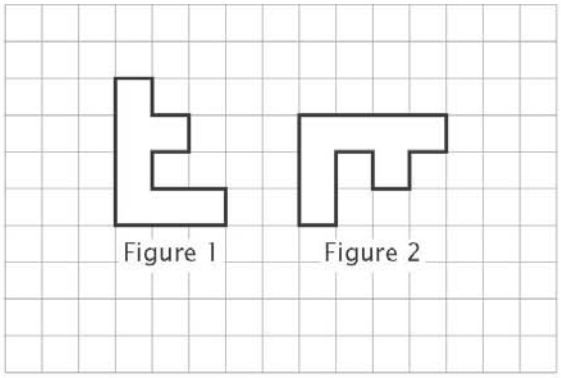
27 Study the figures on the grid below.



Which two transformations could be used to change Figure 1 to Figure 2?

- ○ a flip and a slide
- ○ a slide and a flip
- ○ a counterclockwise 90° turn and a slide
- ○ a clockwise 90° turn and a slide

STOP

APPENDIX F
STATE STANDARDS FOR MATHEMATICS AT GRADE LEVEL 6

Number and Operations

N.1.A.06 compare and order integers, positive rationals and percents, including finding their approximate location on a number line

N.1.B.06 recognize and generate equivalent forms of fractions, decimals and percents

N.1.C.06 recognize equivalent representations for the same number and generate them by decomposing and composing numbers, including expanded notation

N.1.D.06 use factors and multiples to describe relationships between and among numbers, including whole number common factors and common multiples

N.2.B.06 describe the effects of addition and subtraction on fractions and decimals

N.3.C.06 add and subtract positive rational numbers

N.3.D.06 estimate and justify the results of addition and subtraction of positive rational numbers

N.3.E.06 solve problems using equivalent ratios

Algebraic Relationships

A.1.B.06 represent and describe patterns with tables, graphs, pictures, symbolic rules or words

A.1.C.06 compare various forms of representations to identify a pattern

A.1.D.06 identify functions as linear or nonlinear from a table or graph

A.2.A.06 use variables to represent unknown quantities in expressions

A.2.B.06 recognize equivalent forms for simple Algebraic expressions including associative and distributive properties

A.3.A.06 model and solve problems, using multiple representations such as graphs, tables, expressions and equations

A.4.A.06 compare situations with constant or varying rates of change

Geometric and Spatial Relationships

G.1.A.06 identify the properties of one-, two- and three-dimensional shapes using the appropriate geometric vocabulary

G.1.B.06 describe relationships between the corresponding angles and the length of corresponding sides of similar triangles (whole number scale factors)

G.2.A.06 use coordinate geometry to construct geometric shapes

G.3.A.06 describe the transformation from a given pre-image to its image using the terms reflection/ flip, rotation/ turn and translation/ slide

G.3.C.06 create polygons and designs with rotational symmetry

G.4.A.06 use spatial visualization to identify isometric representations of mat plans

G.4.B.06 draw or use visual models to represent and solve problems

Measurement

M.1.A.06 identify and justify an angle as acute, obtuse, straight or right

M.1.C.06 solve problems involving elapsed time (hours and minutes)

M.2.A.06 estimate a measurement using either standard or non-standard unit of measurement

M.2.B.06 select and use benchmarks to estimate measurements of 0-, 45-, 90-, 180-, 360- degree angles

M.2.C.06 describe how to solve problems involving the area or perimeter of polygons

M.2.E.06 convert from one unit to another within a system of measurement (mass and weight)

Data and Probability

D.1.A.06 formulate questions, design studies and collect data about a characteristic

D.1.C.06 interpret circle graphs; create and interpret stem-and-leaf plots

D.2.A.06 find the range and measures of center, including median, mode and mean

D.2.B.06 compare different representations of the same data and evaluate how well each representation shows important aspects of the data

D.3.A.06 use observations about differences between 2 samples to make conjectures about the populations from which the samples were taken

D.4.A.06 use a model (diagrams, list, sample space, or area model) to illustrate the possible outcomes of an event

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BIOGRAPHICAL SKETCH

Feng Liu was born in 1973 in Liaocheng City, Shandong Province, China. As the second child of one three-child family, he attended No.1 High School, Zhongyuan Oil Field in Puyang City, Henan Province, China. Feng Liu graduated from Nanjing Normal University's Computer Science Department with a Bachelor of Science in computer science education in 1995. He has taught computer science courses at postsecondary level including Nanjing Material Polytechnic School and Nanjing University of Finance & Economics for eight and half years.

Feng Liu came to United States at January 2004 to further his education at Georgia College & State University where he earned a Master of Education in educational technology in May 2006. In August of 2006, Feng Liu enrolled as a doctoral fellow in the Educational Technology program in School of Teaching and Learning at the University of Florida (UF).

During his study at UF, Feng Liu has focused on research in the learning technologies. His research interests include the investigation of online learning success and the effectiveness of virtual schooling, the employment of advanced research methods and statistical approaches in educational research, and the use of e-game/simulation for knowledge gain, attitude change and motivation in areas such as science and second language acquisition. He has several publications in these areas.