FACTORS THAT INFLUENCE STUDENTS' PERFORMANCE
IN INTERMEDIATE ALGEBRA CLASSES
AT THE COLLEGE
A Longitudinal Research Study

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Abstract

The purpose of this study is to identify factors that influence students' performance in the intermediate algebra classes at the college by analyzing parameters such as test scores, grades, attitude towards mathematics, time lapse between subsequent courses, placement, and teaching practices. This study will investigate the correlation of several selected variables with performance and compare these results with those found in the literature. Based on the findings, specific solutions for areas needing improvement will be prescribed, and recommendations to improve student performance in intermediate algebra classes at the college will be presented.

The study took place at Richard J. Daley College, in Chicago, IL, and targeted the Intermediate Algebra (Math 112) student population. Data were collected during the fall 2003, spring 2004, fall 2004, and spring 2005, semesters. The results indicate that proper placement and positive attitude of students contribute to improved performance while extended time lapse between subsequent courses hampers their performance. Moreover, an innovative teaching approach, the Keystone method, produced higher student outcomes in intermediate algebra and also in subsequent mathematics courses compared to the traditional approaches.

Introduction

Poor performance and lack of basic mathematical skills of students who start their mathematics study in developmental classes in colleges across the nation has long been a well known fact (Loveless, 2003; Mathematics Education Dialogues, 1999) and has contributed to a vast and growing demand for remedial mathematics education in colleges and universities in the country (U.S. Department of Education, 2008). Moreover, the job market is affected tremendously by the lack of basic skills of the potential employees, the recent graduates (Business Wire, 2000). Numerous studies have been conducted to treat this complex problem by analyzing factors such as assessment results, test scores, attitude towards mathematics, gender, placement, and teaching practices among other factors, and their correlation with performance.

The primary purpose of the research study presented in this paper is to determine some of the factors that influence students' performance in intermediate algebra classes at the college and to recommend follow-up actions to improve teaching and learning. The study will examine possible correlation between performance and factors such as final exam scores, attitude towards mathematics, placement test scores, time lapse between subsequent courses and teaching practices. In every case, the factors studied are measured appropriately and the results are compared with students' grades.

Results on attitude and placement will provide inputs to examine the retention and withdrawal rates for the intermediate algebra sections. Final exam score results will provide a clear spectrum of how the overall performance of the students is distributed during the period of study from fall 2003 to spring 2005. Time lapse between sequential classes is an issue that has not been analyzed in other studies, and it seems to be a factor in the low performance of non-traditional students. When discussing teaching practices, an innovative, assessment-based and learner-centered approach, the Keystone method, was chosen as a teaching technique in the experimental sections. The learner outcomes in the Keystone classes are then compared with those found in the traditional classes.

This study may provide helpful data to several initiatives taken by the City Colleges of Chicago (CCC) in recent years aimed at improving student performance and retention in mathematics courses. The district started taking actions to improve the educational system across all campuses by developing a major project involving the Chicago Public Schools, local universities, CCC faculty and administrators. In 2004, CCC began a reform of its mathematics curriculum in conjunction with the Chicago Public Schools in order to align the corresponding curriculums and reduce considerable remedial instruction in the future.

A work in progress in this direction is the revision and re-structuring of student learning outcomes for the remedial classes. In particular, in the intermediate algebra classes the learning outcomes have been classified in two categories: instrumental skills (lower level cognition) and relational skills (higher level cognition). These categories measure the cognitive knowledge of the students in the corresponding branches. To measure the actual cognitive knowledge of the students at CCC an instrumental- relational skill test was given at five of the seven colleges. In this diagnostic test it was found that the relational items are more difficult for most CCC students compared with the instrumental ones (McCoy, 2005). Daley college students, however, taught under the Keystone methodology, outperformed the other campuses in the district by attaining the highest mean and median scores and the lowest standard deviation on this test (McCoy, 2005). The CCC district office has also performed studies about transition and retention from pre-credit and remedial mathematics courses to college level mathematics courses (Office of Research and Evaluation, 2005). For the period between spring 2002 and fall 2004 at Daley College, it was found that 42% of the students successfully transitioned from pre-credit or remedial math courses to college level math courses earning a C grade or better.

Review of the Literature

Attitude Towards Mathematics

Several studies in the past 30 years have explored the relation between attitude towards mathematics (ATM) and achievement in mathematics (AIM). Most studies show a positive correlation between these two factors, but some indicate the need for more data to support that claim. Neale (1969) defined ATM as "a liking or disliking of mathematics, a tendency to engage in or avoid mathematical activities, a belief that one is good or bad at mathematics, and a belief that mathematics is either useful or useless." As Suydam and Weaver (1975) point out, teachers and other mathematics educators often assume a strong relation between ATM and AIM, believing that students perform better in mathematics when they like mathematics, and therefore "continual attention should be directed towards creating, developing, maintaining and reinforcing positive attitudes." Some researchers have found only a weak correlation (around 0.20) between ATM and AIM (Abrego, 1966; Deighan, 1971; Robinson, 1975). But other studies point to the opposite conclusion. Enemark and Wise (1981) showed that "the attitudinal variables are significant indicators of math achievement" and "a few of the attitudinal variables also showed strong relationships with math achievement even after background and academic orientation variables are controlled." Steinkamp (1982) showed that among several variables determining AIM, ATM was the most important. The correlations found by these studies are above 0.40, and are supported by the findings of other researchers (Kloosterman, 1991; Minato, 1983). Studies conducted at our college in the summer of 2003 also support a strong relationship between ATM and AIM: 24% of the students with negative ATM in pre-credit math (Math 100) and 36% of the students with negative ATM in college credit math (Math135) passed their classes (Internal Report of the Mathematics Department, 2003).

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Placement Tests

A number of studies have shown that placing students in the appropriate mathematics level is a very important factor for retention and performance. Community colleges across the nation use standardized tests such as ACT and SAT to assess the student's math skills at entry. However, some researchers doubt that standardized tests or placement tests alone are enough to determine student entry level. Studies conducted by Bridgeman and Wendler (1989) showed a very weak correlation between SAT scores and grades obtained by freshman students from ten different colleges. Odell and Schumacher (1995) found that the SAT test combined with a placement test produces a better correlation.

Two driving forces have emerged to deal with the math placement test issue, the first one supported by those who are against testing. It is reflected in the study conducted by Glaser and Silver (1994), where placement tests are defined as "attempts to measure human abilities prior to a course of instruction so that individuals can be appropriately placed, diagnosed, certified, included or excluded." The authors believe that placement tests may be used as a medium to inhibit people from obtaining a higher education by becoming an obstacle to their goals. Kingan and Alfred (1994) argue that assigning people to ability groups, commonly known as "tracking," may increase inequities rather that reduce them. In addition, students in remedial classes may feel underestimated with respect to their peers, something that can lead them to withdrawal. Oakes et al. (1992) found that students in the low-track usually receive less instruction, less homework, and more routine skill activities than high-thinking activities compared with those who are in the high-tracks. This is in light of the fact that support services are available to all students.

The second driving force, supported by those who are in favor of testing in conjunction with other measures to place students, is reflected in the studies conducted by Morante (1989) and Truman (1992) who maintain that placement tests must be aligned with curriculum content to improve

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predictability. Bridgeman and Wendler (1991) state that many other factors must be considered when placing students besides non-cognitive or psychosocial factors. Ting and Robinson (1998) consider factors such as self-confidence, commitment, attendance, gender, ethnic background, age, teacher's attitudes, and mode of instruction, among others, as important variables of study.

Time Lapse Between Courses

The relation between time lapse between subsequent mathematics courses and performance is another subject considered in this study. There is no known literature on this subject, but as the study will show, it may be an important variable in determining students' performance. In our study we focus on the time lapse between completion of elementary algebra classes (Math 110) and enrollment in intermediate algebra classes (Math 112).

Test Scores and Grades

Studies have shown that test score results and grades should be correlated if they are to measure accurately a student's proficiency in a subject (Guskey, 1994). Conley (2000) found a direct correlation between average score and letter grade: higher grades imply higher proficiency scores. However, Ornstein (1994) states that more specifications and analysis are involved in the grading process so it's likely that subjectivity will bias the results. Conley (2000) found a lack of correlation between teacher grading systems and student proficiency scores. In the new era of assessment practices, teachers are still in the learning state of integrating those practices with the traditional grading system (Seeley, 1994). In addition, grade inflation has been an issue in many educational institutions where test scores and grades are far apart (Gose, 1997; Ziomek & Svec, 1995). Conley (2000) showed in his study that grade inflation is a real problem; he found that among the students that earned A's in high school, a considerable number did not satisfy the minimum criteria score for college admission.

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Teaching Practice (Keystone Method)

Remedial mathematics education is a major problem in U.S colleges and universities. The "Keystone method" was designed to address the needs of students enrolled in remedial/developmental mathematics courses by targeting the factors that inhibit student learning such as short attention span, inadequate attention to assigned homework, short time horizons, poor attendance and low self-esteem, among others (Siadat, et al., 1997, 2000, 2001). In this method the students' learning are assessed daily by homework-based, time- restricted quizzes. Research has shown that frequent testing has important educational benefits for the learner since it encourages regular study habits and reduces test anxiety (Dempster, 1992; Mawhinney, et al., 1971). The quizzes are cumulative and cover the material from the beginning of the course. Research has also shown the cumulative testing consolidates student learning (Dempster, 1992). Immediate feedback and re-teaching techniques are used until students achieve mastery. In addition, peer tutoring and cooperative group activity are used when the standard deviation of tests scores exceed 25%. Studies have shown that this practice produces positive results not only on student performance in remedial classes but also on persistence of students to enroll in other mathematics classes or classes of other disciplines at the college (Siadat, Musial & Sagher, 2008). In this study we applied the Keystone method in the experimental classes and compared the student outcomes to those in the traditional classes.

Research Design

This study was conducted at Richard J. Daley College and targeted the intermediate algebra student population. Data were collected during the fall 2003, spring 2004, fall 2004, and spring 2005 semesters. A typical student in these classes satisfied one of the following conditions: passed elementary algebra (Math 110), took the placement test, transferred from another institution, or

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received the consent of math chairperson. Very few students transferred from another institution or got the approval of the department chair. Therefore the bulk of students who enrolled in intermediate algebra classes either passed the pre-requisite elementary algebra course, or were placed into intermediate algebra by the Compass placement test. In addition, all students were randomly assigned to these classes. In this report the student and instructor identities as well as their respective classes were kept confidential. All sections in a single semester were grouped into experimental or traditional categories, for research purposes.

The parameters considered in the study were attitudes towards mathematics (positive, neutral, and negative) with scale 1, 0 and -1 respectively; grades (A-D, and F) with scale 4, 3, 2, 1, and 0 respectively; final exam scores with scale (0-50); Compass scores with scale (0-100); time lapse between taking elementary and intermediate algebra courses, with scale (0-8); and teaching practices, Keystone and none-Keystone (traditional) methods. Parameters to be compared were: Attitudes towards mathematics and grades; placement test & grades; time lapse between subsequent courses and success rates; final exam scores and grades; Keystone, non-Keystone classes & general performance.

To have a clear comparison of the parameters involved, two approaches were applied, the first one using graphical representation of the results in the form of charts. The second approach was performing statistical analysis to calculate the correlations between the corresponding parameters, presented in tables.

To obtain the corresponding data, it was necessary to involve the Office of Research and Evaluation of our district office. This office provided electronic files about grades and placement for the intermediate algebra (Math 112) sections, grades for the elementary algebra (Math 110) sections, and grades for subsequent college credit math courses (Math 118, 125 and 140). The Admissions Office at the college provided paper data about grades of the intermediate algebra sections and grades for subsequent math classes for the spring semester 2005. The Mathematics Department provided

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paper data about the final exam scores and the attitude surveys. All data collected were analyzed

through Excel and data management programming, and statistical theory (Freedman, et al., 1998).

Findings

This section presents the analysis of the data collected and summary of the results obtained along the

period of study, 2003-2005.

Attitude Towards Mathematics

Student survey questionnaires were distributed during the fall 2003, spring 2004, fall 2004, and

spring 2005 semesters. A total, N = 816, of student responses were collected. The survey question

was the attitude of students towards mathematics. The responses were categorical and comprised

positive, negative or neutral answers. Figure 1 below shows that 55% of the total student population

surveyed had a positive attitude towards math (ATM), 35% had a neutral ATM, and 10% had a
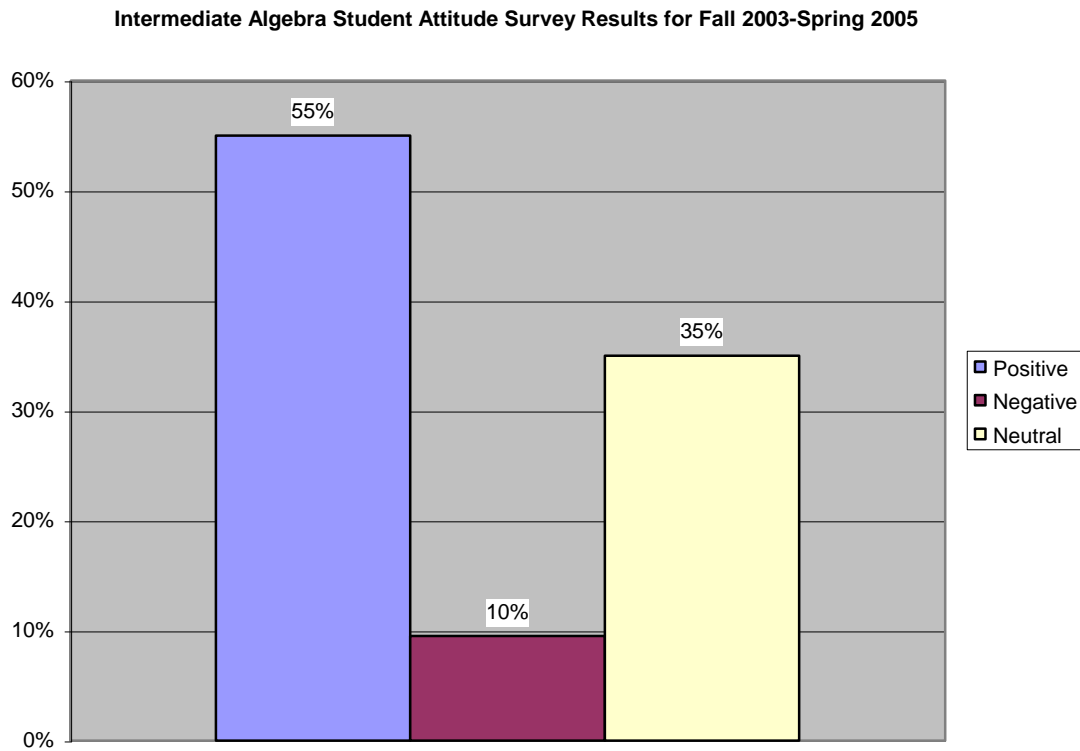
negative ATM.

Intermediate Algebra Student Attitude Survey Results for Fall 2003-Spring 2005

Figure 1

Figure 2 illustrates how negative attitude and performance are related. Only 29.4% of the students with negative attitude succeeded in their classes with a grade of C or better. The graph also shows that almost 35.9% of the students with negative attitude withdrew from their classes.

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Negative Attitude and Performance for
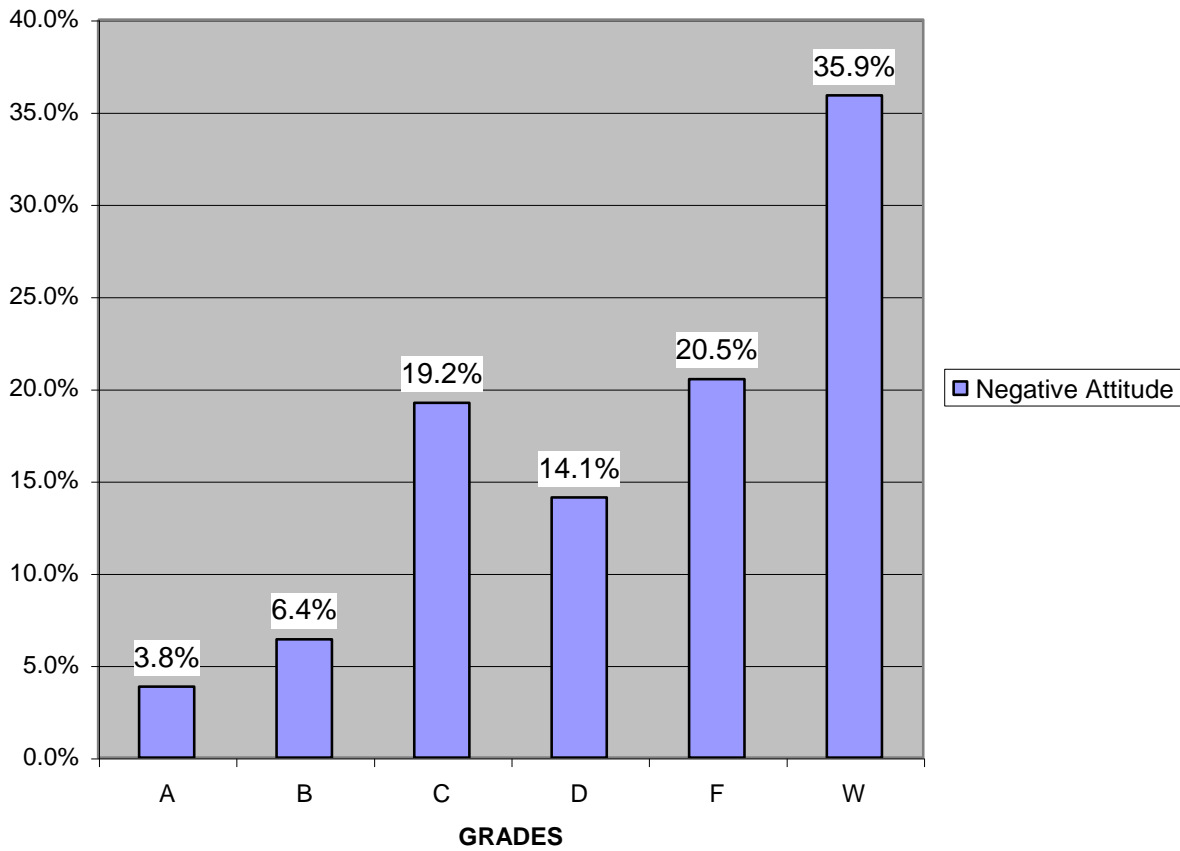**Fall 2003-Spring 2005**

Figure 2

The survey results presented in Figure 3 reveal how positive attitude and performance are related. Of the students with a positive attitude, 46.7% succeeded in their classes with a grade of C or better. The graph also shows that almost 21.1% of the students with a positive attitude withdrew from their classes. Comparing Figures 2 and 3, it can be observed that there is an increase of 17.3% in passing rates and 14.8% decrease in withdrawal rates between students with a positive attitude and students with a negative attitude towards mathematics.

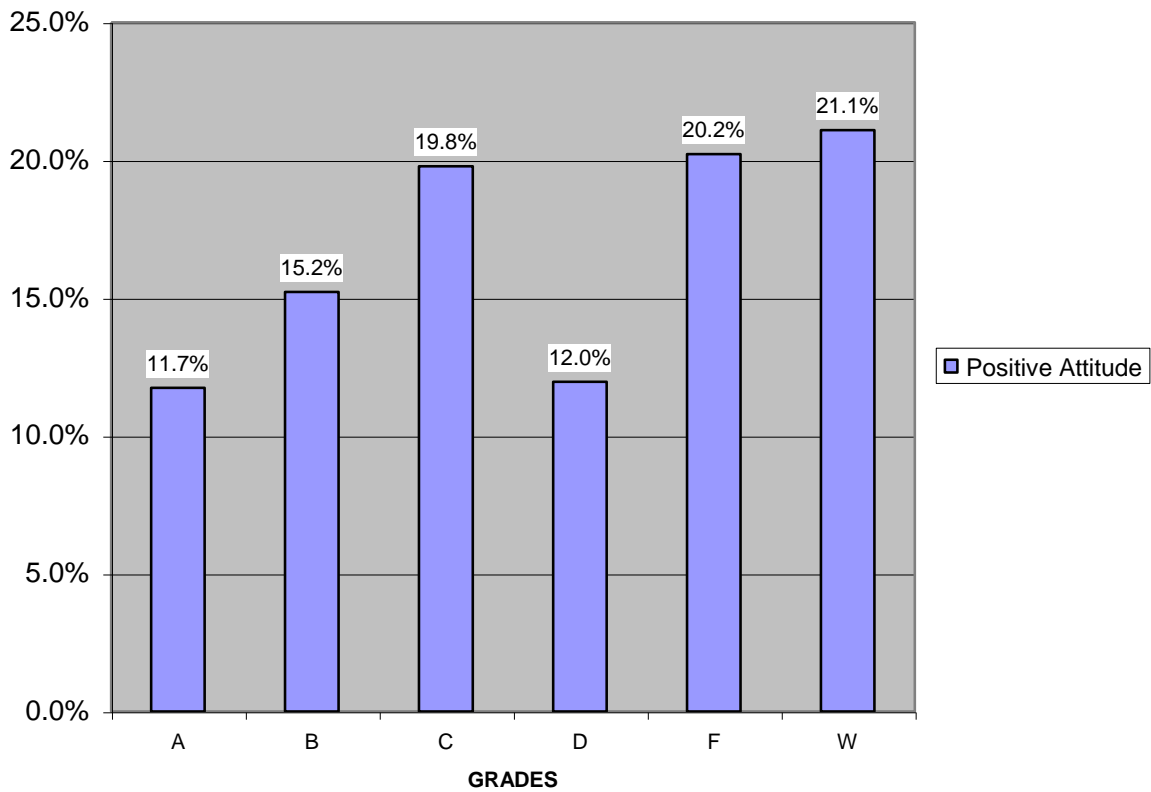**Positive Attitude and Performance for
Fall 2003-Spring 2005**

Figure 3

Table 1 summarizes the frequencies of the grades with respect to the different ATM's. As is seen there was a positive, but weak correlation, $r = 0.14$, between ATM and grades. This is in line with the other findings in the literature and simply states that ATM is a factor among others (ability, effort, teaching, etc.) which influence students' performance.

Correlation Between ATM and Grades

ATM	Grades	Frequency	Correlation Coefficient
Positive	A	54	
	B	70	
	C	91	
	D	55	
	F	93	
	W	97	
Neutral	A	10	
	B	35	
	C	61	r = 0.14
	D	27	
	F	68	
	W	80	
Negative	A	3	
	B	5	
	C	13	
	D	11	
	F	16	
	W	27	
	Total	816	

Table 1

Placement

Figure 4 below displays the performance of (N= 457) intermediate algebra students who were

enrolled in the course through the Compass test from fall 2003 to spring 2005. This group comprised

all students who had scored at least 29 points on the Compass test. The data was obtained from the

Office of Research and Evaluation (2005).

Compass Test Results and Grades for Fall 2003- Spring 2005
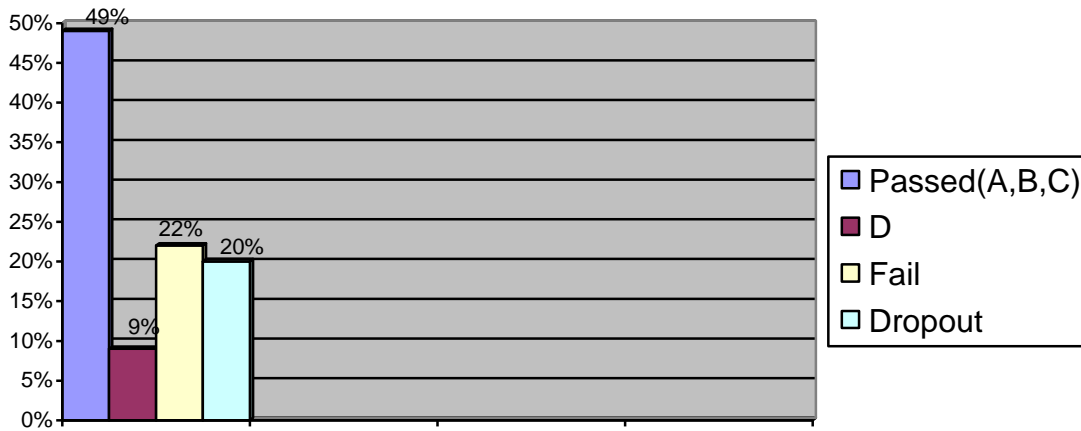

Figure 4

As the chart clearly shows, of the 457 students who were placed in intermediate algebra classes through Compass, 20% dropped the course, with another 31% not earning a passing grade. Thus, 51% of students failed to perform successfully - too high a percentage of student potential to disregard. Additionally, Table 2 below displays a weak correlation, $r = 0.16$, between placement test scores and grades indicating that strong/weak placement scores do not necessarily translate into strong/weak course grades.

Correlation Between Placement Test Scores and Grades

Grades	Frequency	Correlation Coefficient
A	67	
B	91	
C	66	r = 0.16
D	42	
F	101	
W	90	
Total	457	

Table 2

Time Lapse Between Courses

The time lapse between taking elementary algebra (Math 110) and intermediate algebra (Math 112) was measured by semesters. The smallest gap was zero semester between the courses and the biggest gap considered was eight semesters. Figure 5 below presents the gap in semesters and shows the percentages of students (N = 747) failing or dropping their classes for each semester. The data was obtained from the Office of Research and Evaluations (2005).
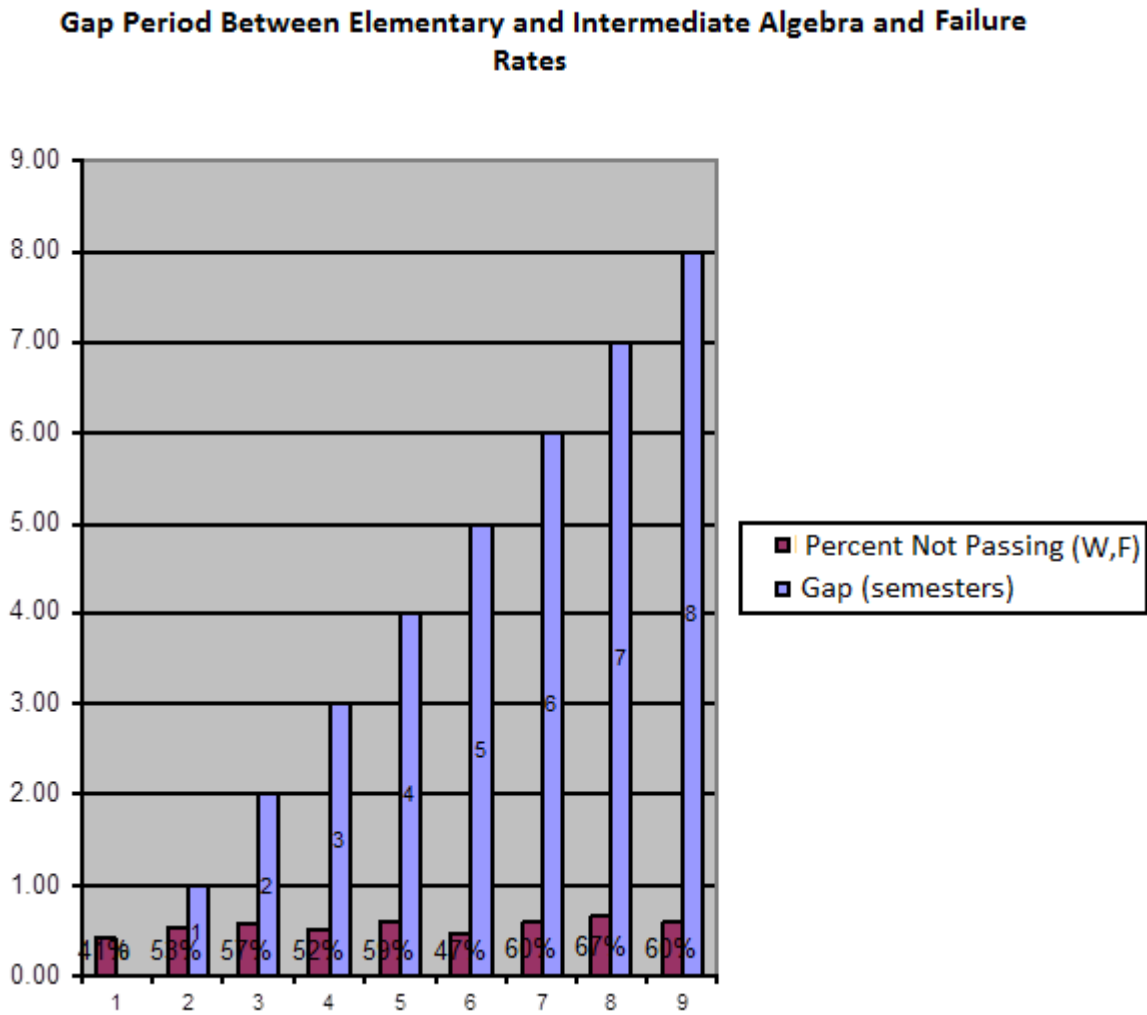

Figure 5

Figure 5 clearly delineates the inverse relation between the time lapse, in semesters, and performance of students in intermediate algebra classes. As is seen, with a few exceptions, the longer the waiting gap, the smaller is the likelihood of success.

To find the correlation between semester gaps and the course grades, the sample size was reduced to N = 526 students to exclude those students who didn't get a grade in the course (students who dropped their classes). Table 3 supports the observations made in Figure 5; it reveals a rather strong negative correlation, r = -0.52, between average course grades and semester gaps.

Correlation Between Average Course Grades and Semester Gaps

Gap	Average	Correlation Coefficient
0	1.33121	
1	1.06154	
2	0.89109	
3	1.09091	
4	0.84615	r = - 0.52
5	1.18750	
6	1.13333	
7	0.88889	
8	0.80000	
Population	526	

Table 3

Test Scores and Grades

Next we display the results found on the final exam scores of students during the study. This exam was departmental, common to all sections, and consisted of 50 questions, two points each, for a total 100 points. There were a total of N = 681 students who took this exam. Figure 6 below shows that the

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overall average on the final exam was 58.8%. The best final score, 61%, was obtained during the last semester of study.

Intermediate Algebra Final Exam Results for Fall 2003-Spring 2005
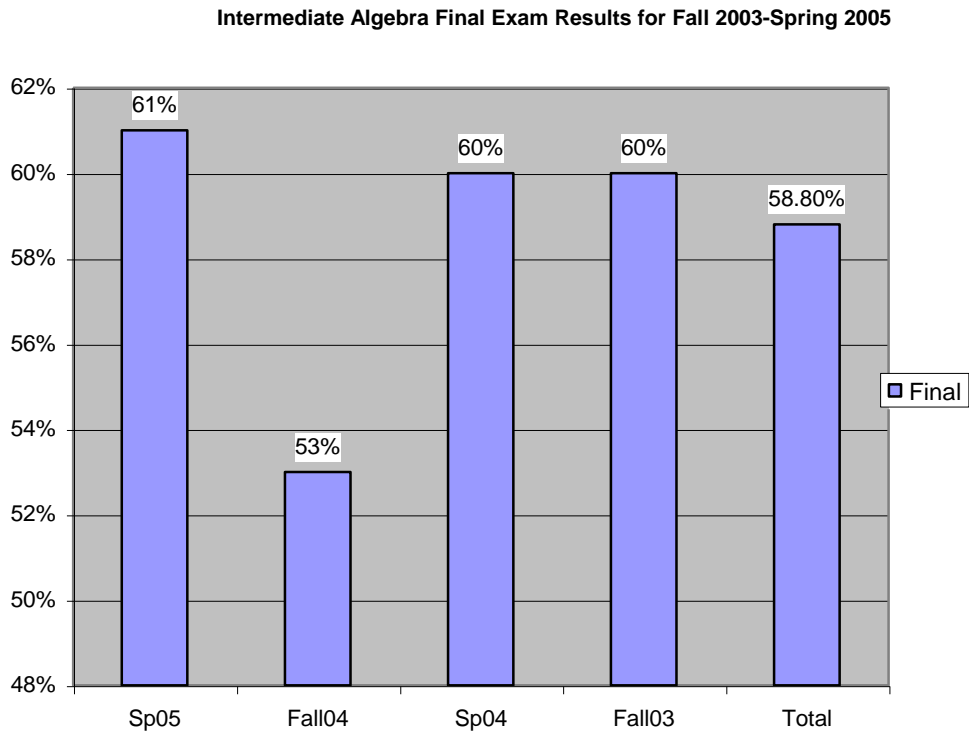

Figure 6

In Table 4, frequencies of grades and also correlation of grades with students' final exam scores are presented. A strong correlation, $r = 0.76$, found between final scores and course grades, implies that students who performed well on the final exam also performed well in the course.

Correlation Between Final Exam Scores and Course Grades

Grades	Frequency	Correlation Coefficient
A	78	
B	151	
C	213	$r = 0.76$
D	128	
F	111	
Total	681	

Table 4

Teaching Practices

We now present the results of the sections called "Traditional Intermediate Algebra Classes." These are the sections that did not implement the "Keystone approach." The sections that belong to this category were evaluated based on midterm and final exams. However, some instructors considered homework, quizzes or additional tests as part of the students' grades. The frequency of the extra assignments and the methodology used to teach these classes were unknown. The total student population for this category who took the final exam was $N = 397$ students. Figure 7 below shows that the overall average for the common final exam was 55% during the two years of collecting data.
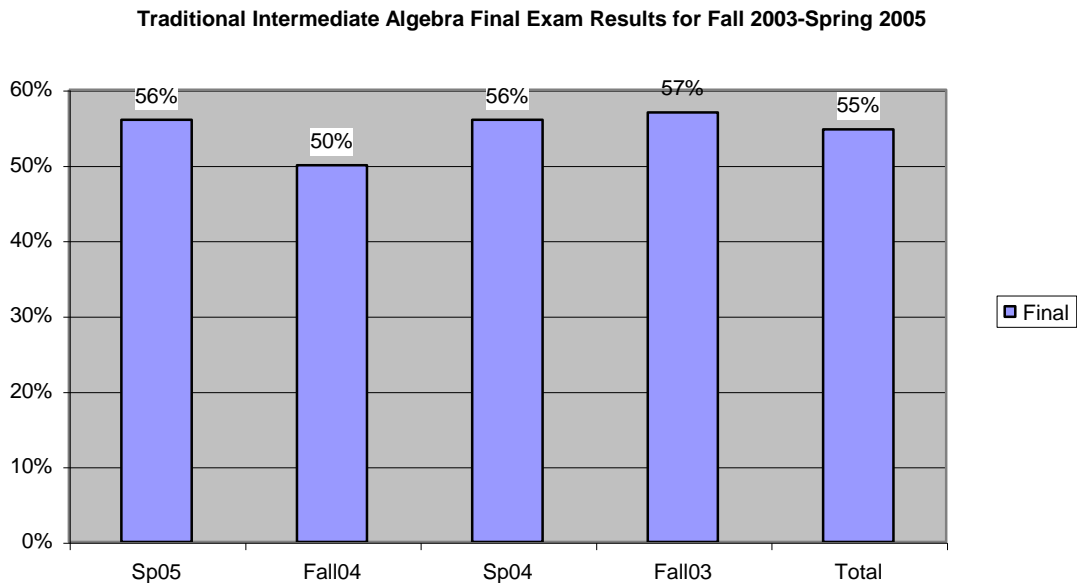
Traditional Intermediate Algebra Final Exam Results for Fall 2003-Spring 2005

Figure7

A comparison of Figure 6 and Figure 7 shows that traditional classes performed below the Math Department averages in all semesters. However, the analysis presented in Table 5 suggests a strong correlation, $r = 0.74$, between final exam scores and final grades obtained in the course.

Correlation Between Final Exam Scores and Course Grades in Traditional Classes

Grades	Frequency	Correlation Coefficient
A	39	
B	83	
C	115	r = 0.74
D	91	
F	69	
Total	397	

Table 5

Figure 8 presents the dropout and pass rates for all intermediate algebra traditional classes during the period of study (2003-2005). As is shown, the overall dropout rate was 27% while the pass rate (C or higher grade) was 53%.

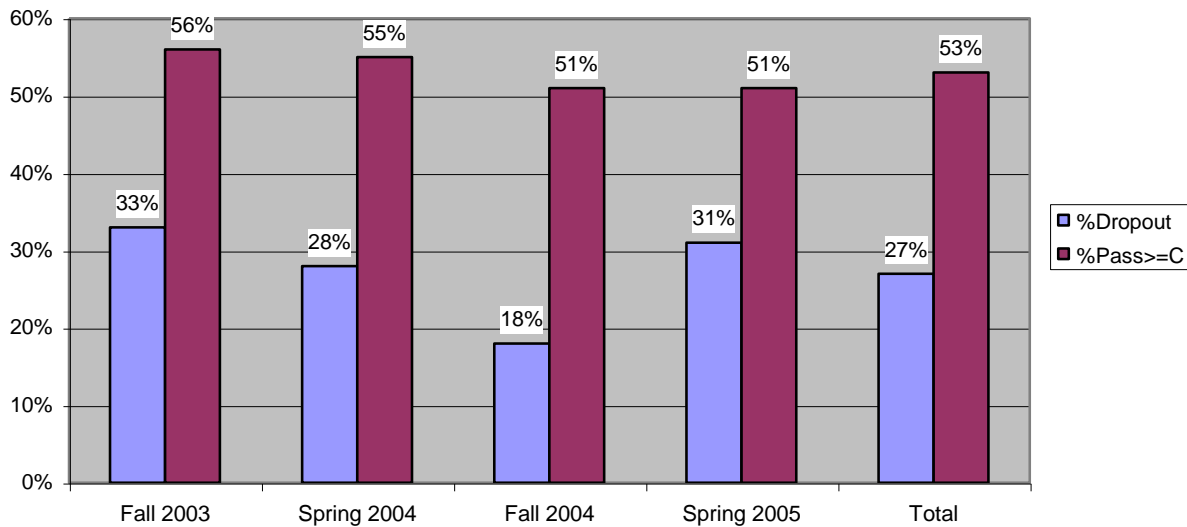**Traditional Intermediate Algebra Dropout and Pass Rates for Fall 2003-Spring2005**

Figure 8

Figure 9 presents the success rates (C or higher grades) for the students in traditional classes when they transitioned from intermediate algebra to college credit math courses. As is seen, the success rate was 62% for Math 118 (general education math), 65% for Math 125 (introductory statistics), and 45% for Math 140 (college algebra).
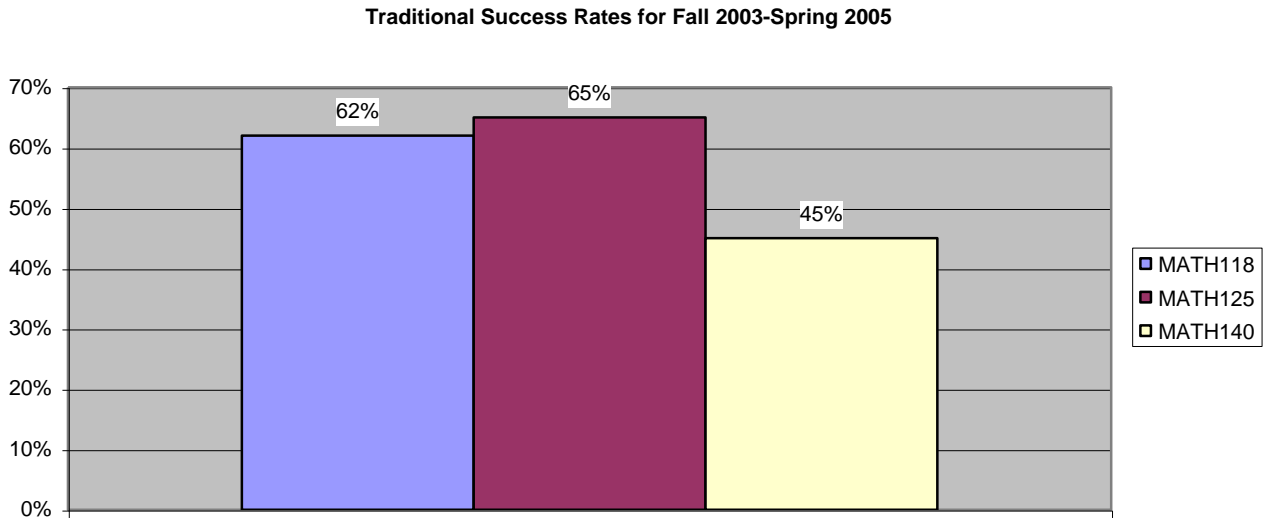
Traditional Success Rates for Fall 2003-Spring 2005

Figure 9

Next, we present the findings of the sections titled the "Keystone Classes." There were a total of N = 284 students enrolled in these classes for the period of study who took the common final exam. The students in these sections were evaluated at every class meeting through cumulative quizzes which were time-restricted and followed by immediate feedback. Subsequently, statistical and item analysis of the quizzes were performed, difficult topics were re-taught and troublesome questions were repeated until a 70% level of mastery was achieved in each class. Keystone classes also received the common departmental midterm and final exams, as did all the traditional sections.

 Figure 10 presents the final exam results for the Keystone intermediate algebra sections for the period 2003-2005. Comparing Figure 7 to Figure 10 shows that the Keystone classes, with

67.75% overall average, had outperformed the traditional classes with 55% overall average, by about
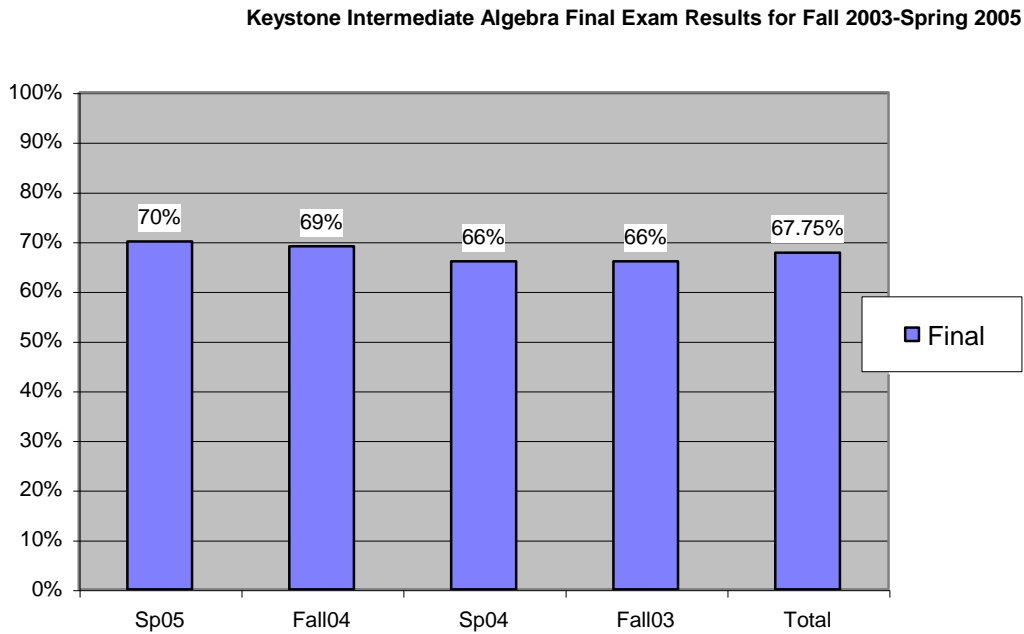
13%--more than one letter grade.

Keystone Intermediate Algebra Final Exam Results for Fall 2003-Spring 2005

Figure 10

In Table 6 frequencies of grades and correlation between final exam scores and student

grades in Keystone classes are presented. As is seen there was a strong correlation, $r = 0.85$, between

final scores and grades in these classes.

**Correlation Between Final Exam Scores
and Course Grades in Keystone Classes**

Grades	Frequency	Correlation Coefficient
A	39	
B	68	
C	98	$r = 0.85$
D	37	
F	42	
Total	284	

Table 6

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Figure 11 shows the dropout and pass rates for Keystone intermediate algebra classes during 2003-2005. As is seen, the overall dropout rate was 28%, while the pass rate was 59%. In spring 2005, the last semester of study, these classes attained the lowest dropout rate, 26%, and the highest pass rate, 63%, in the entire two year period.
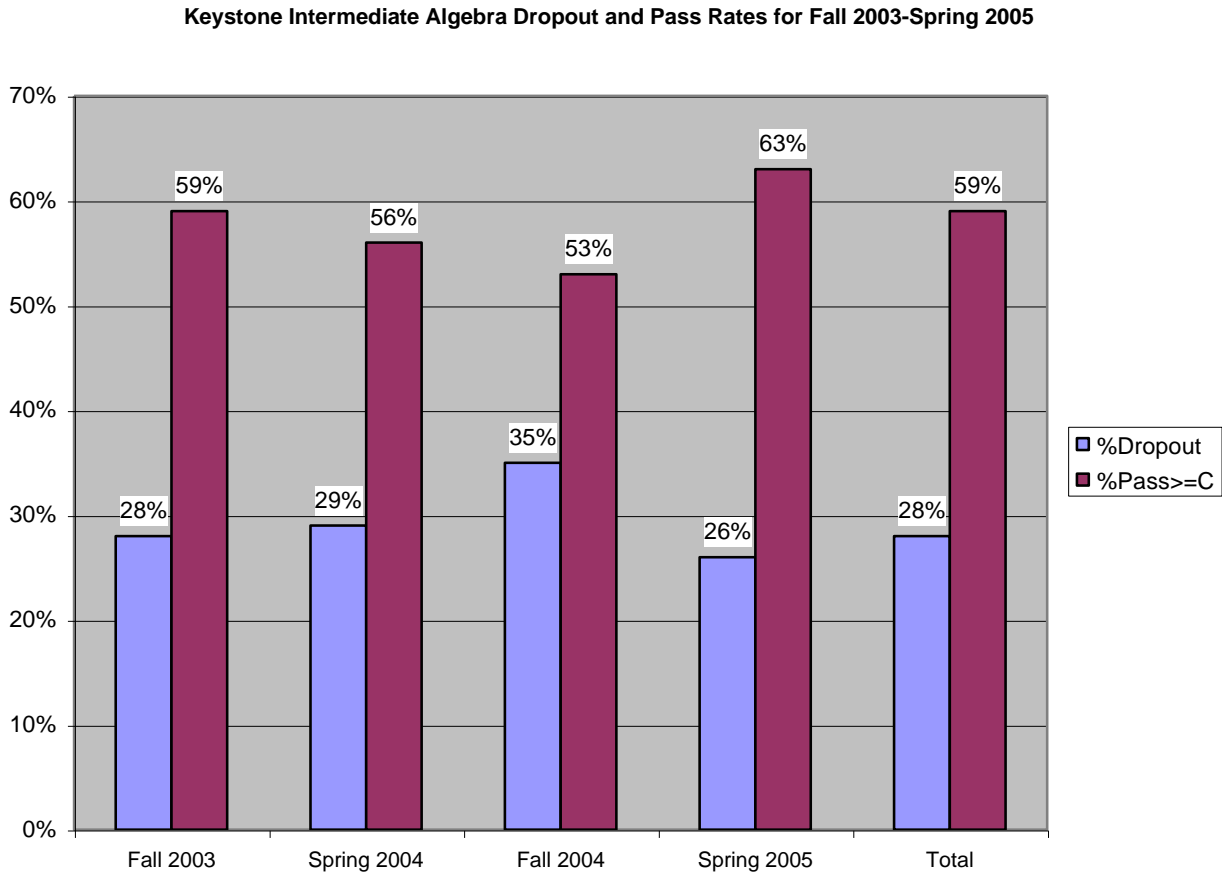
Keystone Intermediate Algebra Dropout and Pass Rates for Fall 2003-Spring 2005

Figure 11

Figure 12 presents the success rates (C or higher grades) for the students in Keystone classes when they transitioned from intermediate algebra to college credit math courses. As is seen in the chart, the success rate was 71% for Math 118 (general education math), 71% for Math125 (introductory statistics), and 64% for Math 140 (college algebra).

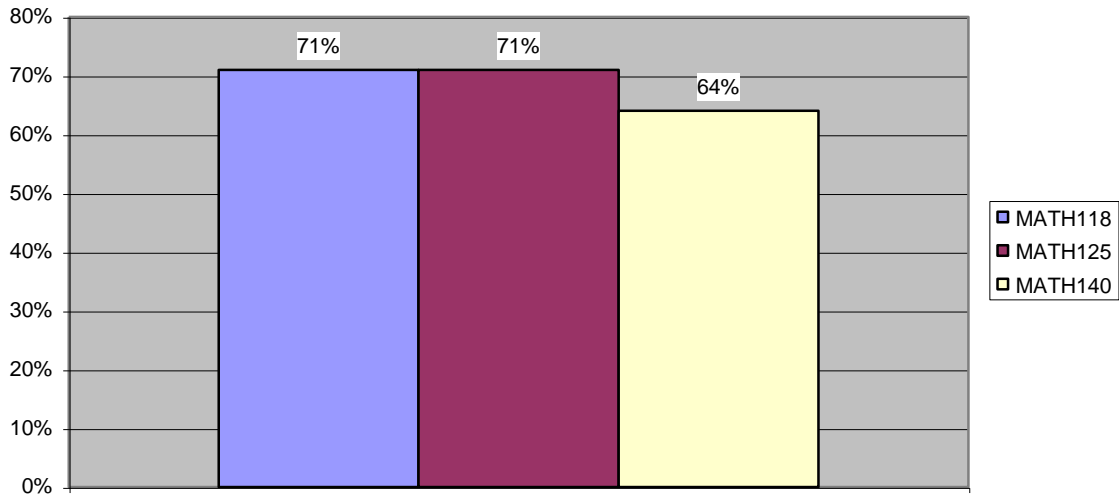**Keystone Success Rates for Fall 2003-Spring 2005**

Figure 12

Figure 13 presents the semester-by-semester comparisons of final exam results between traditional and Keystone classes during 2003-2005. As is shown, Keystone classes have outperformed the traditional classes throughout this period with the highest attainment in spring 2005 semester.

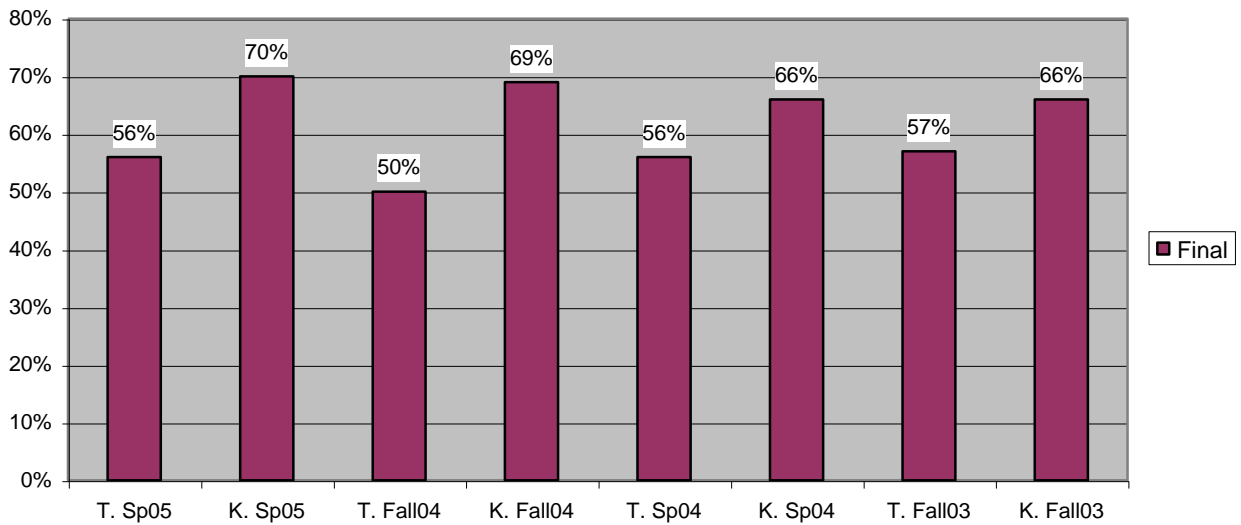**Keystone vs.Traditional Final Exam Results for Fall 2003-Spring 2005**

Figure 13

Figure 14 presents the comparisons in dropout and pass rates (C or higher course grade) between traditional and Keystone intermediate algebra classes for 2003-2005. Even though the assignment of grades in the traditional classes was the instructor's prerogative and did not necessarily reflect students' common final exam scores, the Keystone classes had outperformed the traditional ones. The dropout rates for both groups of classes are comparable.
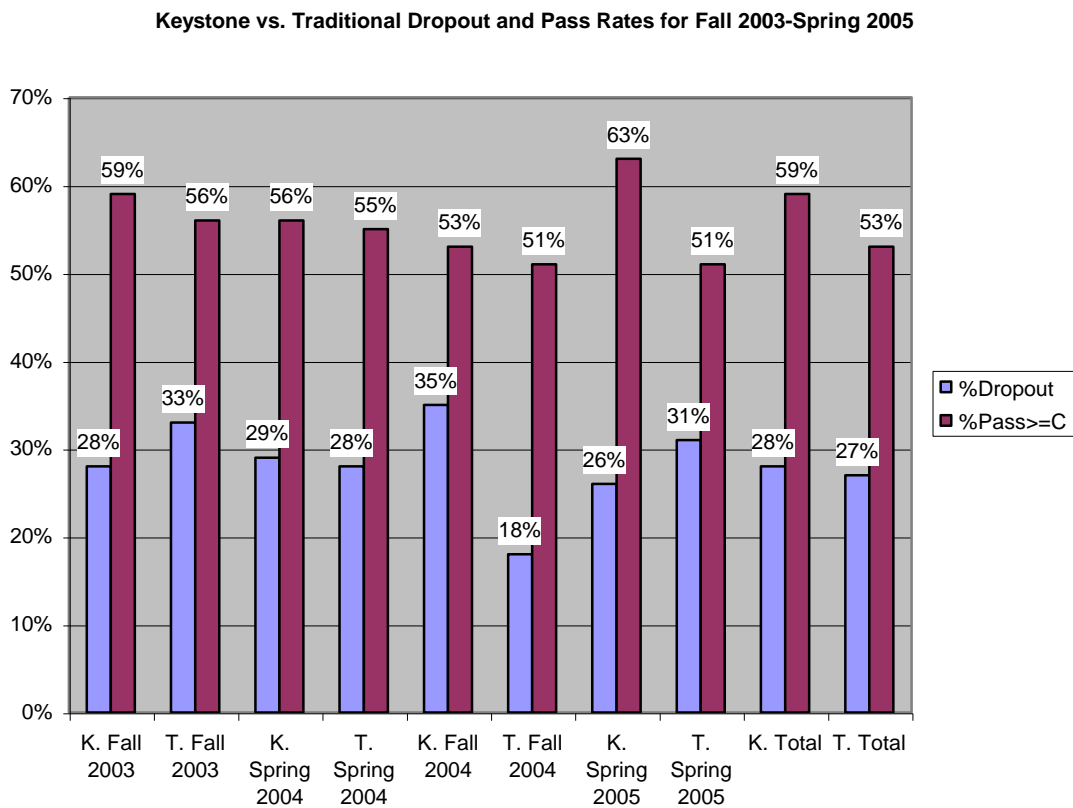
Keystone vs. Traditional Dropout and Pass Rates for Fall 2003-Spring 2005

Figure 14

Figure 15 presents the comparisons in success rates (C or higher grades) for the students in Keystone and traditional classes when they transitioned from intermediate algebra to college level math courses. As the chart clearly shows, the Keystone classes had outperformed the traditional ones in general education math, introductory statistics, and college algebra, by achieving 9%, 6%, and 19%

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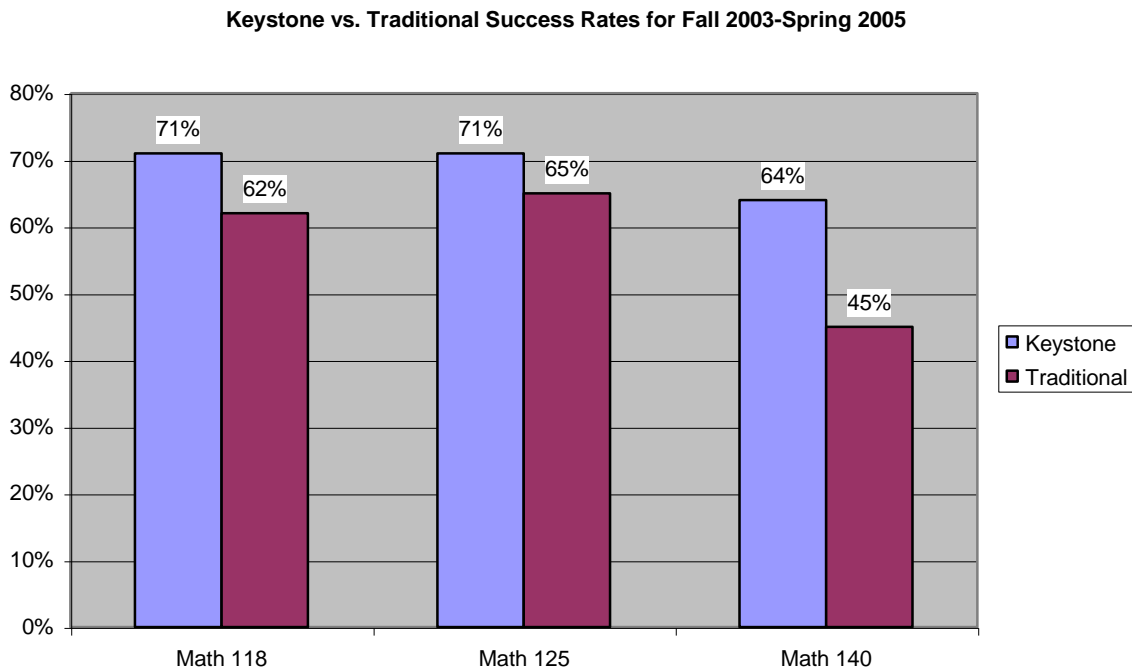higher pass rates, respectively. This amounts to an average of 11.3% higher pass rates for the three courses.

Keystone vs. Traditional Success Rates for Fall 2003-Spring 2005

Figure 15

Discussion

The present study shows that there is a positive correlation between attitude towards mathematics and success in mathematics. Students with positive attitude were more likely to pass their math classes than the students who had negative attitude. The study also shows that proper placement of students into intermediate algebra classes is necessary for their continual success and retention in these classes. Students who enter intermediate algebra by passing the prerequisite elementary algebra classes seem to have been more successful than those who enter through the Compass placement test. This disparity needs to be addressed to further the success of all students taking intermediate algebra

classes. The study also suggests that extended time lapse between sequential mathematics courses could hamper student learning and should be discouraged.

Finally, we have seen that departmentally organized final exam scores correlate very highly with the students' course grades in traditional as well as non-traditional Keystone classes. This measure clearly lends credence to the role of common final exam as an important assessment tool in the classroom. By improving performance and enhancing retention, the Keystone method has contributed to creating a successful learning experience in intermediate algebra classes and has also improved the students' success when they transition to higher level math courses.

Implications for Policy and Practice

In order to improve student attitudes towards mathematics, it is recommended that the colleges offer math awareness workshops that illustrate the importance and usefulness of mathematics in society, along with seminars that present student success stories in mathematics and introduce career opportunities in mathematical sciences.

As we saw from the large set of data presented, about 20% of students placed through the Compass placement into intermediate algebra classes withdrew from their classes. This figure coupled with a 31% failure rate, significantly reduces the success rates in these classes to only 49%. It is recommended that the present system of placement testing be revamped so that it is in line with curriculum course content at the college. This will ensure that students placed into intermediate algebra through the placement test possess the equivalent preparation as those passing the prerequisite elementary algebra classes.

In order to address the negative impact of extended time lapse between sequential mathematics classes, it is recommended that students undergo proper academic advising and mentoring and structure their program of study to complete the mathematics requirements early on at the college, rather than near the graduation.

The strong correlation (0.76 for traditional and 0.85 for Keystone classes) found between final exam scores and course grades supports the notion that good performance in the final exam is directly related to the general performance in the course. It is recommended that common departmental final exam be considered as a general practice in all remedial classes.

Finally, the Keystone methodology has proved to be an effective system in enhancing student performances and retention in intermediate algebra classes. Its effectiveness should be further explored in other mathematics courses and in other disciplines or departments at the college.

Limitation of Study

This study was conducted by one researcher, a full-time mathematics faculty at the college, testing the effectiveness of a specific teaching method in intermediate algebra classes. As such, there may be some confounding of the results due to the teacher effect.

The study also showed that students entering intermediate algebra through Compass, exhibited lower pass rates compared to all those in traditional sections. The research, however, did not extend its scope to study the performance of these two groups on the common final exams.

Finally, the effect of time lapse between sequential math courses on student performance was restricted to elementary and intermediate algebra classes. Future research can expand this study to include other remedial classes, such as pre-algebra or pre-credit math classes at the college.

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