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Lopukhova, Olga P. ***The influence of developmental mathematics classes on the successful completion of the higher level mathematics courses***

Abstract

The intent of the following study was to investigate the influence of developmental mathematics courses on the successful completion of subsequent higher level mathematics courses. The investigation of the problem has taken place at the University of Wisconsin – Stout by administering student survey in Spring semester of 2011-2012 academic year and by collecting additional information and data through collaborative work with Mathematics, Statistics and Computer Science (MSCS) Department and Planning, Assessment, Research, and Quality (PARQ) Office. To achieve the goal the researcher investigated four objectives related to the percentage of students in remedial mathematics courses, completion rates of such courses, influence of mathematics tutoring services, and success rate in the higher level mathematics courses in two populations of students: those who had taken and those who had not taken developmental mathematics courses. The findings of the study revealed positive impact of remedial mathematics courses on students' grade point average, on completion rates of remedial and non-remedial mathematics courses, and on the enrollment and successful completion of higher level mathematics courses up to Calculus I and Calculus II for the population of students who had taken remedial mathematics courses.

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Chapter I: Introduction

Background

Remediation has become one of the most controversial topics in higher education in recent years. Large numbers of students accepted into colleges and universities were underprepared for the content and rigor of coursework at this level. Even though teachers in elementary, middle, and high schools put a lot of effort to provide knowledge and skills (e.g. mathematics, science, and writing), not every student was completely prepared for learning in the college or university on the first day of classes. As a result, one could find high school level classes that were taught in colleges and universities. These courses went by different names, but were known as remedial or developmental courses. According to the U.S. Department, of Education about one third of first-year students nationwide have taken at least one of the remedial courses in 2007–2008 (Sladky, 2010).

Developmental courses were designed to address the deficiencies and prepare students for subsequent college success. That practice has been around as early as the seventeenth century when Harvard College assigned tutors to underprepared students in subjects like Latin and Greek (Brubacher & Rudy, 1976). However, during the twentieth century, the need for remediation in higher education has risen due to the increased demand for higher education by students from all backgrounds (Casazza, 1999).

The demand for remedial courses has increased rapidly in recent decades. According to the National Center for Educational Statistics (NCES) (National Center for Educational Statistics, 2008), about 19% of students at public 4-year institutions (compared with 29% of community college students) reported having taken some remedial coursework in their first year. Mathematics was the most common remedial course reported by beginning postsecondary students: 15% of students in all types of educational institutions were enrolled in remedial mathematics in 2004. About 46% of students in the class of 2011 did not meet the ACT's College Readiness Benchmark for mathematics in the state of Wisconsin. That number indicates potential learners in remedial classes who were

underprepared for college or workforce training (ACT, 2011). Martha Maxwell (1979), a practitioner in the field of developmental studies, noted: "We have always had academically weak, poorly prepared college students. Perhaps we have them in greater numbers today, but then, more students are currently attending college than ever before"(p. 5). Nowadays with budget cuts at every level of education, it might be useful to look at the issue of education of underprepared students from another perspective.

Despite the need, remedial courses were costly to students, colleges, and ultimately to taxpayers. As for the institutions themselves, they have spent large amounts of resources on remediation. Little more than a decade ago it was estimated that colleges spent between $1 billion and $2 billion annually on remedial education programs (Brenneman & Haarlow, 1998; Saxon & Boylan, 2001). According to a brief by the Alliance for Excellent Education (2011), the number has increased significantly and for the 2007–2008 academic year the overall cost of remedial courses in the United States was estimated at $5.6 billion. This amount included $3.6 billion in direct remedial education costs and an additional $2 billion in lost lifetime wages because students enrolled in remedial courses were more likely to drop out of college. The figure also included the cost associated with students enrolled in two-year or four-year institutions during the 2007–2008 school year who had taken one or more remedial courses while in college. In the state of Wisconsin alone, remedial education cost an estimated $107 million during that school year which included $66 million in direct remedial education costs and an additional $41 million in lost lifetime wages because students enrolled in remedial courses were more likely to drop out of college (The Business Journal, 2011).

Developmental courses are costly to students because they usually do not carry college credit; therefore, students pay college tuition and support themselves without earning credits toward their degree. In the 2007–2008 academic year, students paid 42% of total postsecondary costs at public four-year colleges and 14% of costs at two-year colleges (Alliance for Excellent Education, 2011). Consequently, some students were discouraged from enrolling in the developmental courses, and others failed to complete remedial courses

in which they were enrolled.

Numerous surveys indicated that a voluntary approach to remediation did not seem to work. In schools where remediation, learning labs, and counseling services were available to students on a purely voluntary basis, relatively few students used such programs. The results of surveys indicated that those students who did not take advantage of these programs did not succeed as well with college level courses (Zeitlin & Markus, 1996).

In a 2007–2008 survey of University of Wisconsin Stout (UW-Stout) faculty revealed that about 50% of faculty felt that most of the students they taught lacked basic skills for college level work, while nationally only about 30% of faculty expressed similar concern (UW-Stout, 2009).

While the use of developmental courses by higher educational institutions was widespread, little is known about the influence of such courses on the educational success in the subsequent higher level mathematics courses. Evaluation of the influence of remedial courses has a great value since it ensures that the course goals are met and students do, in fact succeed. National Survey described the following as the most often used evaluation measures of the developmental courses and programs (Akst & Ryzewic, 1985):

- remedial course grade;
- test scores;
- grades earned subsequently in college-level math courses;
- students' opinion of the remedial courses;
- college retention rate;
- students' attitude towards mathematics;
- college graduation rates;
- faculty opinion of remedial courses or program.

On one hand, remedial courses might help underprepared students acquire the skills and knowledge necessary to succeed in the college or university. On the other hand, those courses increased the number of requirements to obtain a degree and, consequently, restricted the number of majors available to students, prolonged the time in college and

increased the student cost of getting the degree. Thus, remediation might have negative impact on student retention in the program and college graduation rate.

Scarcity of recent and available resources (e.g., reports, research studies of small or large scale) tended to generate debate about remediation. Therefore, it is crucial to inform policy makers, educators, scholars, and students about the influence of developmental courses on the basis of quality research.

Statement of the Problem

Remediation, as an activity, was intended to meet the needs of students who initially did not have the skills or experience necessary to perform at a level that the college or instructors consider to be "regular" for those students. Therefore, students who remediate successfully in mathematical classes should demonstrate academic outcomes that are comparable to those who did not require remediation in mathematics.

According to the Southern Regional Education Board, few states have exit standards for remedial courses or evaluate the influence of these courses, or collect performance information on their students (Crowe, 1998). In addition, a study of 116 two-year and four-year colleges found only a small percentage of institutions performed any systematic evaluation of their developmental courses or programs (Weissman, Rulakowski, & Jumisko, 1997). As the demand for accountability from local, state, and federal organizations increases, so will the demand for the evaluation of remedial education. This study attempts to address some of the gaps in the literature by examining the influence of remedial mathematical courses at one university.

Purpose of the Study

Remedial coursework enables underprepared students to learn the value of achievement while acquiring the skills necessary to succeed in college level work. The purpose of the study was to describe the influence of remedial mathematical courses through an examination of student short-term academic success in subsequent mathematics courses at UW-Stout. Data collection included an online survey for the students currently

enrolled in mathematics courses at both remedial and traditional levels. Namely, the survey was administered to students taking the following courses at UW-Stout during the Spring semester of 2011–2012 academic year.

- Math - 010 Beginning Algebra,
- Math - 110 Intermediate Algebra,
- Math - 118 Concepts of Mathematics,
- Math - 120 Introduction to College Mathematics I,
- Math - 121 Introduction to College Mathematics II,
- Math - 123 Finite Mathematics with Applications ,
- Math - 153 Calculus I,
- Math - 154 Calculus II,
- Math - 156 Calculus and Analytic Geometry I,
- Math - 157 Calculus and Analytic Geometry II.

Additionally, results from previous surveys, questionnaires, and reports were obtained through collaborative work with Mathematics, Statistics, and Computer Science Department (MSCS), and Mathematics Teaching and Learning Center (MathTLC) at UW-Stout to be used as supplemental statistical data beneficiary to the research project.

Research Objectives

The following are the research objectives:

1. Investigate the percentage of students requiring remedial mathematics courses at UW-Stout.

2. Investigate the completion rate of the mathematics remedial courses at UW-Stout.

3. Examine the influence of tutoring services on the students in the remedial and traditional mathematics courses.

4. Investigate the success rate of the higher level mathematics courses in two populations of students: those who had taken and those who had not taken developmental or remedial mathematics courses.

Importance of Topic

Even though the number of students needing remedial courses has risen recently, it does not necessarily indicate that students are becoming less capable or hard-working. Such factors as increasing enrollment in higher education, higher competition in the job market, and challenges in high school preparation all affected the level of need for remedial education. U.S. Census Bureau data has shown that from 2000 to 2008, there has been an increase in the number of college students across all age groups throughout the country. In 2008, the number of students enrolled only in two-year colleges was 5.3 million which was up from 3.8 million in 2000 (Dawis & Bauman, 2011).

The follow-up research study conducted at the Southwest Virginia Community College (SWCC) revealed some significance of developmental courses. The study compared the effectiveness of the remedial courses offered at the community college for three and five credits. As a result, it was concluded that three-credit courses were just as effective as five-credit courses for developmental students in mathematics. Advantages of that research results included lower costs to students, fewer scheduling problems, and possibly less burnout for students and teachers (Woodard & Sexton, 2010).

All UW-Stout students are required to take at least six credits of mathematics courses and analytic reasoning for graduation. In addition, nine out of 40 undergraduate programs at UW-Stout require completion of higher level mathematical courses (e.g., calculus or higher). Furthermore, many fast growing programs require students to be able to apply their mathematical knowledge in various courses such as physics, engineering, and game design.

Due to the insufficient level of student preparedness, many first year students at UW-Stout were placed into the developmental courses (e.g., Math-010 or Math-110). It was one of the approaches to prepare students for the future, more advanced, courses like pre-calculus, calculus, or higher. Many researchers indicated that if a student struggles with a mathematics course, then it is very likely that the student might encounter even

more difficulties in the subsequent mathematical courses (Maxin Ma, 2000; Fayowski, Hyndman, & MacMillan, 2009). The UW-Stout Chancellor's Enrollment Task Force report indicated that the completion of courses in mathematics has positive influence on student retention and overall success in the programs (Gilberts, 2004). This project was conducted to investigate a more specific question of the influence of developmental math courses a student takes at UW-Stout on her/his performance in subsequent math courses and on her/his selection of math courses.

A few immediate benefits of this research were as follows:

1. The research determined the level of influence of developmental courses on the completion of higher level mathematical courses. Remediation has been an important part of American higher education for many years. Postsecondary institutions invested significant resources in the courses to address the academic deficiencies of entering students. While little research has been done to establish the impact of remedial programs, research suggested that institutions can play a significant positive role in addressing inequities in students' preparation.

2. The results of the study provided valuable information to students, faculty, and other stakeholders about remedial courses at UW-Stout. The various statistical data about the impact of remedial courses on the students' academic progress and achievements play a significant role in distribution of state or federal funding for postsecondary institutions. Unbiased and objective research results might help the policy makers.

3. The knowledge gained from the study had the potential to influence enrollment and retention rates in the remedial courses at UW-Stout. The effectiveness of remedial education has not yet been definitively proven, but it has a great potential to help students to successfully perform at schools (e.g., colleges or universities).

4. The research described student attitude/knowledge/satisfaction of tutoring services provided in both remedial and higher level mathematics courses at UW-Stout. Tutoring process has benefits for tutors and for tutees at the same time. Students gain more from learning with their peers and they learn more through direct communication at

a level with which they are comfortable. Peer tutoring appears to be successful in helping students, and the positive personal connections might influence retention.

5. Further research may be required to identify the influence of the developmental courses on the overall completion/graduation rate. Additional research on how to maximize the benefits of remediation could be appropriate since the burden of the cost for the courses lies on the students' shoulders and the price for not offering the courses appears to be higher.

Assumptions

The study considered an online survey to be a reliable and valuable data collection method which was used to collect the majority of the data for the project. Similarly, the researcher assumed that statistical information gained via the anonymous online survey was based on the truthful answers of voluntary participants. Additionally, it was assumed that all previous surveys, questionnaires, and any other data utilized in the study had high validity and reliability.

Limitations

The study had the following limitations:

1. The results of study were limited to the students at UW-Stout;

2. UW-Stout is a rural branch of the University of Wisconsin system, hence the results may not be generalizable to a population of students in an urban setting;

3. UW-Stout is considered to be a university with a predominantly white student population (UW-Stout, 2010), hence the results may not be generalizable to a more diverse student population;

4. The factor of time constraints, since the data collection/results was limited to one semester; and

5. The results of the study were not generalizable to the student population of the entire state of Wisconsin or the United States.

Definition of Terms

The following list of specialized terms used throughout the paper is provided for the reference of the reader and to prevent any misinterpretations due to slight variations of their use in literature:

Completion Rate – is the term used to compare course credits attempted by students versus course credits completed which is calculated as a percentage (Wisconsin Department of Public Instruction, 2012).

Graduation Rate – is the percentage of the students who graduate from an educational institution (Wisconsin Department of Public Instruction, 2012).

Remedial or Developmental Course – is a course offered at a postsecondary institution (college or university) for students identified as lacking the knowledge that college-level courses assume their students to have (a.k.a., basic–skill training, nontraditional course–work) (Education Commission of the States, 2012).

Retention Rate – is defined as a percentage of students who started in one of the semesters (fall or spring) and continued to stay enrolled at the university for the following semester for at least one credit (Education Commission of the States, 2012).

Short-term Success – is defined as passing for developmental or traditional mathematics course(s) with a grade of C or better during the research investigation.

Under-prepared – is described as (Education Commission of the States, 2012) diverse group that varies with ability, educational background, income, culture, and life experience (Dzubak, 2011).

Chapter II: Literature Review

Students have struggled with basic skills for centuries. This paper investigated the connection between developmental and traditional mathematics courses at a rural university. The focus of the following chapter pertained to the long history of remediation in education. The background of this subject was discussed from the colonial period through the nineteenth century and World War II, to the GI Bill in 1940, and included the twenty-first century as well. Discussion about professional organizations in remedial education and an overview of the issues in recent years nationally and locally completed the chapter.

The Colonial Period

Colleges in colonial America, such as Harvard and the College of William and Mary, were founded with help from church groups. As a result, they pursued two purposes: to prepare ministers and to train professional men. More and more students tended to choose occupational specializations as time went by: the percentage of college graduates going into the ministry was 50% during the first half of the eighteenth century. By 1761, however, this had fallen to 37%, and by 1801 to 22%. Revivalism brought the figure back to 30% by 1836, but then a steady decline set in: 20% in 1861, 11% in 1881, and 6.5% in 1900 (Brubacher & Rudy, 1976).

Very few children attended school and only some parents could afford tutors for them in colonial America. Colleges immediately faced student shortage problem and started admitting students who could not completely meet all admission requirements. To help this category of students, colleges provided a few additional courses.

The trend of colleges in the nineteenth century was to increase entrance requirements and change curriculum by dropping some subjects down into the secondary level. A good example of such changes was the way of putting mathematics into curriculum at Yale University. Arithmetic was not on the list of entrance requirements until 1745. Euclidean geometry was a senior-level class in 1720, which was moved down to the sophomore status

by 1743. Later, in 1825, the same subject dropped to the third term of freshman year and thirty years later geometry had become an admission requirement to Yale (Brubacher & Rudy, 1976).

With higher admission requirements and the development of stricter college curriculum, many students needed extra help to keep up with academics. Such demand made colleges establish the institution preparatory departments, which were, in essence, secondary schools. One of the first, famous, and controversial, existed at the University of Wisconsin from 1849 until 1880 (Curti & Cartensen, 1949).

From Nineteenth Century to World War II

During the time frame from the end of the nineteenth century and until World War II, the government became involved in higher education. The Morrill Act of 1862, signed by President Lincoln, granted 30,000 acres of land to each state to sell and to create and support agricultural and mechanical arts colleges. The second Morrill Act in 1890 expanded the program, and gave life to land-grant college education for Blacks and other minorities (Gordon, 2003).

As the nineteenth century unfolded, opportunity for women appeared for the first time to get an education in degree-granting colleges. One of the well known colleges was the Emma Willard School, founded by Emma (Hart) Willard in 1821. In Wisconsin, the Female Normal Institute was founded in 1851 and was licensed to award degrees. Preparatory training of girls was usually mediocre in comparison to that of boys. Women's colleges found it difficult to maintain the same standards as men's colleges (Brubacher & Rudy, 1976).

The Hatch Act of 1887 enriched the college curriculum with subjects in applied science and helped to form agricultural extension services and courses for farmers (Gordon, 2003). The Morrill Acts made possible the development of agricultural colleges and land-grant colleges which were among the first institutions that welcomed applied science and mechanic arts in their curriculum (Brubacher & Rudy, 1976).

Despite the growing number of secondary schools and overall improvement of education in general, many students were entering colleges and universities underprepared. The gap between secondary and collegiate education could not longer remain without attracting attention. To resolve this issue, the National Education Association formed The Committee of Ten in 1892. Members of the committee were secondary school teachers, administrators, and college faculty. Some of the recommendations of the Committee were about course content for all high school students, including the study of Latin, Greek, and modern languages; physical and biological sciences; history; algebra and geometry or commercial mathematics. The report (National Education Association, 1893) warned:

> The preparation of a few pupils for college or scientific school should in the ordinary secondary school be the incidental, and not the principal object. At the same time, it is obviously desirable that the colleges and scientific schools should be accessible to all boys or girls who have completed creditably the secondary school course. (pp. 51–52)

The Committee of Ten (National Education Association, 1893) also brought up the issue of better training of teachers, expressing confidence that the colleges and normal schools could prepare more qualified teachers.

Colleges hoped that new higher standards for secondary school students and teachers would lead to fully prepared students entering the colleges. That did not happen: over half of the students who entered Harvard, Yale, Princeton, and Columbia in 1907 did not meet entrance requirements. A few years later about 350 colleges had preparatory departments (Maxwell, 1979).

The GI Bill and Increased Enrollment

One of the biggest changes to college education in the twentieth century came in the post-World War II years with the passage of the GI Bill of Rights. The assumption was that only a few veterans would take advantage of it. By the fall of 1946, more than a million veterans enrolled in colleges. The bill also provided funding to create reading and study-skills programs, tutoring services, and academic advising (Casazza, 1999).

The 1970s were described as years of increased enrollment in colleges and universities. Many of the students were first-generation college students, which meant they were the first ones in their families to pursue education after high school. First-generation students often scored in the bottom third of academic tests, but were eager to work hard to find the way to a better career and better life than their parents (Casazza, 1999).

Professional Organizations

Late 1960s were known as the years of identifying remedial or developmental courses as a field of study. Developmental education was viewed as an independent area of education with its own research base. The National Center for Developmental Education (NCDE) was one of the first organizations that developed out of the consortium of four-year and community colleges in western North Carolina in 1976. The mission of NCDE included reviewing and evaluating remedial studies programs, providing training for developmental faculty and staff, and assisting institutions in improving their remedial studies programs. The NCDE founded two journals associated with developmental education: the Journal of Developmental Education and Research in Developmental Education (Spann, 1996).

At the same time the National Association for Remedial/Developmental Studies in Postsecondary Education (NAR/DSPE) was formed by faculty members in Chicago. Now it is known as National Association for Developmental Education (NADE) and continues to organize conferences nationally, bringing faculty and advisors together to share ideas on teaching, research, and program structures in developmental education (National Association for Developmental Education, 2012).

A number of other organizations were founded from 1980 to 1990 to help improve teaching of underprepared students and to lift morale of educators involved in developmental education. These organizations encouraged collaboration between members of the different groups who have made significant contributions to remedial studies. The national, state, or regional conferences were a great way to network for developmental teachers. The organizations encouraged research in the developmental field through

journals and conferences to make sure that future programs will help students learn how to learn.

Developmental Education Today

Developmental education was and is a field of practice and research within higher education with a theoretical foundation in developmental psychology and learning theory. It promoted the cognitive and affective growth of all postsecondary learners, at all levels of the learning continuum. Developmental education was sensitive and responsive to individual differences and special needs among learners (National Association for Developmental Education, 2011).

The National Center for Educational Statistics (NCES) has conducted national studies regarding the size and the extent of programs for underprepared students. The most recent data was published by NCES in a statistical analysis report in the spring of 2011. The following data for 4-year institutions was presented: 39% of students in public non-doctorate, 24% of students in public doctorate, 26% in private non-doctorate, and 22% in private doctorate institutions reported having ever taken a remedial courses in mathematics (Aud et al., 2011).

Another report of the NCES published in 2000 analyzed the changes in the remedial education from 1995. According to the report, the average length of time that students were enrolled in remedial courses was less than one year. In the fall of 2000, institutions that offered remedial courses reported that 60% of their students spent, on average, less than one year on remedial courses, 35% reported that their students spent, on average, one year on such courses, and 5% reported an average time of more than one year in remediation (Parsad & Lewis, 2003).

One more concern that followed from remedial education was the high percentage of college student drop outs. This resulted in dramatically low graduation rates. For instance, among high school students of 1992 who enrolled in college and did not take any remedial courses, 57% earned their bachelor's degree within eight years. However, among students

who took one or two remedial courses, only 29% earned bachelor's degree within eight years, and among those who took three or four developmental course, only 19% received a degree (Strong American schools, 2008).

Developmental Education at UW-Stout

Many programs at the University of Wisconsin-Stout (UW-Stout) as a polytechnic university have concentrations and majors that require knowledge of higher level mathematics courses (e.g., pre-calculus, calculus). Businesses and industry, the economy and the security of the state and of the country depend on well–educated college graduates. At UW-Stout, students have an opportunity to succeed in mathematics courses, even if their knowledge in mathematics does not allow them to take high level courses during the freshman year in college. There are two types of remedial courses available at UW-Stout: Math-010 (Beginning Algebra) and Math-110 (Intermediate Algebra).

According to the Board of Regents report (2003), the percentage of freshman students requiring mathematics remediation in 2001-2002 was significantly smaller than percentage of freshman students required remediation in 1990-1991. In 2001-2002, 11.7% of college freshmen enrolled within the UW System schools required remediation; in 1990-1991, that percentage was as high as 20.6% (Board of Regents of the University of Wisconsin System, 2003). Furthermore, developmental education had shown an influence on students' retention rate and overall success in their academic life. The second year retention rates for 2001-2002 academic year stayed relatively high (about 75%) for both groups of students: those who had taken remediation math courses and those who had not. Additionally, as it followed from the Board of Regents report, for students who were not required to enroll in developmental math courses, retention rate was 77% and for those who were required to enroll in developmental math courses and completed them during the first year, retention rate was 76%. To describe the six-year retention rate, the researchers looked at the 1996-1997 cohort of freshmen. Those data indicated that 53% of students enrolled in remedial math courses completed their program requirements and graduated compared to

the 64% of graduates who have not taken any remedial courses (Board of Regents of the University of Wisconsin System, 2003). Remediation was not the only factor in determining retention or graduation rates. However, the availability of developmental mathematics courses increased student potential success in their programs and added at least 1000 graduates to the 1996-1997 cohort.

Summary

Developmental education has a long history in higher education of America. There was no golden age when all students came to college fully prepared. For a wide variety of reasons, some students of all eras came to college under-prepared. Colleges responded with special classes and tutors, eventually creating programs to meet the needs of these students. Funding levels have risen and fallen, but remedial courses or other type of assistance have continued to exist. Even with all sorts of school reforms, developmental education has not gone away, nor is likely to disappear in the foreseeable future.

Chapter III: Methodology

The following chapter was written with the intent to give a detailed description of the research methods, sample selection, instrumentation, data collection, data analysis, and limitations of the chosen methodology. Overall, this chapter provided the foundation for the circumstantial discussion of the results in Chapter IV and base for Chapter V, which summarized the study by providing conclusions and recommendations.

Research Method

This study investigated possible connection between completion of remedial math courses and completion of higher level math courses at UW-Stout utilizing the quantitative descriptive research method. One of the concise definitions of quantitative type of research stated that it was a research "testing objective theories by examining the relationship among variables. These variables can be measured, typically on instruments, so that numbered data can be analyzed using statistical procedure" (Creswell, 2009, p. 233). Additionally, descriptive analysis of data "for variables in a study includes describing the results through mean, standard deviations, and range of scores" (Creswell, 2009, p. 228).

To achieve the goal of this study the methodology of quantitative descriptive analysis assisted in collecting and analyzing data obtained through a student survey at UW-Stout and various related reports from previous years.

Supplemental documentation was obtained from the MSCS Department and PARQ Office. In particular, faculty of MSCS Department and office staff at PARQ Office provided valuable data that indicated enrollment in remedial mathematics courses, success rate in those courses, and student evaluation of mathematics tutoring services at UW-Stout. To ensure that human subjects were protected, all data provided by the UW-Stout divisions were anonymous and confidential. The raw data for the recent years were analyzed by the researcher and used only to fulfill the study objectives.

Sample Selection

The research sample for the student survey included UW-Stout students enrolled in mathematics classes during the Spring semester of 2011-2012 academic year. Namely, the survey was administered to students taking the following courses:

- Math - 010 Beginning Algebra,
- Math - 110 Intermediate Algebra,
- Math - 118 Concepts of Mathematics,
- Math - 120 Introduction to College Mathematics I,
- Math - 121 Introduction to College Mathematics II,
- Math - 123 Finite Mathematics with Applications ,
- Math - 153 Calculus I,
- Math - 154 Calculus II,
- Math - 156 Calculus and Analytic Geometry I,
- Math - 157 Calculus and Analytic Geometry II.

According to the Access Stout system, the sample included 43 sections with 1429 students enrolled in the aforementioned courses during the Spring semester of 2011-2012 academic year. This number represented about 15.6% of the total population of UW-Stout students according to the UW-Stout Fact Book (2011). The choice of the specific sample accounted for the purpose of the study to investigate similarities and differences between the two groups of UW-Stout students: those who had taken the remedial math courses (Math–010 and Math–110) and those who had not taken developmental math courses. One of the objectives of the study was to identify the short-term success of students in remedial and non-remedial math courses. The student survey was administered only once during the Spring semester of 2011-2012 academic year. However, additional materials from recent years, such as reports and questionnaires, were used in the study to achieve all of the objectives.

Instrumentation

A student survey was used as the main instrument for collecting necessary data for the study. No existing instruments were found that could successfully obtain the desired data and fulfill the research objectives. Consequently, the survey was developed by the investigator and approved by the research advisor and the UW-Stout Institutional Review Board (IRB). Complete student survey was provided in Appendix A.

Qualtrics software was used to administer the student survey online and to guarantee its confidentiality. Qualtrics is a web-based survey software that is available to all students, staff, and faculty at UW-Stout to utilize in their teaching, learning, and research projects. Since the instrument was designed specifically for this study, no measures of validity or reliability have been documented. To perform the subsequent statistical analysis, data was exported into a Microsoft Excel document to form the necessary visual representations of the results, such as charts, graphs, and tables.

Data Collection

To perform the study, the researcher submitted required documentations and received permission from the UW-Stout IRB to administer the student survey. The data collection took place on the UW-Stout campus during the Spring semester of 2011-2012 academic year, which included survey administration and collection of supplemental reports and questionnaires. The survey included blocks of questions related to the students' demographics, enrollment and completion of math courses, and students' knowledge about and satisfaction with tutoring services available at UW-Stout.

Student survey results, along with supplemental documentation received through collaborative work with the Mathematics, Statistics and Computer Science (MSCS) Department and Planning, Assessment, Research, and Quality (PARQ) Office, were obtained to achieve the research objectives. In accordance with the law protecting human subjects involved in the research project, participation of students was voluntary and all information obtained and used in the research was confidential.

Data Analysis

All data collected throughout the study was examined from multiple perspectives and various statistical tools were utilized.

Application of quantitative statistics resulted in transforming original raw data into meaningful information. More precisely, the following statistical methods were used: Student t-test, χ^2 test, and methods of descriptive statistics such as calculation of means, medians, and quartiles. Such information served as a base to draw conclusions and make recommendations of the study.

Limitations

The study has encountered the following limitations:

1. The results of the study were limited to the students at UW-Stout. All information gained through the research tools was related to the UW-Stout students and none of the students from other educational institutions participated in the research. Consequently, no results could be generalized to other students except for those enrolled in the various Spring math courses of 2011-2012 academic year at UW-Stout.

2. UW-Stout is considered to be a rural branch of the University of Wisconsin system, hence the results may not be generalizable to a population of students in an urban setting. Location of UW-Stout and the number of students enrolled in the university programs put the institution into the category of somewhat small universities. The population of the city where UW-Stout is located counted to about 16,000 (U.S. Census Bureau, 2010a), and when compared to the closest cites like St. Paul or Minneapolis with a population of about 285,000 (U.S. Census Bureau, 2010b), it put the university into category of rural institutions.

3. UW-Stout is considered to be a university with a predominantly white student population, hence the results may not be generalizable to a more diverse student population. According to the UW-Stout Fact Book (2011), there were 8,282 white students enrolled in UW-Stout programs which was 88.5% of the total population of students

enrolled in the Fall semester of 2011. The significantly small percentage of other-than-white students in the student population at UW-Stout indicated that the study results may not generalizable to a more diverse population of students.

4. Data collection and analysis from the student survey was limited to only one semester and consequently the constraint of time had impact on the research results. Data collection form student survey took place during the Spring semester of 2011-2012 academic year, which limited the research to the specific sample and data, and added constraints to applicability of the study results in a more broad population and time-frame.

5. Due to the fact that the major instrument of the research, the student survey, was developed specifically for the project, the validity and reliability of the instrument was not documented.

6. The results of the study were not generalizable to the student population of the entire state of Wisconsin or the United States. The sample of students was limited to a specific group of UW-Stout students and was not considered as a sample representing students enrolled in major state or national universities. Therefore none of the results might be extended or applied to the students in other educational institutions of the state of Wisconsin or the United States.

Chapter IV: Analysis of Results

This study was conducted to identify the level of influence of remedial mathematics courses on the successful completion of the subsequent higher level mathematics courses. Research goal was achieved by collecting data from various sources. In particular, online student survey was administered for UW-Stout students enrolled in various mathematics courses during Spring semester of 2011-2012 academic year and previous questionnaires and reports were obtained through collaborative work with MSCS Department and PARQ Office.

The aim of the following chapter was to organize the results of analysis performed throughout the research. The findings were presented in the blocks of information according to the four research questions. Each subsection contained an overview of results.

Demographics

The study included students taking mathematics courses at UW-Stout. In particular, the student survey was administered to the students enrolled in the following courses during the Spring semester of 2011-2012 academic year:

- Math - 010 Beginning Algebra,
- Math - 110 Intermediate Algebra,
- Math - 118 Concepts of Mathematics,
- Math - 120 Introduction to College Mathematics I,
- Math - 121 Introduction to College Mathematics II,
- Math - 123 Finite Mathematics with Applications ,
- Math - 153 Calculus I,
- Math - 154 Calculus II,
- Math - 156 Calculus and Analytic Geometry I,
- Math - 157 Calculus and Analytic Geometry II.

The student survey revealed that among all of the participants, 59.4% were females. The number of males responded to the survey questions was about 1.5 times less than the

number of female participants.

All of the participants were willing to indicate the age group with which they identify themselves. The majority of the students, which was about 86%, indicated the age group of 18-22 years. The next group included students of age 23-27 and consisted of about 9% of respondents. Other age groups (27-32,33-37,38-42, and over 42) ranged from 0.48% to 1.93% of learners.

Students from 32 out of 42 undergraduate programs offered at UW-Stout participated in the survey. The majority of the participants were from the B.S. in Business Administration and B.S. in Applied Science Programs. Other programs with significant number of respondents were B.S. in Retail Merchandising and Management, B.S. in Manufacturing Engineering, and B.S. in Graphic Communications Management. Among the participants were students who did not decide what program to choose as well as those with double major(s).

The student survey showed that students could take basic and remedial mathematics courses at different stages of their educational career: high school, technical college, or university. There were 18 students who indicated taking basic mathematics courses in high school, 13 students who have taken developmental mathematics courses at technical colleges, and 10 participants indicated that they have taken some developmental mathematics courses at universities others than UW-Stout.

Research Objective 1: Investigate the percentage of students requiring remedial mathematics courses at UW-Stout.

As it was evaluated from one of the reports, the average enrollment for the last seven years was 157 students in Math-010 and 471 students in Math-110 (Foley, 2010).

The enrollment in remedial mathematics course Math-010 showed fluctuating pattern over the last seven years with one noticeable increase in 2008-2009 academic year when the number of students reached 261 learners in the developmental mathematics course. The enrollment in Math-110, on the other hand, stayed at a higher level of 420 students and

above with noticeable increase to 564 students in 2010-2011 academic year (Foley, 2010). Complete data of enrollment in Math-010 for the period of seven years from 2004-2005 academic year until 2010-2011 academic year were presented in Figure 1. Complete data of enrollment in Math-110 for the period of seven years from 2004-2005 academic year until 2010-2011 academic year were presented in Figure 2. .

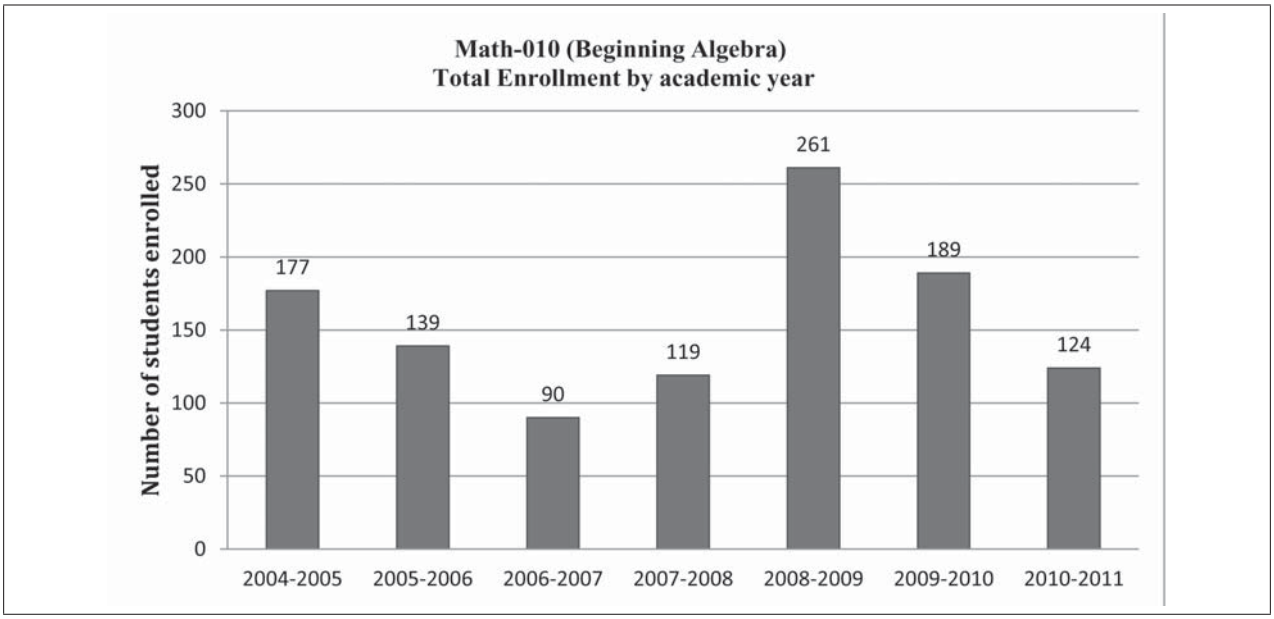

Figure 1. Total Enrollment in Math-010 by academic year

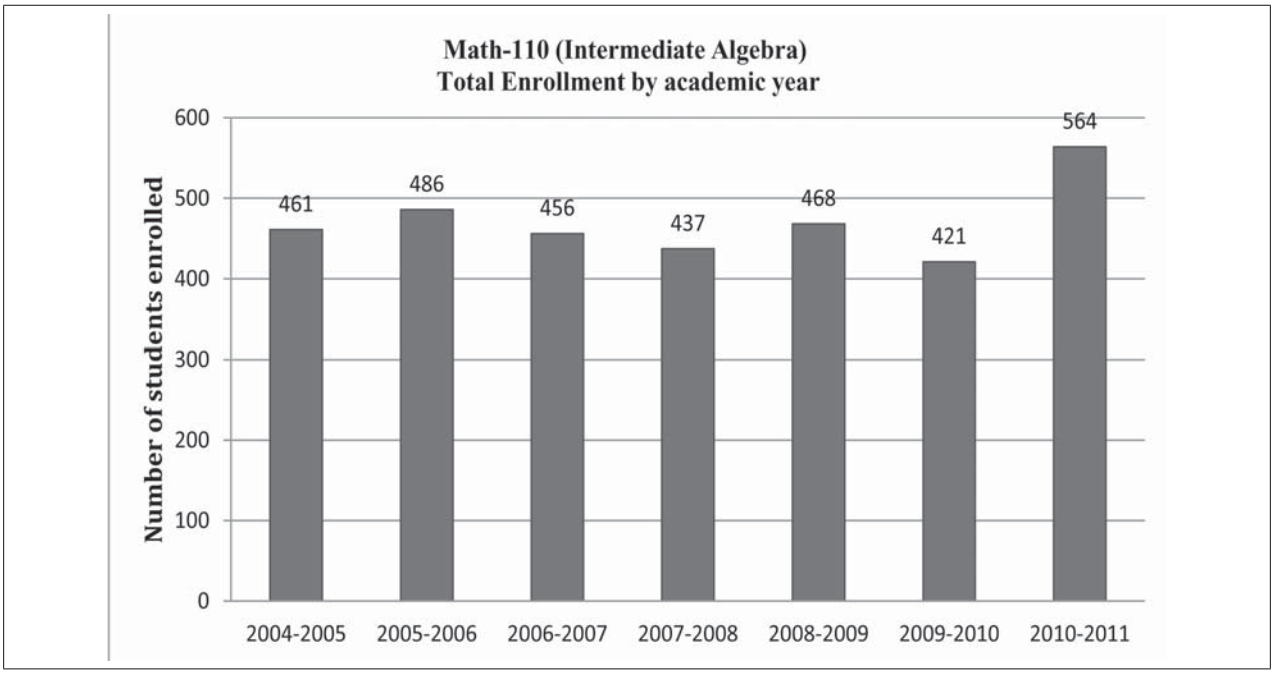

Figure 2. Total Enrollment in Math-110 by academic year.

Total enrollment in both Math-010 and Math-110 courses for the period of seven years from 2004-2005 academic year until 2010-2011 academic year was presented in Figure 3. It was determined that the highest percentage of students enrolled in remedial mathematics courses was during 2004-2005 academic year. A total of 9.5% of student body population at UW-Stout in 2004-2005 academic year was enrolled in remedial mathematics courses. The lowest number of students in remedial mathematics courses was in 2006-2007 and 2007-2008 academic years and it comprised of 6.5% of student body population at UW-Stout in 2006-2007 and 2007-2008 academic years.

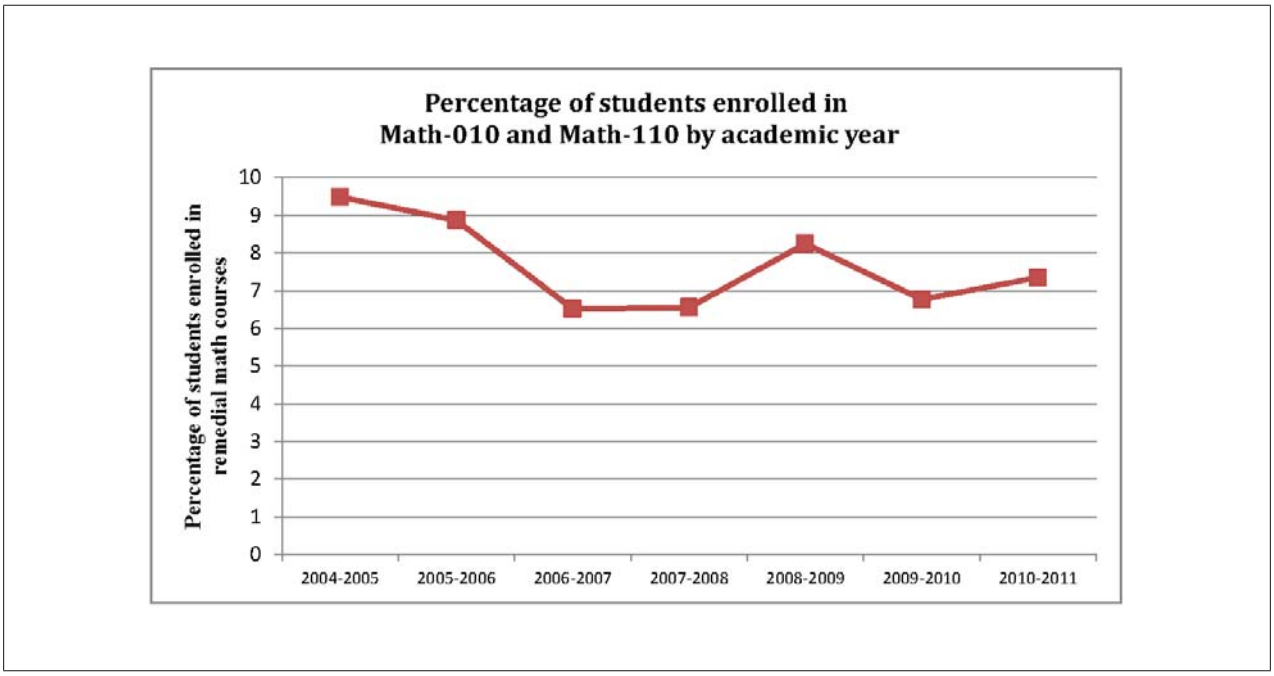

Figure 3. Percentage of students enrolled in Math-010 and Math-110 by academic year.

According to the Access Stout, the number of students enrolled in remedial mathematics courses during the Spring semester of 2011-2012 academic year consisted of 41 students in Beginning Algebra (Math-010) and 146 students in Intermediate Algebra (Math-110). However, as it followed from various reports and course descriptions at the UW-Stout website, Math-010 was considered to be remedial and this 2-credit course did not count toward the degree. Additionally, Math-110 (4-credit course) was considered to be only a prerequisite to the mathematics courses and did not count toward the General Education requirements for mathematics at UW-Stout. Consequently, the number of

students who were not qualified for the General Education mathematics courses was 187, which was about 2% of UW-Stout student population of 2011-2012 academic year.

Roughly half of the student survey participants indicated taking developmental mathematics courses at UW-Stout. Additionally, 24% of participants have had a record of taking remedial mathematics courses in technical colleges or other universities, including some branches of the University of Wisconsin. The student survey from the Spring of 2011-2012 academic year revealed that about 45% of all respondents had taken at least one remedial mathematics courses at UW-Stout. While most students, about 34%, were taking Math-110 (a.k.a., Intermediate Math), 7.4% of respondents had taken both developmental courses, Math-010 and Math-110.

With regard to the relation between gender and remedial education in mathematics, the majority of respondents who were required to take any of the remedial courses at UW-Stout (about 65%) were females. Distribution of the student survey participants among the age groups has shown that 87% of them fell into the age group of 18-22, other age groups (23-27, 28-32, 33-37, 38-42, and over 42) had a percentage ranging from 1.1% to 2.2% of respondents.

Research Objective 2: Investigate the completion rate of the mathematics remedial courses at UW-Stout.

According to the report provided by PARQ Office and data from the Math Teaching and Learning center (Foley, 2010), failure/withdrawal (f/w) rates for the period of Fall 2004 -Spring 2011 in Math-010 and Math-110 were 15% and 18.4% accordingly. Recent data from 2010-2011 academic year suggested that the percentage of f/w rates in Math-010 was 19.9% and in Math-110 was 20.2%. Therefore, the average completion rate for both courses in 2010-2011 academic year were about 80%. The failure/withdrawl (f/w) rates for the Math-010 for the eight years from 2003-2004 academic year until 2010-2011 academic year were provided in Figures 4. It showed decreasing pattern in percentage of students with f/w grades and therefore higher completion rates in Math-010 course. The

failure/withdrawl (f/w) rates for the Math-110 for the eight years from 2003-2004 academic year until 2010-2011 academic year were provided in the Figures 5. It showed similar to Math-010 decreasing patten of f/w grades. The highest f/w rate was in 2003-2004 academic year and comprised of 28% of all students enrolled in Math-110 during that year. The lowest f/w rate was in 2007-2008 academic year and comprised of 13% of all students enrolled in Math-110 during that year.

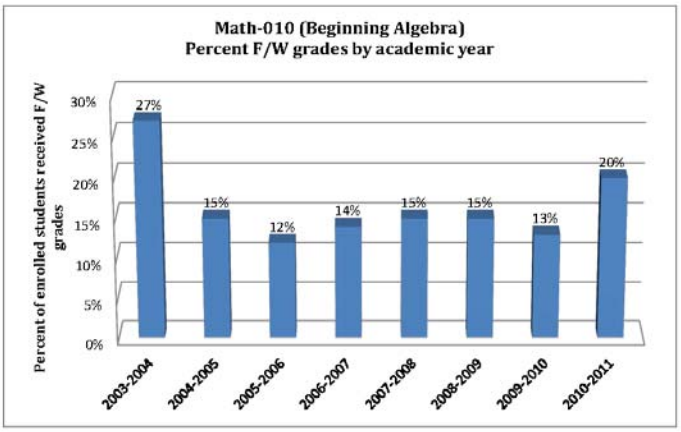

Figure 4. Percentage of students received grades of F/W in Math-010 by academic year.

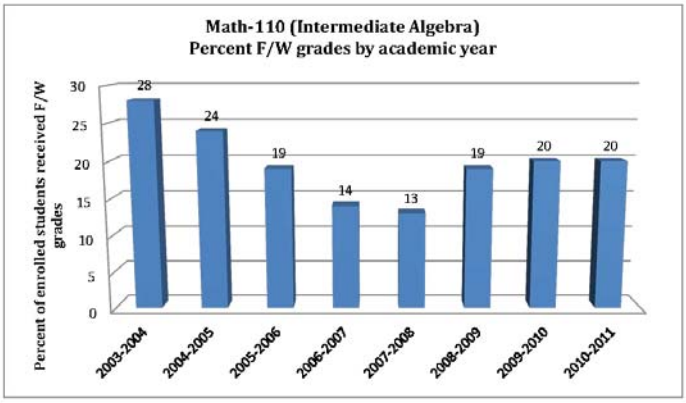

Figure 5. Percentage of students received grades of F/W in Math-110 by academic year.

As it followed from the survey results, the completion rate for both remedial

mathematics courses was on the high level and consisted of 40% completion rate for Beginning Algebra and 87.5% for the Intermediate Algebra. It appeared that most students taking Math-010 received a grade of B, whereas the highest percentage of students in Math-110 achieved a grade of A. Students with a grade of B in Math-010 and students with a grade of A in Math-110, percentage-wise, were 13% and 38% correspondingly. However, students who had taken Math-010 had a strong tendency not to share the information about their grades in the course, while students in Math-110 were more willing to share their final grades. Particularly, 60% of respondents in Math-010 preferred not to share the information about their final grades while only 7% of respondents in Math-110 did not provide the final grade for the course.

Research Objective 3: Examine the influence of tutoring services on the students in the remedial and traditional mathematics courses.

To answer this objective researcher analyzed data obtained from the online student survey and reviewed information obtained from MSCS Department and PARQ Office. In particular, factors like attendance of tutoring services, rating of usefulness of tutoring services, and tutees' satisfaction were analyzed.

UW-Stout provided various tutoring options for students: Mathematics Tutor Lab (MathLab) and Math Teaching and Learning Center (MathTLC).

MathTLC was designed to work specifically with students who took remedial mathematical courses (Math-010 and Math-110). Since 2004, when the MathTLC was opened, the f/w rates in aforementioned courses dropped significantly from 29% to 20% in the 2010-2011 academic year in Math-010 and Math-110. The failure/withdrawl (f/w) rates for the Math-010 and Math-110 for the few recent years were provided in Figures 4 and 5. Additionally, data from 2010-2011 academic year provided in Figure 6 had shown that among all students who attended MathTLC in 2010-2011, 12.1% were enrolled in Math-010 and 71.9% were enrolled in Math-110 during that academic year.

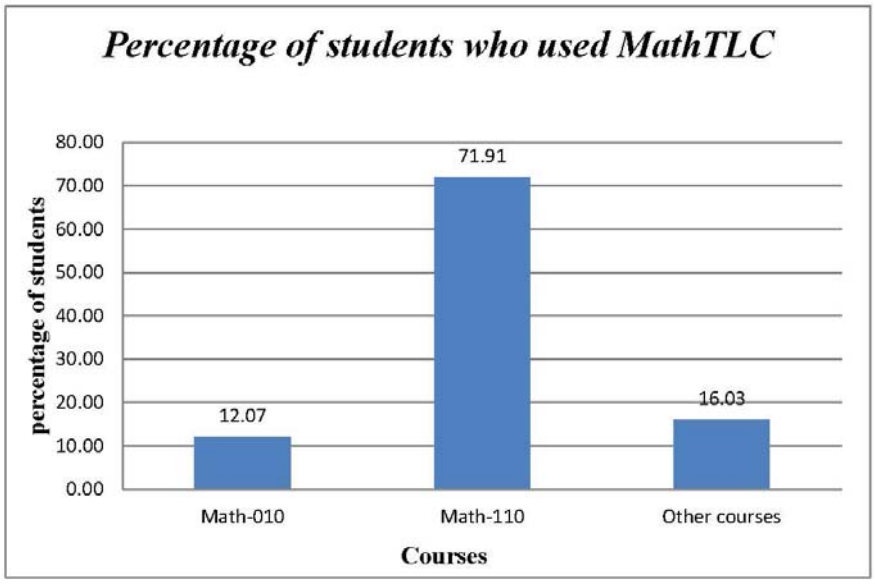

Figure 6. Percentage of students from remedial and non-remedial mathematics courses who used MathTLC during the 2010-2011 academic year.

MathLab, on the other hand, was a tutoring lab run by MSCS Department. Student tutors as well as faculty worked at MathLab to provide help with homework, review exercises, and any other assignments or projects. This lab served students who needed help with Math-118, Math-120, Math-121, Math-123, Math-153, Math-154, Math-156, Math-157, and Elementary Statistics (Stat-130).

In a recent student survey conducted by PARQ Office (2012) in December of 2011 suggested that students were satisfied with the overall quality of help from the MathLab tutors and used the services quite often. In particular, 48% of respondents claimed to be using the tutoring services and 16.4% of respondents indicated that they have used the MathLab more than 16 times during the Fall semester of 2011-2012 academic year. Additionally, 54.55% of respondents strongly agreed with the statement that they would come back to the MathLab if they needed additional assistance (PARQ Office, 2012). Data in Figure 7 had shown the percentage of students who used MathLab 1-5 times, 5-16 times, or more than 16 times in the Fall of 2011 academic year.

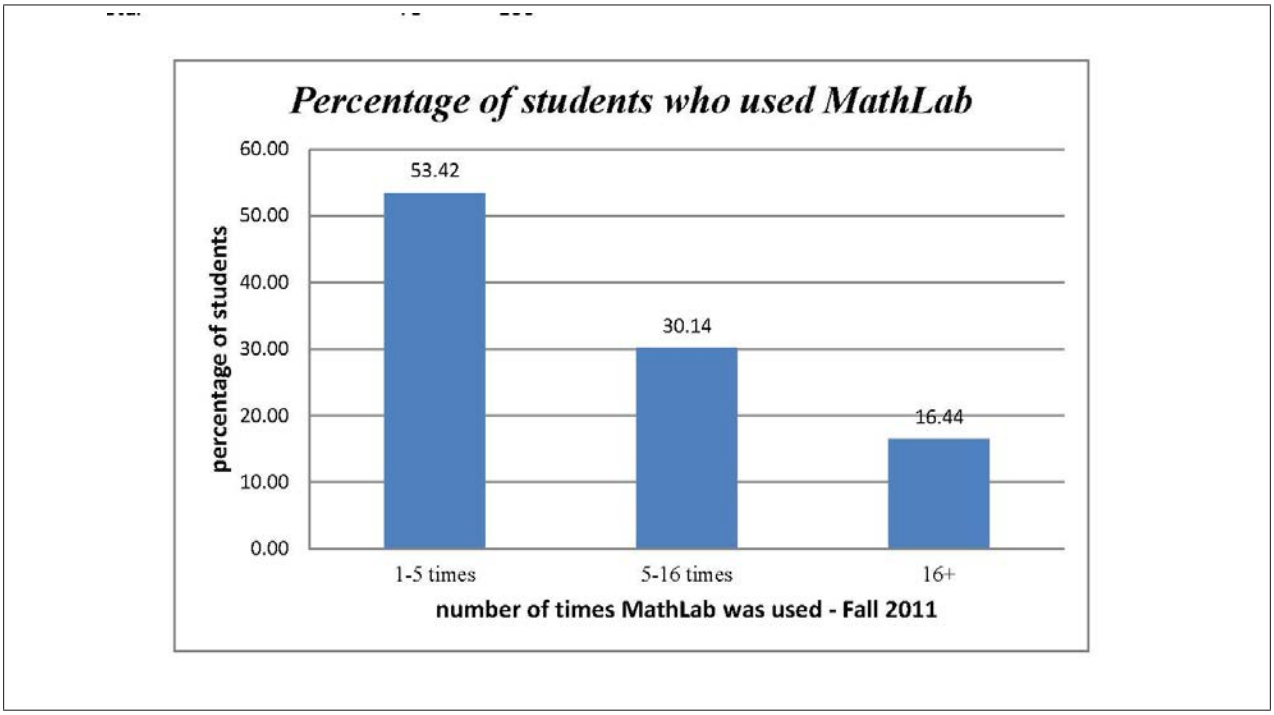

Figure 7. Percentage of students from various mathematics courses and number of times when MathLab was used during the Fall of 2011 academic year.

The student survey administered in Spring semester of 2011-2012 academic year showed that students were aware of the existence of mathematics tutoring services at UW-Stout: 86% of respondents knew about MathTLC and MathLab and about 52% of the students used at least one of the tutoring services on the regular bases. Additionally, 44% of students ranked the MathTLC as useful tutoring service and 46% of respondents found the MathLab to be useful as well. Figure 8 showed distribution ratings of usefulness of both mathematics tutoring services available at UW-Stout. Many respondents had found the MathTLC and the MathLab be useful and very useful.

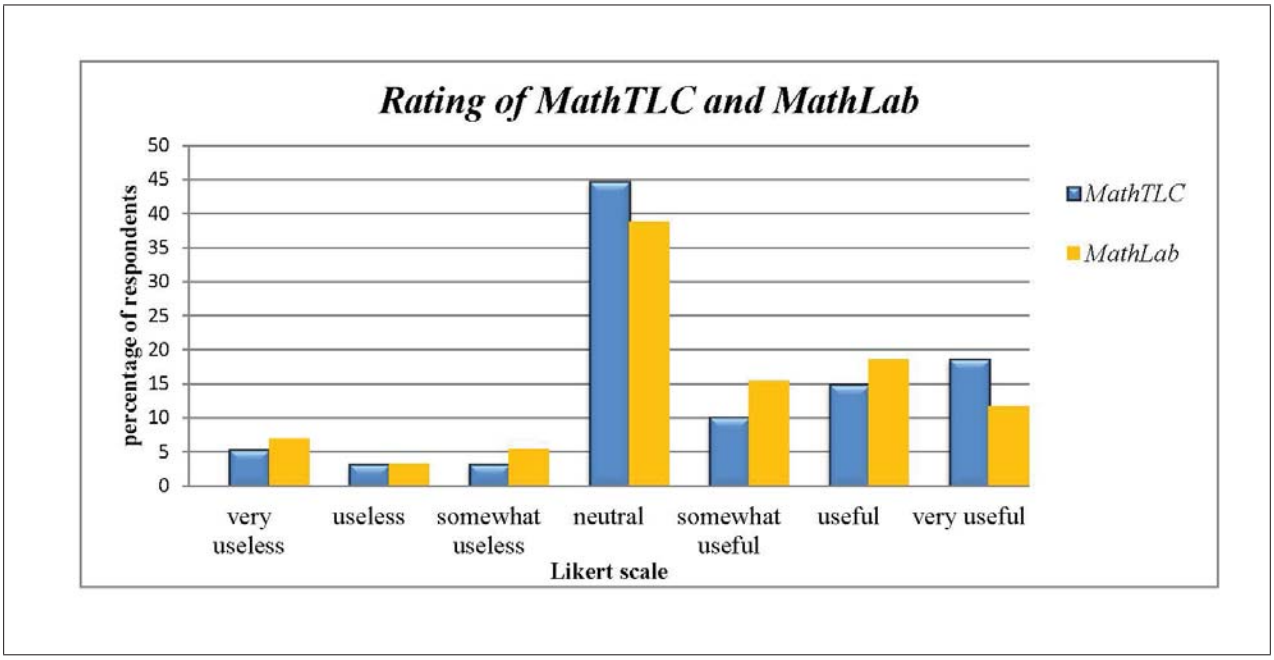

Figure 8. Ratings of MathTLC and MathLab using the seven-level Likert scale.

In the distribution ratings of usefulness of MathTLC and MathLab, the median value as well as first quartile were located at "neutral" on the seven-level Likert scale (see Appendix A). Additionally, third quartile was located at the "useful" level indicating that more than 25% of respondents found both tutoring services for mathematics courses at UW-Stout as "useful" and "very useful".

Detailed statistical analysis of two populations of students (those who have taken remedial mathematic courses and those who have not taken such courses) and relation of their grade point average (GPA) to the utilization of tutoring services were not possible to perform due to the insufficient student responses related to the grades in the remedial and non-remedial courses.

Research Objective 4: Investigate the success rate of the higher level mathematics courses in two populations of students: those who had taken and those who had not taken developmental or remedial mathematics courses.

At UW-Stout mathematics courses could be typically counted towards student's degree when learner successfully completed the course with the grade of C or higher on the standard grading scale. Additionally, grade point average (GPA) was suggested to be

maintained on the specific level depending on the program in which student was enrolled. Consequently the success rate of the higher level mathematics courses in two populations of students might be described by the grades obtained and GPA maintained by students in mathematics courses.

The student survey revealed that some students have taken basic, developmental or remedial courses, or the equivalent to those mathematics courses in educational institutions other than UW-Stout and enrolled in remedial mathematics courses at UW-Stout as well. Such information allowed further break down of the data and helped to identify more details in the objective. The following paragraphs give detailed description of the data for two populations of students, those who have not taken and those who have taken remedial mathematics courses, in each of the higher level mathematics courses.

It was determined that in Math-118 (Concepts of Mathematics) 88.2% of students who took remedial courses at UW-Stout obtained a grade of C and higher and all (100%) of students without any remedial math courses had a grade of C and higher in that course. However, the highest GPA (3.5) for students in Math-118 was in a group of learners who had taken developmental mathematics courses not only at Stout but also in some other educational institutions. The lowest GPA was noted in a group of respondents who had taken remedial mathematics courses at UW-Stout and were enrolled in Math-118. Further analysis using t-test indicated that GPA differ statistically significantly with the p-value of 0.038 for two populations: students who had not taken remedial mathematics courses and those who had taken those courses. Moreover, the chi-squared test showed that distribution of grades in two populations differ with $p < 0.001$.

The picture for the Math-120 (Introductory College Mathematics I) was different and about 86%-88% of students had a grade of C and higher regardless of developmental mathematics courses taken at UW-Stout or not. For those who had taken remedial courses at other institutions in addition to UW-Stout, the success rate was almost 100%. Students in Math-120 course who had never taken developmental mathematics courses had GPA of 2.78 which was slightly higher than the GPA of those who had taken some developmental

mathematics courses at UW-Stout or other institutions with the value of 2.33. According to the t-test results, GPA for non-remedial students was greater than GPA for remedial students with $p = 0.17$. The percentage of survey respondents who received a grade of C or higher in Math-118 and Math-120 courses was shown in Figure 9. It indicated three categories of respondents: those who had taken remedial mathematic courses in institutions other than UW-Stout, those who had taken remedial mathematics courses at UW-Stout, and those who had never taken remedial mathematics courses.

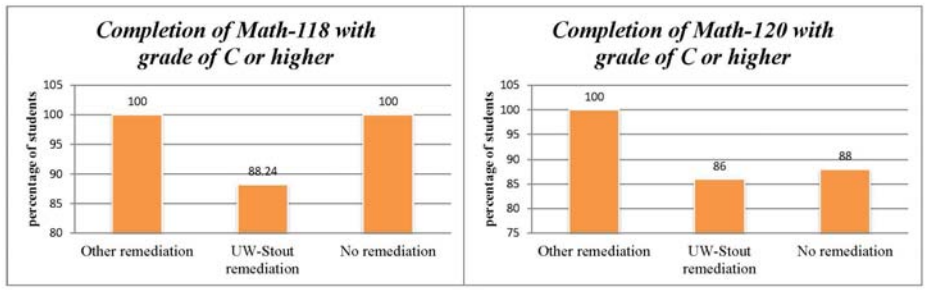

Figure 9. Percentage of student survey respondents who reported receiving grade of C or higher in Math-118 and Math-120.

In Math-121 (Introductory College Mathematics II) course, most of the students who had been previously enrolled in UW-Stout remedial courses completed the course with a grade of C (36%) and most of those without history of taking remedial courses completed the course with a grade of B (39%). However, a grade F for all groups of students, with and without remedial education, was relatively high and comprised of 12%-16% of all respondents. The GPA score for students without remedial history was higher than GPA score for students with any remedial history: at UW-Stout or other institution. The results of t-test showed some statistical evidence of GPA in the non-remedial group being grater then GPA in UW-Stout remedial group of students with $p = 0.14$. Nevertheless, chi-squared test indicated that the grade distributions in two populations of students differ with $p < 0.001$.

The data for the next course, Math-123 (Finite Mathematics with Applications),

showed that on average 24% of all respondents received a grade of C regardless of their engagement in developmental education. The range of GPA score for the students in this course was between 2.2 and 2.6, with the average GPA of 2.4, regardless of students engagement in developmental mathematics courses in or outside of UW-Stout.

The percentage of survey respondents who received a grade of C or higher in Math-121 and Math-123 courses was shown in Figure 10. It indicated three categories of respondents: those who had taken remedial mathematic courses in institutions other than UW-Stout, those who had taken remedial mathematics courses at UW-Stout, and those who had never taken remedial mathematics courses.

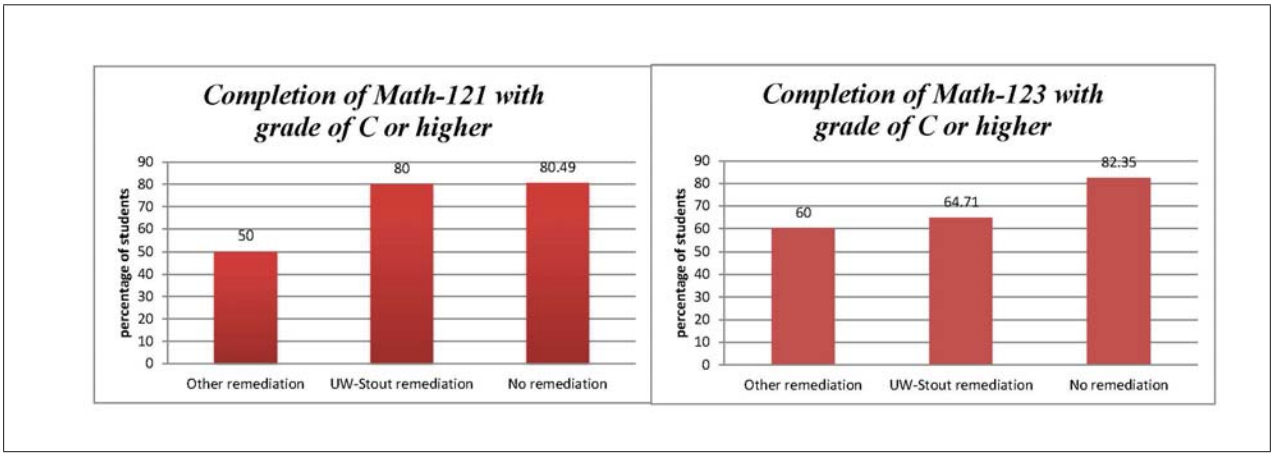

Figure 10. Percentage of student survey respondents who reported receiving grade of C or higher in Math-121 and Math-123.

Students completed Math-153 (Calculus I) course with a grade of C or higher in 100% of the cases either they had taken developmental mathematics course at UW-Stout or they had taken it in other institutions. However, students who were not previously enrolled in any remedial mathematics courses completed Math-153 with a grade of C or higher in 97% of cases. Additionally, there was a slight difference of 0.1 between GPAs for two populations of students: those who had taken developmental mathematics courses and those who had not taken them.

The Population of students who completed Math-154 (Calculus II) showed that 50% of students who had taken some remedial courses at UW-Stout received final course grade

of C and only 18.18% of students with grade of C had never taken remedial courses. The positive difference in GPA was toward the students without any remedial history and was equal to 0.48. Additionally, none of the students had received grades lower than grade of C in Math-154.

Further analysis using t-test showed no statistically significant differences between GPAs in both Math-153 and Math-154 with $p = 0.44$ and $p = 0.41$ correspondingly. None the less, the results of the χ^2 test for those courses indicated difference in distribution of grades with $p = 0.008$ for Math-153 course and $p < 0.01$ for Math-154 course. It needs to be noted that the populations of students who have taken Math-153 course with remedial mathematics courses and those who have taken Math-153 without any remedial courses yielded too few observations for high-quality statistical analysis.

The percentage of survey respondents who received a grade of C or higher in Math-153 and Math-154 courses was shown in Figure 11. It indicated three categories of respondents: those who had taken remedial mathematic courses in institutions other than UW-Stout, those who had taken remedial mathematics courses at UW-Stout, and those who had never taken remedial mathematics courses.

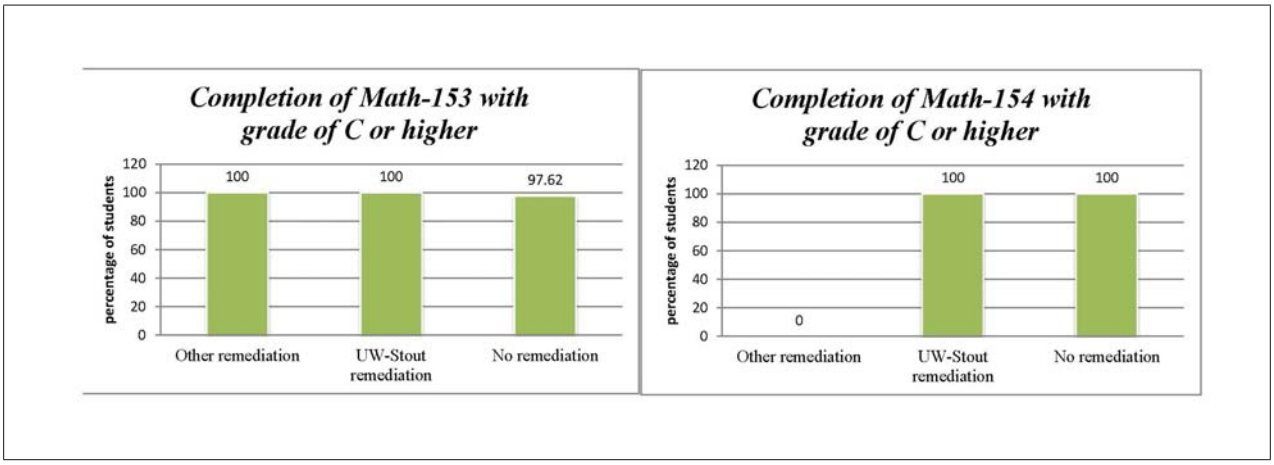

Figure 11. Percentage of student survey respondents who reported receiving grade of C or higher in Math-153 and Math-154.

The last two courses, Math-156 (Calculus and Analytic Geometry I) and Math-157 (Calculus and Analytic Geometry II), had a similar pattern indicating that only students

who had never taken developmental mathematics courses were enrolled and completed those courses with grade of C and higher. Grade point average for students in Math-156 and Math-157 was on average 2.8 with a highest value in Math-157.

The percentage of survey respondents who received a grade of C or higher in Math-156 and Math-157 courses was shown in Figure 12. It indicated three categories of respondents: those who had taken remedial mathematic courses in institutions other than UW-Stout, those who had taken remedial mathematics courses at UW-Stout, and those who had never taken remedial mathematics courses.

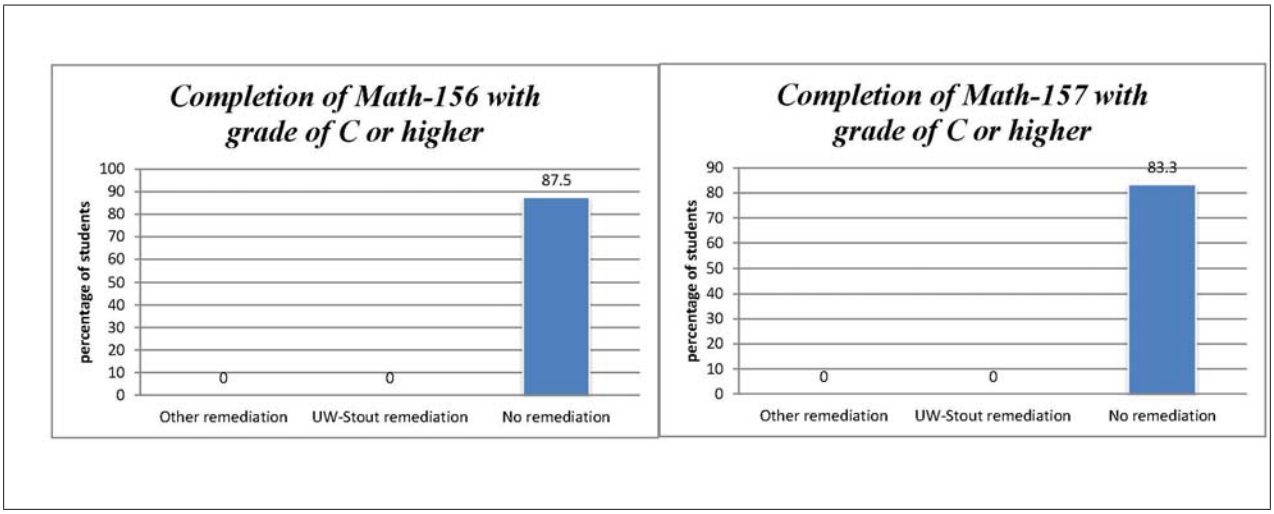

Figure 12. Percentage of student survey respondents who reported receiving grade of C or higher in Math-156 and Math-157.

One of the indicators describing the depth and breadth of students' mathematical knowledge at UW-Stout was how far students pursued the mathematics course sequence during their learning experience at the university. Although the sequence and level of higher level mathematics courses that students have taken at UW-Stout might be dictated by program requirements, explained by personal preferences, financial resources, or justified by any other reasons, such data could bring additional perspective to the study. Nevertheless it was worth to mention that population of students who have taken both remedial mathematics courses outside UW-Stout and at UW-Stout enrolled in the subsequent higher level mathematics courses up to Calculus I (Math-153). Data showed

that students who have taken remedial mathematic courses only at UW-Stout enrolled to the subsequent higher level mathematics courses up to Calculus II (Math-154). Additionally, all students who have history of taking developmental education in any educational institution (including UW-Stout) showed high level of completion with grade of C and higher in both courses, Calculus I and Calculus II.

The student survey included a self-evaluation piece to help students think critically and to evaluate their performance based on personal opinion, assumptions, and perceptions. When asked to do a self-evaluation of their performance in higher level mathematics courses (Math-118 and higher) students' responses distributed as follows:

- 24.18% of students who have taken remedial mathematics courses rated their performance as poor, bad, or very bad;
- 63.74% of students who have taken remedial mathematics courses rated their performance as fair, good, or very good;
- 15% of students who have not taken remedial mathematics courses described their performance as poor, bad, or very bad;
- 77.88% of students who have not taken remedial mathematics courses described their performance as fair, good, or very good.

Chapter V: Summary, Conclusions, and Recommendations

Mathematics skills were considered one of the important components of success in college and beyond. Unfortunately, many students entered academia underprepared to earn required grades in higher level mathematics courses and in many situations had to take remedial mathematics courses. The discussion in Chapter I and II about developmental education outlined the widespread nature and significance of that phenomena of American higher education.

The study aimed to identify the influence of the developmental mathematics courses on the successful completion of subsequent higher level mathematics courses considering a group of students at a rural branch of the University of Wisconsin. The data collection and analysis included information from the student survey administered during the Spring semester of 2011-2012 academic year. The data was supplemented by information obtained from reports and questionnaires from previous years provided by the MSCS Department and PARQ Office.

Chapter V–Summary, Conclusions, and Recommendations provided conclusive overview of the research findings. The summary contained key points of the study for each of the four research objectives and it followed by the overall conclusion for the research. The chapter was concluded with recommendations on sample selection, data collection and data analysis, and possible further research on the subject matter.

Summary

Research Objective 1: Investigate the percentage of students requiring remedial mathematics courses at UW-Stout. The study has shown that the enrollment in Math-010 (Beginning Algebra) course for the past seven years had a fluctuating pattern with a spike of enrollment in 2008-2009 academic year. The average annual enrollment in Math-010 was 157 students; this presented on average 1.9% of the student body population at UW-Stout for a period of seven years. The demand for the Math-110 (Intermediate Algebra) course was consistently high with average annual

enrollment of 471 students for the last seven years; this number presented on average 5.7% of the student body population for that time period. The enrollment in Math-110 increased with the growing population of students admitted to UW-Stout during the 2004-2011 academic years.

The recent data from the student survey administered in Spring semester of 2011-2012 academic year showed that about half of the participants have taken some kind of developmental mathematics courses at UW-Stout. Almost one quarter of the respondents admitted taking remedial mathematics courses not only at UW-Stout but in other educational institutions including technical colleges.

Research Objective 2: Investigate the completion rate of the mathematics remedial courses at UW-Stout. Analysis of various reports provided by PARQ Office for the period of Fall 2004-Spring 2011 had shown high completion rate in both Math-010 and Math-110. More specifically, on average 85% of students successfully completed Math-010 and 81.6% of students successfully completed Math-110 during the period of 2004-2011 academic years. On average, the completion rate for both courses in 2010-2011 academic year alone was 80%.

The student survey results had shown that 20% of students in Math-010 course completed it with a grade of B and 43% of students in Math-110 course completed it with a grade of A. Overall, the completion rates for both courses were on the high level with only a few students reporting failure/withdrawal (f/w) grades in Math-110. In particular, the average completion rate evaluated from the student survey responses for both courses, Math-010 and Math-110, was 63.75%.

Research Objective 3: Examine the influence of tutoring services on the students in the remedial and traditional mathematics courses. Both, Mathematics Teaching and Learning Center and Mathematics Tutor Lab, had a positive impact on both populations of students, one that included students who had not taken any remedial mathematics courses and another that included students who had taken at least one remedial mathematics course.

According to the results from the student survey administered by PARQ Office in December of 2011, almost half of the respondents indicated using MathLab regularly and about 55% of respondents expressed their intent to continue using tutoring services.

In addition, the student survey of Spring 2011-2012 academic year had shown that a majority of the respondents used at least one of the tutoring services on a regular basis. Furthermore, on average 45% of the respondents rated both tutoring services as "useful" and "very useful".

The findings of the study about the mathematics tutoring services supported some of the views presented at UW-Stout reports. Tutoring process has benefits for tutors and for tutees at the same time. Students gain more from learning with their peers and they learn more through direct communication at a level with which they are comfortable. The UW-Stout Student Enrollment/Retention/Graduation report indicated that tutoring services have had a positive impact on student academic success (UW-Stout, 2006). Such services helped learners to pass their courses and exams, as well as decreased the pressure from the upcoming exams (UW-Stout, 2006).

Research Objective 4: Investigate the success rate of the higher level mathematics courses in two populations of students: those who had taken and those who had not taken developmental or remedial mathematics courses. As it followed from the findings, both populations of students have shown a high level of success rates in subsequent higher level mathematics courses, Math-118 (Concepts of Mathematics), Math-120 (Introduction to College Mathematics I), Math-121 (Introduction to College Mathematics II), Math-123 (Finite Mathematics with Applications), Math-153 (Calculus I), Math-154 (Calculus II), Math-156 (Calculus and Analytic Geometry I), Math-157 (Calculus and Analytic Geometry II). In particular, the percentage of students who have taken remedial mathematics courses at UW-Stout and who received a grad of C or higher in subsequent higher level mathematics courses was on average 64.87%. Students in that population retained an average GPA of 2 with the highest average of 3.1 in Math-153 course. The percentage of students who have not taken remedial mathematics

courses at UW-Stout and who received grades of C and higher in higher level mathematics courses was on average 89.91% with the percentages raging from 80.5% to 100%. Students without any remedial history retained an average GPA of 2.9 with the highest average of 3.3 in Math-118.

Students who had taken remedial mathematics courses were able to enroll in the subsequent higher level mathematics courses up to Calculus I (Math-153) and Calculus II (Math-154). Those students had shown high level of performance and completion rates which, in some instances, were even better than for the population of students who had not taken remedial mathematics courses and were enrolled in Calculus I or Calculus II courses.

Conclusions

The major goal of the study was to investigate the influence of developmental mathematics courses on the successful completion of subsequent higher level mathematics courses. In accordance with this goal, four research objectives were stated and studied in depth. More specifically, research objectives covered the following aspects:

- percentage of students requiring developmental mathematics courses,
- completion rate of the mathematics remedial courses,
- influence of tutoring services,
- and success rate of the higher level mathematics courses in two populations of students: those who had taken and those who had not taken developmental or remedial mathematics courses.

On a broad scope, there were about 2% of the UW-Stout student population who required remedial mathematics courses at UW-Stout in 2011-2012 academic year. A closer look at the student survey administered during the Spring semester of 2011-2012 academic year revealed that almost half of the participants had taken at least one remedial mathematics course at UW-Stout, and almost a quarter of the respondents had taken remedial mathematics courses at other educational institutions.

Results of the completion rate analysis have shown high level of completion rates for students in all subsequent higher level mathematics courses. Additionally, both mathematics tutoring services available at UW-Stout had shown to be a valuable assets in students academic life. MathTLC had shown great success as a result of accessible and convenient tutor lab and tutors who are trained for Math-010 and Math-110. MathLab had shown its importance and usefulness for students in remedial and higher level mathematics courses as a result of knowledgeable tutors and professors and number of tutors available at the tutoring service daily. More importantly, study revealed high success rate in the subsequent higher level mathematics courses in both populations of students: those who had taken and those who had not taken developmental or remedial mathematics courses.

As a main conclusion of the study, it was important to indicate that remedial mathematics courses have a positive influence on the short-term and overall student academic success. The availability of developmental mathematics courses at UW-Stout has proven their significance and importance by the fact that students with remedial history were able to enroll and successfully complete such high level mathematics courses as Calculus I and Calculus II. Students in those courses had maintained high GPA which on average was 3.0. Furthermore, factors like mathematics tutoring services that were well-organized and recognized as very useful by students, high level of students' confidence in themselves being able to perform good or very good in higher level mathematics courses added significance to the study and helped to deduce the positive effect of remedial mathematics courses on the students' success in the subsequent higher level mathematics courses.

The results of the study contained valuable information to students, faculty, and other stakeholders about remedial education. The research has found positive influence of developmental education on students' academic success which might help students in making decisions about courses, programs, and career choices. The results of this study might help to eliminate the negative stereotype about remedial education, and might encourage students to pursue subsequent higher level mathematics courses, and inspire

them to pursue a predominantly male careers associated with mathematics. Faculty might be influenced by the research results and might view students who completed any of the remedial mathematics courses as hard workers who were firmly set on their career pathway. For stakeholders, data analysis and results would bring different perspective of the significance of remedial education and would impact the decision about distribution of state or federal funding related to the developmental mathematics course.

Limitations

The study has encountered the following limitations:

1. The results of study were limited to the students at UW-Stout.

2. UW-Stout is considered to be a rural branch of the University of Wisconsin system, hence the results may not be generalizable to a population of students in an urban setting.

3. UW-Stout is considered to be a university with a predominantly white student population, hence the results may not be generalizable to a more diverse student population.

4. Data collection and analysis was limited to only one semester and consequently the factor of time constraints was present in the research.

5. The results of the study were not generalizable to the student population of the entire state of Wisconsin or the United States.

Recommendations

The study was limited to one university and to a number of students enrolled in specific mathematics courses. Consequently, for the purpose of giving detailed explanations and getting statistically significant results it was recommended to include in study all population of students enrolled in any mathematics courses at the university.

Additionally, since the constraint of time was a factor of the study, it was recommended to administer student survey at least twice per academic year. Data relative to the time that passed before students enrolled in subsequent higher level mathematics courses after completing remedial mathematics course(s) and data relative to the period of

time that was needed for students in order to finish all of the mathematics courses (including remedial courses) required in the program was recommended to include in future research on the subject matter. Ideally, a longitudinal study of one cohort of students would be more beneficial and would reveal more details about the influence of remedial mathematics courses not only on the successful completion of subsequent higher level mathematics courses but also would provide more information about influence of developmental mathematics courses on the retention and graduation rates.

Additional resources would bring new aspects to the depth of the study. Resources like placement test results would show the percentage of students assigned to a specific course (remedial or non-remedial) and would add information about students who were required to take developmental mathematics courses. Interviews with students from various mathematics courses (remedial and non-remedial) was recommended as an optional research methodology that would help find answers to the questions related to the instructor's teaching methods, class atmosphere, after-class activities that enhanced course materials and encouraged learners to complete the mathematics course(s).

Further research was recommended to investigate the influence of developmental mathematics courses on the successful completion of subsequent higher level mathematics courses. In accordance with the discussion in Chapter I and Chapter II of the study, as well as research results presented in Chapter IV, underprepared students as well as remedial education in general were a national concern. For centuries, higher education institutions were finding large numbers of freshman students who were not prepared for college-level mathematics courses. Rationales for studying the issues related to underprepared students in mathematics were common on all levels: local, state, or national. One reason was that remedial education has imposed its high costs on the students, institutions of higher education, and ultimately on taxpayers. Another reason was that developmental mathematics courses take time to complete even though they did not count towards a student's degree. Thirdly, factors like increased enrollment in higher education institutions, higher competition in the job market, and level of preparation in mathematics at a high

school level all impacted the remedial education. The amount of factors, the level and the scope of their significance, and number of people that were impacted by them all were in favor of continuing the research on the connection between developmental mathematics courses and subsequent higher level mathematics courses at institutions of higher education.

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Appendix A: Student Survey Questions

This research has been reviewed by the UW-Stout IRB as required by the Code of Federal Regulations Title 45 Part 46.

1. What is your gender?

- Male
- Female

2. Please indicate your age group:

- No answer
- 18-22
- 23-27
- 28-32
- 33-37
- 38-42
- Over 42

3. What is your major? (text box)

4. Have you ever taken basic or developmental or remedial math courses at a school other than UW-Stout:

- Yes (indicate school name and course title in the box);
- No

5. Have you ever taken Math-010 (Beginning Algebra) or Math-110 (Intermediate Algebra) courses at UW-Stout?

- Only Math-010
- Only Math-110
- Both Math-010 and Math-110
- None of the two

6. If you had taken Math-010 (Beginning Algebra) at UW-Stout what was your class grade:

Dropdown menu:

No answer; A;B;C; D;F; W; Incomplete;

7. If you had taken Math-110 (Intermediate Algebra) at UW-Stout what was your class grade:

Dropdown menu:

No answer; A;B;C; D;F; W; Incomplete;

8. What math courses you have been enrolled in at UW-Stout:

- Math-118 (Concepts of Mathematics),
- Math-120 (Intro to College Math I),
- Math -121 (Intro to College Math II),
- Math-123 (Finite Math with Applications),
- Math -153 (Calculus I),
- Math-154 (Calculus II),
- Math-156 (Calculus and Analytic Geometry I),
- Math-157 (Calculus and Analytic Geometry II) (multiple answers possible)

Drop-down list next to each course title:

- No answer
- Did not take
- Taken, got a grade of A
- Taken, got a grade of B
- Taken, got a grade of C
- Taken, got a grade of D
- Taken, got a grade of F
- Taken, but dropped (grade of W/WS/WU)
- Taken, got grade of I (incomplete)
- Currently enrolled

Math-118 drop-down

Math-120 drop-down

Etc.

9. What is your opinion of your performance in college mathematics courses (Math-118/120/121/123/153/154/156/157)?

My performance is...

- Very bad
- Bad
- Poor
- Neither good nor bad
- Fair
- Good
- Very good

10. Which of the following math tutoring services at UW-Stout do you **know** about?

- MathTLC (JHSW 203)
- MathLab (JHSW 236)
- Both MathTLC and MathLab
- None

11. Which of the following math tutoring services at UW-Stout did you **use**?

- MathTLC (JHSW 203)
- MathLab (JHSW 236)
- Both MathTLC and MathLab
- None

12. Rate the usefulness of MathTLC tutoring services:

- Very useless
- Useless
- Somewhat useless
- Neutral
- Somewhat useful
- Useful
- Very useful

13. Rate the usefulness of MathLab tutoring services:

- Very useless
- Useless
- Somewhat useless
- Neutral
- Somewhat useful
- Useful
- Very useful