Entry-level College Mathematics Success Predictors: Developmental Performance, ‘Stopping-out’ and Demographics

by

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Date ............... February 2, 2012 .........................................................
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Introduction: Summary

In recent years, postsecondary institutions have been faced with an ever-increasing number of students ill-equipped for college-level courses. This is particularly true in the United States, including the University of Alaska Anchorage (UAA). These institutions have experienced high student attrition rates in entry-level courses where the highest attrition rates tend to occur in mathematics classes. To prepare these ‘high risk’ students for entry-level college courses, a number of postsecondary institutions have established pre-college level, developmental or remedial classes.

Many questions remain unanswered as to which factors will improve the success of these ‘high risk’ students. This study will attempt to answer some of these by examining the relationship between student academic performance in an exit-level, pre-college, developmental mathematics course, together with other performance factors, and student academic performance in subsequent, entry-level college mathematics courses. The population will consist of students who successfully completed Intermediate Algebra, the exit-level developmental mathematics course, and who subsequently enrolled in one of the following three mathematics courses: College Algebra, Elementary Statistics, or Applied Finite Mathematics while attending UAA during the five-year period from 2001 to 2006.

The ex post facto research design provides for the use of historical data and a longitudinal approach. The longitudinal approach tracks the progress of the same cohort of students attending the University of Alaska Anchorage during the five-year period from 2001 to 2006, collecting data each year as the students proceed through their courses and programs of study.

The intent of the study is to identify trends that attempt to explain the differences in academic performance of students enrolled in college-level mathematics courses, in particular College Algebra, Elementary Statistics, or Applied Finite Mathematics. An Academic Success model will be developed summarizing these trends.
Introduction — 2

Three sets of variables or performance factors will be used in the study:

- Demographics;

- Course Performance in Intermediate Algebra and one of the entry-level college mathematics courses, measured by the student’s final course grade, where success is defined as a grade of A, B, or C; and

- ‘Stopping-out’ measures, where Duration of ‘Stop-out’ is defined as the length of time a student allows to pass before enrolling in the subsequent course in a prescribed sequence of courses, measured by the number of semesters between enrollments.

Unique to this predictive model is:

- the inclusion of the three college-level mathematics courses: College Algebra, Applied Finite Mathematics, and Elementary Statistics;

- the inclusion of the course Intermediate Algebra as a developmental mathematics course rather than a college-level course; and

- the inclusion of the factor ‘stopping-out,’ although common among college students, has not been extensively researched.

The predictive model produced from this study will use information commonly available at all postsecondary institutions. It will benefit two-year and four-year, public and private colleges and universities. The study’s findings are expected to support secondary and postsecondary counsellors, faculty, staff, and advisors as they assist students with their programs of study, specifically the selection and timing of courses. Application of the findings will enhance curriculum design, facilitate student success and reduce student attrition rates, particularly in entry-level college mathematics courses.
Chapter 1: Statement of the Problem: *What identifying factors facilitate the smooth progress of developmental mathematics students to complete successfully required college-level mathematics courses?*

The intention of this study is to discover the means to improve the retention rate for students enrolled in entry-level college mathematics courses by identifying factors that facilitate the smooth progress of developmental mathematics students to complete required college-level mathematics courses successfully. The approach to achieve this is to explore the relationship between the demographic and academic performance factors of students in an exit-level developmental mathematics course and their academic performance in a subsequent, entry-level college mathematics course.

To assist the struggling, underprepared students enrolled in entry-level college courses and to reduce the escalating student attrition rates, a number of colleges and universities have instituted remedial education (remedial) or developmental education (developmental) courses. It is apparent that the reason for the lack of preparedness experienced by students is more than attitude. Many students have not acquired the academic concepts, information, or skills formerly expected of ‘college-bound’ high school graduates (Baiocco & DeWaters 1998, p. 15).

Developmental education provides the foundation to assist these underprepared students to succeed in higher education and achieve their goals. The term ‘developmental education’ or ‘developmental’ has evolved from terms used to identify the educational theories, approaches and practices that promote the intellectual, physical, and social development of the individual.

In practice, developmental courses are designed to strengthen and broaden the academic as well as the personal skills of the individual. A developmental course is comprehensive in nature. It is designed to serve the needs of a diverse group of students exhibiting vast differences in learning styles, academic abilities and
personal attributes. This course addresses the needs of students by employing a wide range of resources and interventions within the institution. The goals of the course are to develop the talent and to correct the academic weaknesses of the individual student while emphasizing skills relevant to students transitioning between high-school level and college-level courses. These developmental programs and courses support the changing demographics, educational needs, and diversity of postsecondary students currently entering postsecondary institutions.

A remedial course, in comparison, is focused entirely on correcting a specific set of academic skills or knowledge deficiencies. The term ‘remedial education’ or ‘remedial’ is derived from the root meaning to ‘heal, cure, or make whole’. Remedial courses and programs focus on improving academic skills using a medical model where specific weaknesses are diagnosed, appropriate treatments are prescribed, and the student (patient) is evaluated to determine the effect of the ‘treatment’ (Clowes 1980, p. 8).

Boylan and Saxon describe the following differences between these two theories:

Successful developmental education...involves more than just the teaching of basic skills. Understanding that there is a link between personal and academic growth is the key difference between ‘developmental’ and ‘remedial’ education. For developmental intervention to be successful, student development must be promoted through services such as advising, counseling, and tutoring. For these treatments to be effective, developmental educators must attend to non-cognitive variables. (Boylan & Saxon 1998, p.12).

In spite of concerted efforts to clarify the basic definitions, terminology, research, and practice in the field of developmental education, these remain in a constant state of flux, subject to challenges from outside and inside the field. The lack of consensus in definitions persists even today. The terms remedial and developmental continue to be used interchangeably in practice and research at most postsecondary institutions. The U.S. Department of Education, Office of Vocational and Adult Education, in its current publications failed to discriminate between them using both
remedial education and developmental education interchangeably to describe programs designed to help students ‘acquire the skills needed to persist and succeed in college’ (Office of Vocational and Adult Education 2004, p. 1). Consequently, these terms will be used interchangeably throughout the remainder of this study unless specifically differentiated.

At postsecondary institutions with developmental programs, including UAA, the majority of the developmental course offerings have been in the area of mathematics. A study conducted by the National Center for Educational Statistics entitled *Remedial Education at Degree-Granting Postsecondary Institutions in Fall 2000* maintains that institutions typically offer more remedial courses in mathematics than in reading or writing. In fall 2000, 40 percent of postsecondary institutions, public, private, two-year, and four-year, offered three or more different remedial mathematics courses as compared to 24 and 23 percent respectively that offered three or more reading or writing courses. This is a strong indication of the needs of students. The number of remedial courses offered by postsecondary institutions in the United States averaged 2.5 mathematics courses, 2.0 reading courses, and 2.0 writing courses (National Center for Educational Statistics 2003, p. 10).

The demand for developmental mathematics classes continues to grow. In 2007 according to Barbara Pytel’s article ‘College Remedial Math Increasing; Are Advanced Math Classes Helping or Hurting?’, colleges have been inundated with students in need of remedial classes in mathematics. The problem has become so overwhelming that colleges are forced to rewrite textbooks, do more reteaching, and force students to take remedial courses without credit (Pytel 2007, p.1). In 2009, the requirement for college remedial mathematics courses is ever increasing (Hagopian 2009, p. 1). At the University of Alaska Anchorage, approximately 49 sections of developmental mathematics classes, 7 sections of developmental reading classes, and 33 sections of developmental writing classes are offered each semester.
Chapter 1: Statement of the problem — 6

Despite increases in developmental or remedial class offerings, student attrition rates and the number of non-success grades continue to increase in the entry-level college mathematics courses. This raises two questions:

- What factors are affecting the poor performance of developmental mathematics students in college-level mathematics courses? and
- What factors will ensure smooth progress of developmental mathematics students to complete required college-level mathematics courses?

In 2003, the findings from the first comprehensive investigation of student attrition in entry-level college courses at the University of Alaska Anchorage were published in the report *Increasing Student Success: Focus on Attrition*. This report summarized the collected student information and course data for the period between 2000 and 2002. The findings confirmed that the highest attrition rates tend to occur in entry-level mathematics courses. At UAA the overall attrition rate in mathematics courses is 41 percent and the attrition rate for the entry-level college mathematics courses Math A107 (College Algebra); Math A270 (Applied Finite Mathematics), and AS 252 (Elementary Statistics) ranges between 19 percent and 41 percent (Rice 2003, p. II).

Moving beyond the descriptive stage of the report *Increasing Student Success: Focus on Attrition*, this research study addresses the challenge faced by members of the staff and faculty at postsecondary institutions; reconciling the issues of academic quality, open access and student success. To address this challenge, the following questions are to be considered:

- What effect does ‘stopping-out’ between the successful completion of the exit-level developmental mathematics course and the enrolment in the entry-level college mathematics course have on the successful completion of the entry-level college mathematics course?
What effect does the course grade of the exit-level developmental mathematics have on the successful completion of the entry-level college mathematics course?; and

What combination of variables, can best predict the academic success of students enrolled in entry-level college mathematics courses?

The expression ‘stopping-out’ describes the situation where students allow two or more semesters, including summer semesters, to pass before enrolling in the subsequent mathematics course in a prescribed sequence of classes. Although ‘stopping-out’ is a common phenomenon among college students and in particular among developmental students (Doucette & Hughes 1990, p. 25), little has been researched or written about this phenomenon.

The first question, ‘What effect does Duration of ‘Stop-out’, the number of semesters between the successful completion of the exit-level developmental mathematics course and the enrolment in the entry-level college mathematics course have on the successful completion of the mathematics course, Academic Success?,’ will be addressed in this ex post facto study by examining the relationship between the length of the student’s ‘stopping-out’ time referred to in this study as Duration of ‘Stop-out’, and the student’s Academic Success or performance in the college-level course. The design of this study provides for the use of historical data which allows for the application of a longitudinal approach required to control for the ‘stopping-out’ phenomenon.

The second question, ‘What effect does the grade in the developmental mathematics course, Developmental Course Grade, have on the successful completion of the entry-level college mathematics courses, Academic Success?,’ will be addressed in this ex post facto study by examining the relationship between the grade in the developmental mathematics course, Developmental Course Grade, and the student’s performance in the college-level course when the effects of the other variables are controlled.
The third question, ‘What combination of variables can best predict the Academic Success of students in entry-level college mathematics courses?’ will be addressed by developing a predictive model of student Academic Success. This model will include performance in the developmental mathematics course, measured by the Developmental Course Grade, as well as other factors including: Age, Ethnicity (described as a numerical value assigned to each group), Course Load (described as the number of credit hours taken during the same semester as the college-level mathematics course), College GPA (Grade Point Average), Developmental Attempts (the number of repeat enrolments of developmental course), and Duration of ‘Stop-out’ (the number of semesters between the successful completion of the exit-level developmental mathematics course and the enrolment in the entry-level college mathematics course). This information will be analysed to identify which characteristics or combination of characteristics best predicts Academic Success in an entry-level college mathematics course.

The population for this study identified as ‘Population’ will be selected from the set of students who were enrolled at UAA during the period between summer semester 2001 and spring semester 2006. In particular, only those students from this set who completed the exit-level developmental mathematics course, MATH A105 (Intermediate Algebra), and who subsequently enrolled in one of the following entry-level college mathematics courses: MATH A107 (College Algebra), MATH A270 (Applied Finite Mathematics), or AS A252 (Elementary Statistics) during this 5-year period will be considered.
Chapter 2: Discussion of the Problem, its Setting and Context:

Attrition in college-level courses at postsecondary institutions

Attrition has been and is currently a serious problem at a preponderance of postsecondary institutions throughout the United States. This is confirmed by the statistics maintained by these institutions identifying course, program and institutional attrition rates. Student attrition refers to the number of students who failed to complete a given course, program or degree. Attrition rate is defined as the ratio of the number of students no longer in a particular setting (course, program or institution) compared to the total number of students originally in the setting’s population.

Types of Postsecondary Institutions

The term ‘postsecondary’ in North America refers to a host of diverse higher education institutions. Each category of institution has a unique definition. The descriptions of the institutions referred to in this study follow.

- Community colleges, referred to as junior colleges in some areas of the United States, are postsecondary institutions characterized by a two-year curriculum often culminating in a certificate or an associate degree. The programs offered are designed to prepare students for transfer to a four-year postsecondary institution or to prepare students for direct employment in a selected occupation.

- Four-Year Colleges are four-year postsecondary institutions offering Bachelor’s degree programs in a variety of fields. A number of these colleges offer graduate degrees in selected fields, generally at the Master’s Degree level.

- Universities are broad based institutions offering degrees in a variety of disciplines at degree levels ranging from certificates to Ph.Ds. Often universities are large institutions composed of individual colleges. Within the university structure, there are categories of universities described by the
primary mission of the institution as teaching universities or research universities.

- **Technical Schools**, at times referred to as *institutes of technology*, are characterized by programs specializing in the sciences and/or engineering. These may be two-year schools, four-year colleges, or universities. In the case where the technical school is a two-year institution, it is frequently considered a ‘trade’ school where students completing the prescribed program are employed in one of the ‘trades’ as electricians, plumbers, computer technicians, or other skilled workers.

**National View of College-Level Attrition: Definition and Possible Causes**

For more than two decades there has been an ongoing discussion regarding the academic structure of secondary and postsecondary curriculum and the abilities of the students enrolled in these courses within the United States. With the publication of *A Nation at Risk: The Imperative for Educational Reform*, a call was sent forth throughout the country for reform in the nation’s schools. This publication described the decline of standards in high schools where the curriculum had been diluted and diffused to a point where schools no longer adequately prepared students for courses and programs of study at institutions of higher education. The areas of the curriculum most profoundly affected were the areas of mathematics and the natural sciences (National Commission on Excellence 1983, ‘Findings’, p. 1).

By 2000, in colleges and universities throughout the United States, the number of students failing to complete their degrees and leaving postsecondary institutions had climbed dramatically. To address this problem, the number of remedial and developmental courses and programs at the postsecondary level increased radically. According to the National Center for Educational Statistics (NCES) and others, approximately 90 percent of all postsecondary institutions and 78 percent of universities include remedial or developmental courses in their curriculum offerings. The majority of these offerings are in the area of mathematics (Boylan et al. 1992; National Center for Educational Statistics 2003, p. iii; Pytel 2007; Shults 2000).
Chapter 2: Discussion of Problem, its Setting and Context — 11

Although these courses assisted some students, the matter of student attrition continued. In 2009, the stage was set once again, at the national level, to examine the reasons for the dramatic decline in the rate of educational attainment in the U.S. Academics, legislators, business executives, and journalists were bemoaning the failure of the United States to continue to build the human capital needed to satisfy the economic, social and political needs of the country. There was agreement that educating more people and educating them better was the single best way to improve economic opportunity and to reduce inequality.

An examination of the completion rate (the ratio of those who started college to those who earned a bachelor’s degree) at postsecondary institutions over a 40-year period from 1968 to 2007 revealed that the completion rate hardly changed while the time required to complete the degree increased markedly (Bound, Lovenheim & Turner 2007). This is a disturbing picture when contrasted with the remarkable gains in educational attainment in other countries. It is now recognized that the United States can no longer claim it is ‘first’ in building human capital. The 2008 document produced by the Organisation for Economic Co-operation and Development (OECD) reported that the 2006 higher education attainment rate for 25- to 34-year-olds in the United States was nearly identical to that of 55-to 64-year-olds, a group 30 years their senior. Moreover, in 2006, the United States ranked 10th among the 30 members of the OECD in its tertiary attainment rate. This is a huge drop from preceding years when the U.S. ranked 5th in 2001 and 3rd in 1998. Contributing to this change in ranking is the poor completion rate of students entering college. Only 56 percent of entering students finish. This outcome places the United States second to the bottom of the rank-ordering of countries by completion rate (Organisation for Economic Co-operation and Development 2008, p. A1.3a). To add to this picture, the proportion of college-age students earning degrees in natural science and engineering fields in 2000 was substantially higher in 16 counties in Asia and Europe than in the United States (National Science Board 2004).
Chapter 2: Discussion of Problem, its Setting and Context — 12

The United States has lost its edge in higher education. President Obama, recognizing the gravity of this situation, set an ambitious goal for American higher education by stating that ‘By 2020, America will once again have the highest proportion of college graduates in the world’ (Obama 2009).

The United States can no longer rely on the inflow of talent from overseas. Since 2001, there has been a marked reduction in the number of foreign student enrolments. Universities in Asia and Europe are becoming more aggressive in their efforts to compete for top students from all over the world. India, China, and South Korea among others are actively engaged in improving their own educational systems (Labi 2008, p. A22). In the future, promising students from these countries will have better educational opportunities at home. This can be seen even now when in 2007, China’s foreign enrolment ranked fifth in the world (Hvistendahl 2008). Clearly, these trends place a heavy burden on the U.S. educational system, demanding that it increase the rate of graduates among its own population.

Central to increasing the number of graduates at postsecondary institutions in the United States is the abatement of rising attrition rates. A contributing factor influencing the increase in attrition rates is the rise in the number of underprepared students at many postsecondary institutions within the U.S. An end result of the increase in underprepared students is high student attrition rates in entry-level college courses, in particular, entry-level college mathematics courses.

Alaska’s Attrition Record: Description and Possible Causes

To examine the phenomenon of student attrition more fully, it is important to review who is entering postsecondary institutions and how they arrive. For this study it is essential to compare the characteristics of students, in general, from throughout the United States to those in Alaska.
Alaska became a state in 1959. Prior to that time it was a U.S. territory. It has a land mass of 572,000 square miles, equivalent to approximately one-fifth the size of the contiguous 48 states (Lower 48), with a population of 664,000 residences, ranking 48th out of the 50 states. The population density is approximately 1.1 residents per square mile, ranking 50th among the states. There are three major population centres: Anchorage (275,000), Fairbanks (31,500) and Juneau (31,000). The ethnic groups consist of Whites (69 percent), Blacks (3.5 percent), American Indian and Alaska Native (15.6 percent), Asian/Pacific Islanders (4.0 percent) and Hispanic (4.1 percent). About half of all Alaska Natives are Eskimos and approximately a third of Alaska Natives are American Indians.

A recent article by Megan Holland in the Anchorage Daily News on May 27, 2008 titled ‘Dropout Numbers Plague UA Frosh’ examined the attrition rates of high school and college students within Alaska. It cites a report released by the Postsecondary Education Commission of Alaska describing a study completed by Ron Phipps of the Institute for Higher Education Policy. One finding of the study states that Alaska has one of the lowest high school and college graduation rates in the country, ranking eighth from the bottom among the fifty states in the percent of ninth graders graduating from high school in four years and fourth from the bottom in high school seniors going directly to college. Moreover, Alaska ranked last among the fifty states in postsecondary education completion rates with only one of twenty ninth-graders completing a college degree in ten years.

Within the United States 74 percent of those students beginning high school in the year 2000 graduated in 2004, leaving 26 percent who did not graduate. In comparison, in Alaska, of those students starting high school in 2000, only 67 percent graduated, leaving 33 percent who did not complete the curriculum necessary to receive a high school diploma. The national high school graduation rate was 74 percent, of those 46 percent enrolled in a postsecondary institution leaving 28 percent who did not. While in Alaska, only 67 percent of the high school students graduate, of those only 33 percent of the high school graduates enrolled in a
postsecondary institution, leaving 34 percent who did not. Nationally, of those who started college, 38 percent stayed in their home state for college. While in Alaska, only 20 percent stayed at home.

To summarize, in 2000, a third of Alaska’s high school students did not graduate, another third graduated but did not enrol in a postsecondary institution. On the national level, one-quarter of high school students failed to graduate and another quarter graduated but did not continue their education at a postsecondary institution (Kassier & Hill 2008, p. 2). When so few high school students graduate and even fewer continue their education at a postsecondary institution, the state of Alaska is faced with a major educational and economic problem, that of producing a citizenry composed of underprepared adults who lack the skills to become productive members of the community and society at large. Rather, these adults are unable to qualify for employment opportunities that provide wages sufficient to afford a reasonable living. Instead, they are unable to contribute to or improve their community and soon become a drain on the resources of others.

This problem is a direct result of the falling educational attainment levels among the young adults in the state. Above and beyond this serious concern, there is the added problem in Alaska that of students completing high school and entering college only to find themselves unprepared for college work. This has been extensively documented in recent years at the University of Alaska Anchorage.

**University of Alaska Anchorage: Description and Student Characteristics**

The University of Alaska Anchorage (UAA) is one of three university centres within the University of Alaska System located in the city of Anchorage in South Central Alaska. Anchorage has a population of 280,000 representing 43 percent of Alaska’s residents from several ethnic groups. These groups include White (75 percent), Black (5.7 percent), Alaska Native and American Indian (5.5 percent), Asian/Pacific Islanders (6.1 percent), and Hispanics (7.7 percent).
Chapter 2: Discussion of Problem, its Setting and Context — 15

Examining the information of the 2000 US Census (U.S. Department of Commerce, Economic and Statistic Administration, U.S. Bureau of the Census 2000) the population of Anchorage is identified by the following characteristics:

- **Place of Birth:** approximately 33 percent of Alaska’s population were born in Alaska, 57 percent were born in another state in the U.S., 2 percent were U.S. citizens born outside of the U.S. and 8 percent were foreign born. In comparison, the average statistics for the United States finds that approximately 59 percent were born in the state they reside; 30 percent were born in other states, 1 percent were born outside of the U.S. and approximately 10 percent were foreign born;

- **Military Population, Civilian Veterans:** 17.1 percent of the Alaska’s population is comprised of civilian veterans as compared to an average of 12.7 percent of the total population in of the U.S.;

- **Military Population, Active Military:** 4.4 percent of Alaska’s population includes active military personnel as compared to an average of 0.64 percent of the total population of the U.S.;

- **Alaska Native Population:** 15.6 percent of Alaska’s population are Alaska Native and nearly half, 7.3 percent, reside in Anchorage;

- **Population Mobility into the state in the last ten years:** Alaska’s population grew by 14 percent, Anchorage’s population increased by more than 25 percent, while the average growth for the U.S. was 13.2 percent with the largest growth occurring in the Western and Southern states including Nevada with a 66 percent increase in population.

- **Population Mobility out of the state in the last five years:** 17.9 percent of the population moved to a location outside of Alaska. In the United States the most significant losses in population occurred in the Midwest. The population losses for any given state were generally less than 17 percent (U.S. Department of Commerce, Economic and Statistics Administration, U.S. Bureau of the Census 2000).
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The composition of the 2006 undergraduate student body at the University of Alaska Anchorage mimics the population of the city and the state. The student profile consists of White (70 percent), Black (3.5 percent), Alaska Native and American Indian (9.9 percent), Asian/Pacific Islander (6.4 percent) and Hispanic (4.3 percent). The statistics for the ethnic groups of White, Black and Hispanics are most closely aligned with those ratios for the entire state of Alaska while the percentages for the two groups Alaska Native and American Indian and Asian/Pacific Islander are more closely aligned with the ratios for the city of Anchorage.

Within the city limits of Anchorage there are three universities, UAA (21,456 full-time equivalent students), Alaska Pacific University (500 full-time equivalent students), and Charter College (307 full-time equivalent students). The closest location to Anchorage with a college or university with more than 2000 students is University of Alaska Fairbanks (5034 full-time equivalent students) in the city of Fairbanks, Alaska 261 miles away.

Prior to 1986 the University of Alaska System consisted of three university centres together with thirteen community colleges; Anchorage Community College being the largest. In the mid-1980s, the State of Alaska faced severe budgetary problems due to falling oil prices. The budget supporting higher education in Alaska was at an all-time low. To deal with these serious financial cutbacks, the President of the University of Alaska System restructured the system by combining twelve of the thirteen separate community colleges with the three universities. This reduced the number and cost of duplicate administrative staff and teaching faculty. In Anchorage, these cost saving measures created a new institution, the University of Alaska Anchorage, a composite institution joining a community college with a four-year university; combining Anchorage Community College with the University of Alaska, Anchorage.
After restructuring in 1986, UAA became the first ‘hybrid’ institution in the United States, where the mission of this newly formed institution embodied the missions of the two former institutions. This new mission merged the mission of a community college with the mission of a university, thereby creating a mission more comprehensive than traditional four-year universities within the United States. UAA had an open-door admission policy permitting any student to attend but maintained strict entry standards for its professional programs. By 2008, there were 22 ‘peer’ institutions located throughout the nation. It is expected that more ‘hybrid’ institutions will emerge to cope with funding shortages; thereby expanding the impact of this study’s outcomes.

The unique aspects of the University of Alaska Anchorage (UAA) include:

- in its student body, having a significant number of Alaska Native students and other minorities;
- in its mission, combining a community college with a university; and
- in its location, an urban commuter university isolated from other population centres with colleges and universities.

Yet, UAA faces similar concerns as other postsecondary institutions regarding student attrition.

The new mission of UAA creates a university where there is a preponderance of underprepared students entering Alaska’s postsecondary institutions. This challenge is identified by Kassier and Hill.

A problem for Alaska—is that so few high school students go on to college. …a third of Alaska’s high school students don’t graduate, and another third graduate but don’t enroll in college. The remaining third graduate and enroll in college—but some enroll in colleges outside Alaska. So in the end, only one-fifth of Alaska high school students enroll in colleges and universities in Alaska.

Nationally, about one-quarter of high school students fail to graduate and another one-quarter graduate but don’t go to college. Nearly half graduate and go on to college, mostly in their home states.
A second problem is that many high school graduates aren’t prepared for college. A 2006 report estimated that as many as two-thirds of incoming UA freshmen weren’t prepared to do college-level math and English. Poorly prepared students can be from anywhere, but the problem is especially worrisome in Alaska Native communities. (Kassier & Hill 2008, p. 2)

The Institute of Social and Economic Research at the University of Alaska Anchorage conducted a study confirming that 28 percent of full-time freshman within the University of Alaska System, UA, do not return for the second year. Phipps (1998) suggests that the reason for this phenomenon resulting in low college graduation rates is an increase in the number of underprepared students entering college. These first-time college freshmen lack the preparation for college-level courses (Holland 2008, p. A1). A 2006 report estimates that as many as two-thirds of incoming students to the colleges and universities within the University of Alaska System are not prepared for college-level mathematics and English courses (Veazey 2006). Particularly troublesome are the poorly prepared Alaska Native students. In 2008, the student population at the University of Alaska Anchorage consists of 9 percent Alaska Natives. This is a 40 percent increase since the year 2000. Generally, the academic achievements of these students are comparable to other entering freshman during their first year. Starting in the second year, Alaska Native students leave the university at disproportionately high rates. Among those beginning in 2005, fewer than 60 percent of Alaska Native freshman continued on to their second year as compared to 70 percent of all freshman continued on to their next year. While 75 percent of Alaska Native students graduated from high school in 2000, only 6 percent completed bachelor’s degrees by 2008, either at a postsecondary institution in Alaska or at an institution outside the state.

An explanation for the increase in underprepared students is offered by Ron Phipps of the Institute for Higher Education Policy and released by the Postsecondary Education Commission of Alaska. Phipps describes Alaska as a state of individualism where people in the past could live well if they were willing to work hard, train on the job, and travel to remote locations of the state to work at labour-intensive jobs in the oil, lumber, mining or fishing industries. In recent years,
Alaska, similar to other states with a high percentage of labour-intensive jobs, has changed. It is fast becoming a place where workers without a post-high school education cannot compete for existing employment opportunities. Jobs that were once performed by unskilled workers with on-the-job training now require at minimum a two-year technical degree.

Consequently, students who dropped out of high school or who did not earn above-average grades in their high school classes and were expecting to achieve financial success by entering the labour force are discovering that it is no longer possible to do so. They are returning to school for a postsecondary education and finding themselves woefully underprepared (Holland 2008, p. A1).

UAA, with its open-admission policy and low tuition costs, is generally the first choice of a first-year or returning college students. During the period from 2000 to 2007, the enrolment at the Anchorage campus of UAA increased by 18 percent. A contributing factor to this impressive increase has been the rise in the number of students from minority groups, particularly Alaska Native, Asian, and Hispanic, with the Alaska Native enrolment increasing by more than 40 percent. These minority students, in particular Alaska Natives, face major cultural, academic, and social challenges while attending a large institution in an urban environment. With nearly two-thirds of incoming freshman at the University of Alaska lacking the academic preparation to do college-level mathematics and English courses, these minority students find themselves ill-prepared for the college experience especially college-level courses (Erickson & Hirshberg 2008, p. 2).

Historically, among University of Alaska Anchorage degree seeking freshman, only 25 percent receive their bachelor’s degree in six years. Comparably, less than 12 percent of Alaska Native students attending UAA complete their degree in six years (Erickson & Hirshberg 2008, pp. 1-2). Based on these percentages, Alaska ranks last in the United States among the national statistics of college freshman receiving bachelor’s degrees within six years (Holland 2008, p. A1). This persistently low
college graduation rate has prompted this study to identify the factors that contribute to academic success in college-level mathematics courses. Although essential, this study is only one step toward increasing the overall graduation rate at UAA and reducing the attrition rate in college-level courses.

**Attrition at the University of Alaska Anchorage**

In 1999, Gary Rice, Associate Vice Provost of Institutional Research, Office of Institutional Planning, Research and Assessment (OPRA) at the University of Alaska Anchorage designed and implemented a strategy for tracking the progress of all students attending UAA. This model of analysis and data collection tracks students for ten years, beginning the semester they enter the institution. The model links the institution’s accountability to its mission by assessing whether the institution has been successful in providing learning support to students working to achieve their academic goals.

Rice’s cohort model is longitudinal in nature and is designed to accept additional data as it becomes available each semester. Information may be accessed and compared in a myriad of ways based on a variety of characteristics. In spring 2001, the definitions and parameters were established for the system.

In spring 2002, faculty members in the Department of Mathematical Sciences at the University of Alaska Anchorage became acutely aware of the declining completion rates of students enrolled in college-level mathematics courses. Of those completing the classes, even fewer received grades (A, B, or C) qualifying them for subsequent mathematics courses. Other disciplines, as well, became interested in their student attrition rates. A college-wide committee was formed to collect student information and course data for the period between 2000 and 2002. This data was then entered into the system, Rice’s cohort model.
In 2003, the initial findings from the cohort model were revealed. Among these were:

- the highest rate of attrition occurs among first-time freshmen;

- attrition rates (leaving courses or college) are higher among minority students than majority students, Alaska Native students being the highest. (Alaska Native students are those students who are at least one-eighth Alaska Eskimo, Indian or Aleut. A number of these students come from small villages outside of Anchorage.);

- the highest student attrition occurs in the fall semesters while the lowest occurs in the summer semesters;

- the students who are not retained, Attritors, fail to complete approximately 1.8 of their classes per semester;

- the students who are not retained, Attritors, are less likely to persist and return the following year;

- the highest attrition rate of the six campuses comprising UAA occurs at the Anchorage campus;

- there tends to be an inverse relationship between attrition rate and course number; the highest attrition rates occur at entry-level courses, numbered: 050-099 and at General Education Requirement (GER), college-level courses, numbered: 100-299;

- the attrition rates on the Anchorage campus are the same for regular and adjunct faculty (part time instructor) when considered as a group;

- the attrition rates among full-time faculty reveals that there is an inverse relationship between attrition rate and the faculty member’s rank; the highest student attrition rates occurring in classes taught by Full Professors;

- the attrition rate is highest in the morning sections of a course as compared to afternoon and evening sections of the same course;

- the attrition rate is highest in large classes, over 30 students;
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- the attrition rate is highest in General Education Requirement (GER) courses; the highest attrition occurring in the quantitative skills and natural science courses; and

- the attrition rate is highest in the academic discipline of Mathematics (41 percent); more than 58 percent higher than the next highest attrition rate in the area of Chemistry (26 percent). (Rice 2003, pp. I-II)

Furthermore, in 2003, UAA’s Chancellor identified student success as one of the institution’s highest priorities. It became clear that these initial findings on attrition were simply the beginning. The challenge was to move beyond these to the next level of research. The stage was set for this study, building upon the existing data to address specific questions and concerns to measure student success and goal attainment.

**Researcher’s Interest in Student Attrition**

The matter of high attrition among underprepared college students has been of personal interest and concern to me for more than 38 years. As a college educator, I have addressed my concerns and attempted to improve the issue of student attrition:

- as a mathematics professor, helping ‘high risk’ students successfully complete college-level mathematics courses;

- as a developmental educator, teaching basic mathematics classes using a holistic approach to prepare these students for success in subsequent courses; and

- as a college administrator, designing and implementing a developmental education program integrating entry-level college courses, in mathematics, reading and writing, with learning resources, with the aim of enhancing the classroom experience.
In these roles I have worked with and taught underprepared students in many different settings from small, rural, remote Alaska villages with populations of less than 100 people to large, urban, metropolitan communities of over 500,000 people.

While living in Nome, a small rural city in western Alaska on the Bering Sea, I directed the Eskimo Teacher Education Program from 1979 to 1982. This program delivered college courses to Alaska Native students living in 13 of the 19 remote villages in the Bering Straits Region. These students were completing course work toward a Bachelor’s Degree in Education offered through the University of Alaska Fairbanks while maintaining a subsistence lifestyle. Many were already working in the village school either as Inupiaq language teachers or as teacher aides. Having spent more than two years travelling to these remote villages teaching college-level mathematics and science courses, I developed an understanding of what was required to meet the needs of underprepared minority students, in particular Alaska Native students.

In 1982, I moved to Anchorage where I established the Division of Developmental Education and Learning Resources at Anchorage Community College. As Director and later Dean of this division, I was able to design a comprehensive developmental education program. Within two years of its inception this program received an Exemplary Developmental Education Award from the National Center for Developmental Education (NADE) at Appalachian State University. The program was also cited in the National Directory of Exemplary Developmental Education Programs published by NADE in 1986. All of the developmental courses offered through this program including mathematics courses had attrition rates of less than 20 percent, some as low as 10 percent. This is considerably lower than the current attrition rates in the developmental mathematics courses which range between 40 to 50 percent.
Beginning in 1987, after the University of Alaska was restructured the developmental education program developed in 1982 changed dramatically. The new program was no longer comprehensive in scope or definition. The support services including tutoring, workshops, and counselling were no longer linked to the specific needs of the students enrolled in the developmental courses. Instead, the program reverted back to its remedial roots where the primary teaching method was lecturing. The student support services were no longer coordinated with the academic courses. Instead, the classes were moved to a new department entitled College Preparatory and Developmental Studies. As a result of these changes, the student attrition rates for the classes taught through this new department increased dramatically, equalling the high attrition rates found in the same courses taught through the traditional academic departments. These rates generally range between 40 and 60 percent.

During the restructuring process the faculty members teaching in the original program were offered positions in their respective academic departments of mathematics, English, and education. I accepted a full-time tenured teaching position in the Department of Mathematical Sciences Since that time, I have been teaching underprepared students in developmental and entry-level college mathematics courses.

**Discussion of the Problem: Purpose of the Study**

**Setting**

Mathematics is exciting and challenging for some students. For others, it can be frustrating and defeating. The majority of these latter students complete the minimum requirement of mathematics courses while in high school and find they are unprepared for college work. For them, mathematics is the barrier to future goals and occupations. These underprepared students, often the students who are not retained in college mathematics courses, are those of interest in this study.
As evidenced by Tinto (1993, pp. 14-15; 2007), Bowen, Chingos, and McPherson (2009, p. 4) and the National Center for Educational Statistics (2002, p. 7), the student attrition rate across all postsecondary institutions in the United States has remained at approximately 32 percent for decades, from the early 1970s to 2001. Beginning in 2002, this rate has been steadily rising. The rate of attrition in college mathematics is far greater. At UAA, in particular, the rate of attrition in mathematics is at an alarming 41 percent (Rice 2003, p. II), with the highest rates occurring in mathematics courses taught at the college-entry level, in particular General Education Requirement, courses. A similar situation occurs with course repetitions. Overall, at UAA, approximately 1 in 5 college preparatory enrolments are course repeats (Rice 2003, p. II).

To decrease the overall attrition rate and the attrition rate in college-level mathematics courses, a number of higher education institutions offer developmental courses. Developmental programs providing instructional support systems afford students courses and services that will complement and supplement existing instruction, integrating campus services and community-based services. These systems include remedial/developmental courses, tutorial services, academic counselling and advising, testing and placement services, and faculty support services.

Students find these services encouraging and often helpful. It is essential that these courses and programs be shown effective, providing students with the skills and abilities to succeed in their subsequent courses. The developmental efforts at the University of Alaska Anchorage are typical of most postsecondary institutions in structure and in the lack of serious institutional concern regarding the effectiveness of these efforts.

Of late, the student attrition rates for remedial classes taught through the College Preparatory and Developmental Studies department have equalled the attrition rates of the same classes taught in the traditional academic departments. Generally, these
attrition rates averaged between 40 and 50 percent. These high attrition rates in remedial and entry-level college courses have been a cause for concern at UAA since the early 1990s.

**Objective**

The intention of this study is to identify factors that facilitate the smooth progress of developmental mathematics students to complete successfully required college-level mathematics courses in an effort to reduce student attrition rates in entry-level college mathematics courses. This study examines the relationship between the demographic and the academic performance factors of students in an exit-level developmental mathematics course and their academic performance in a subsequent entry-level college mathematics course. The three objectives are:

- to examine the relationship of the length of the student’s ‘stopping-out’ time between completing the exit-level developmental mathematics course and enrolling in the entry-level college mathematics course and the student’s performance in the college-level course;

- to examine the relationship between the student’s performance in the exit-level mathematics course and the student’s performance in the college-level course; and

- to develop a predictive model of student Academic Success in an entry-level college mathematics course. This model will include a combination of Demographic, ‘Stopping-out’, and Course Performance variables that can best predict the Academic Success of entry-level college mathematics students.

The Population for this study is limited to those students attending UAA during the period from 2001 to 2006 who, after successfully completing MATH A105 (Intermediate Algebra), the exit-level developmental mathematics course, have enrolled in one of three entry-level college mathematics courses: MATH A107
Research Questions and Hypotheses

The design of this study includes three sets of data variables organized by Demographics, ‘Stopping-out’ measures, and Course Performance outcomes.

There are four Demographic variables:

- Age;
- Ethnicity;
- College GPA; and
- Course Load.

There are two ‘Stopping-out’ variables:

- Developmental Attempts, number of repeat enrolments in the developmental course; and
- Duration of ‘Stop-out’, time between enrolment in the developmental mathematics course and the entry-level college mathematics course.

There are two Course Performance variables:

- Developmental Course Grade, academic performance in the exit-level developmental education course, Intermediate Algebra, and
- College Course Grade, academic performance in one of three entry-level college mathematics courses, College Algebra, Applied Finite Mathematics, or Elementary Statistics.

The research questions are listed in the following paragraphs.
Research Question 1: Does the Duration of ‘Stop-out’, the length of time between successive enrolments in the exit-level developmental course and the entry-level college course in the mathematics sequence, predict Academic Success in the college-level mathematics course when the effects of the Demographic and the Course Performance variables are controlled?

Null Hypothesis: The Duration of ‘Stop-out’, the length of time between successive enrolments in the exit-level developmental course and the entry-level college course in the mathematics sequence, does not predict Academic Success in the college-level mathematics course when the effects of the Demographic and the Course Performance variables are controlled.

Research Question 2: Does the Developmental Course Grade predict Academic Success in entry-level college mathematics when the effects of the Demographic and ‘Stopping-out’ variables are controlled?

Null Hypothesis: The Developmental Course Grade does not predict Academic Success in entry-level college mathematics when the effects of the Demographic and ‘Stopping-out’ variables are controlled.

Research Question 3: Which combination of the Demographic, ‘Stopping-out’, and Course Performance factors (Age, Ethnicity, College GPA, Course Load, Developmental Attempts, Duration of ‘Stop-out’, and Developmental Course Grade) best predicts which entry college-level mathematics students will achieve Academic Success.

Null Hypothesis: A unique parsimonious combination of the factors (Age, Ethnicity, College GPA, Course Load, Developmental Attempts, Duration of ‘Stop-out’, and Developmental Course Grade) that will predict which entry college-level mathematics students will achieve Academic Success does not exist.
Variable Sets and General Definitions of Terms

The variable sets used in this study are:

- Demographic;
- ‘Stopping-out’ and
- Course Performance.

**Demographic Variable Set**

*Age:* an interval representing the age of the student in years.

*Ethnicity:* a numerical variable with 6 levels—Alaska Native, Asian/Pacific Islander, Black, Hispanic, White and Other (in no implied order) where each level is designated as a numerical value, 1-6.

*College GPA:* an interval representing the grade point average of a student at the time the student is entering the college-level mathematics course.

*Course Load:* a numerical value, greater than or equal to three, representing the number of credit hours a student is taking during the semester in which the student is enrolled in the college-level mathematics course. A full-time student is defined as one whose course load is twelve or more credit hours, while a part-time student has a course load of less than twelve credit hours.

**‘Stopping-Out’ Variable Set**

*Developmental Attempts:* number of enrolments in the developmental mathematics course. This measure represents the number of attempts a student made to complete the developmental course.

*Duration of ‘Stop-out’:* number of semesters between the last enrolment in the developmental course and the first enrolment in the college-level course.
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**Course Performance Variable Set**

*Developmental Course Grade:* grade of A, B, C, D, F, W, or AU earned in the exit-level developmental mathematics course, Intermediate Algebra.

*College Course Grade:* grade of A, B, C, D, F, W, or AU earned in the selected entry-level college mathematics course.

**General Definitions of Terms**

*Academic Success* is defined as a grade level equivalent to an A, B, or C (4.0 to 2.0) earned in the selected college-level mathematics courses: College Algebra, Applied Finite Mathematics, or Elementary Statistics. The grades will be coded A=4, B=3, and C=2.

*Stopping-out* refers to the phenomenon of a student waiting one or more semesters before enrolling in the subsequent course in a sequential program of coursework. It will be equal to the number of semesters between completing the first course and enrolling in the second course.

*Unsuccessful Completion* is defined as any other permanent grade. These include; D, F, W (Withdrawal), and AU (Audit). The Audit (AU) grade was only counted as an Unsuccessful Completion or Non-Success grade if the student began the course with the intent of earning a letter grade of A, B, C, D, or F and later changed to audit status prior to the 12th week of the semester.

Although some researchers would have elected to group Audit (AU) grades with Incomplete (I) grades and remove them from the study, this researcher elected to use the grade designations applied at the University of Alaska Anchorage. At UAA, the grades of Audit (AU) and Withdrawal (W) are grouped in a grade category separate from the Incomplete (I) grade.
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The Incomplete (I) grade is considered a temporary, ‘Non-Academic’ grade that is used to indicate that the student has made satisfactory progress in the majority of the work in the course, but for unavoidable circumstances is unable to complete the course. A student may apply to receive an Incomplete (I) grade if the student is expected to pass the course and has only a minor portion of the course material to complete before receiving a final grade. The instructor will only grant this grade option by completing an Incomplete Grade Contract form if there is a high probability that the student will receive a grade of A, B, C, or D upon completion of the material. If the student does not complete the material, the faculty member may assign a failing grade of F. The grading process for an Incomplete (I) grade is not considered complete until official confirmation is received by the Registrar from the faculty member that the grade has been converted to an ‘Academic Grade’. If this confirmation is not received from the faculty member prior to the deadline set by the faculty member on the Incomplete Grade Contract, no later than a year from the assignment of the I grade, then the ‘I’ grade will remain as a permanent grade on the transcript (University of Alaska Catalogue, 2003-2004, p. 75).

The Audit (AU) and Withdrawal (W) grades are considered permanent grades and are listed in the grade category ‘Other Designations’. The AU grade indicates enrolment in a course for information only, no credit received. The W indicates withdrawal from a course. The grades in ‘Other Designations’ do not carry grade points and are not used to calculate GPAs (University of Alaska Anchorage 2003, p. 74).

As the developmental course Intermediate Algebra and the college-level courses College Algebra, Elementary Statistics, and Applied Finite Mathematics are considered required courses, students rarely if ever decide to audit these classes at the outset of a semester. Often a student applies to receive an Audit grade (AU) just prior to the twelfth week of a semester. Students, generally, select this option if they are convinced that their current average in the course will result in a punitive grade on their transcript for the course. These students who received the Audit (AU) grade
were those counted in this study, not those who initially enrolled in the course with the intent of receiving an Audit grade.

Although the Audit (AU) grade option is often viewed by students as equivalent to the Withdrawal (W) grade, faculty members set the requirements for this option of Audit (AU) in their courses; often these requirements are different from those of a Withdrawal (W). Both grades are considered permanent and carry no credit. As a result of their designation at UAA, the Audit (AU) grade will be treated in the same manner as the Withdrawal (W) grade in this study, that of an Unsuccessful Completion, Non-Success grade, defined as any permanent grade other than an A, B, or C.

**Significance of the Study**

This study will provide staff and faculty members at postsecondary institutions with information to meet one of their greatest challenges, that of reconciling the issues of lowering attrition without reducing academic quality, open access and student success. It moves beyond the descriptive research stage to address the following questions:

- What effect will various ‘stopping-out’ intervals between the successful completion of the exit-level developmental mathematics course and enrolment in the entry-level college mathematics course have on the successful completion of the entry-level college mathematics course?;

- What effect does the grade in the exit-level developmental mathematics course have on the successful completion of the entry-level college mathematics course?; and

- Which variables will best predict the academic success of students in entry-level college mathematics courses?
Model of Academic Success

One outcome of the study is a model of Academic Success. It will be developed to attempt an explanation of the differences which exist in the academic performance of students in College Algebra, Elementary Statistics, or Applied Finite Mathematics upon completing Intermediate Algebra.

Performance Factors

Three sets of variables or performance factors will be used:

- Course Performance in Intermediate Algebra and one of the entry-level college mathematics courses, measured by the student’s final course grade, where success is defined as a grade of A, B, or C;
- ‘Stopping-out’ time related measures, where Duration of ‘Stop-out’ is defined as the length of time a student allows to pass before enrolling in the subsequent course in a prescribed sequence of courses, measured by the number of semesters between enrolments; and
- Demographics.

Unique Features

Unique to this predictive model, distinct from other models, is its inclusion of:

- the three college-level courses: College Algebra, Applied Finite Mathematics, and Elementary Statistics; and
- ‘stopping-out’ which is common among college students, but has not been extensively researched.

Applications

It is expected that this predictive model will identify a combination of Demographic, ‘Stopping-out’, and Course Performance variables that can best predict the Academic Success of entry-level college mathematics students. Significant gains are
anticipated from the use of the predictive model at two-year and four-year, public and private postsecondary institutions when using information commonly collected and available at these institutions. Findings are expected to benefit secondary and postsecondary counsellors, faculty, and advisors as they assist students with their programs of study, specifically the selection and timing of courses. Applications of the findings include influencing curriculum design, facilitating student success and reducing student attrition rates, particularly in entry-level mathematics college courses.

As teaching faculty become aware of the findings, students will benefit from the latest information and improved advising. Students, by enrolling in the proper course in a timely manner, will have fewer course repetitions and will improve their grades in the developmental mathematics classes as well as the entry-level college mathematics courses, reducing the amount of time spend fulfilling degree requirements and improving their overall grade point averages (GPAs).
Chapter 3: Literature Review: Theoretical basis of factors contributing to reduced student attrition and increased academic success

Overview

As a means of discovering a partial solution to the on-going problem of student attrition in college-level mathematics courses, this chapter establishes the basis for this study by reviewing the existing relevant research in the areas of student attrition and academic success. The study investigates the specific factors affecting these areas and their potential impact upon the smooth progress of developmental mathematics students to complete required college-level mathematics courses successfully. Specifically, it examines the relationship between student academic performance in an exit-level developmental mathematics course and subsequent academic performance in an entry-level college mathematics course.

The review of literature is organized into four sections, each addressing the research findings regarding student attrition and academic success and their relationship to the following:

- Demographic variables;
- Stopping-out variables;
- Course Performance variables; and
- Developmental Education.

The variables selected for this study are treated as viable factors to reduce student attrition and increase academic success as a student progresses from the developmental mathematics course, Intermediate Algebra, to a subsequent entry-level college mathematics course.
These variables include Demographic data consisting of:

- Age;
- Ethnicity;
- College Grade Point Average; and
- Course Load.

The ‘Stopping-out’ factors are:

- Duration of ‘Stop-out’, time between enrolments; and
- Developmental Attempts, number of times the developmental course had been attempted.

The Course Performance measures are:

- Developmental Course Grade in the exit-level developmental mathematics course; and
- College Course Grade in the entry-level college course.

Call for Reduced Student Attrition and Improved Academic Success

Prior to Vincent Tinto’s 1993 study *Leaving College, Rethinking the Causes and Cures of Student Attrition*, most retention research involved correlation studies that had little basis in a conceptual or theoretical framework. Tinto’s study collected data on students from a national sample of fall 1990 freshman students. The data was collected from the American College and Testing Program (ACT) survey of institutions. This information is self-reported by the institution and collected every year for ten years. From his findings in this study Tinto projected that of the 2.1 million students entering higher education for the first time in 1993, over 1.5 million would leave their first institution without receiving a degree. Of those, 1.1 million would leave higher education altogether without completing either a two-year or four-year degree program (Tinto 1993, p. 1).
Chapter 3: Literature Review — 37

This pattern continues. The 2002 study completed by the National Center for Education Statistics asserts that nearly one-third (31.7 percent) of beginning postsecondary students left their institution without a degree or credential within three years of entering the institution. Students attending public two-year institutions were much more likely to leave the college without completing a degree than students enrolled in public four-year institutions (43.6 percent versus 18.8 percent). Students who did not plan to complete a degree at their initial institutions had higher rates of attrition than students with higher degree objectives (27.7 percent versus 17.9 percent at four-year institutions and 59.0 percent versus 43.0 percent at two-year colleges) (National Center for Education Statistics 2002, pp. 7-50).

The 2009 national research study, Crossing the Finish Line: Completing College at America’s Public Universities, completed by Bowen, Chingos, and McPherson confirms that the student attrition rate at public postsecondary institutions in the United States is at an all-time high with only 56 percent of entering students finishing college. This rate placed the U.S. second to the bottom of the rank-ordering by completion rate when compared to 30 countries in the Organisation for Economic Co-operation and Development (Organisation for Economic Co-operation and Development (OECD) 2008, Table A1.3a). With the number of college graduates in the United States in serious decline, there has been tremendous loss of human capital over the past decade (Bowen, Chingos, & McPherson 2009, p. 1).

This current level of educational attainment in the United States is unacceptable, particularly when compared with the dramatic progress of other countries around the world. Of particular concern is their inability to complete degrees in science and engineering. By 2010 it is projected that the United States will face a shortage of 12 million qualified workers for the fastest-growing sectors of the job market where most will require at minimum a bachelor’s degree (Bowen, Chingos, & McPherson 2009, p. 223).
Many postsecondary institutions tend to ‘under report’ the number of students who have departed, skewing the data on attrition. These institutions collect data on their students and attempt to track their attendance and performance. It is particularly difficult to track undeclared majors or non-degree seeking students, many of whom are attending part-time. Institutions will often keep students on the rolls for several semesters even though they are no longer attending.

As the process of student withdrawal is longitudinal in nature, student assessment must also be longitudinal in structure. According to Tinto (1993, pp. 112-115), data collection must be obtained at a number of different points in the student’s passage through the institution, tracing the student’s movement from entry to exit. Any system used to measure attrition needs to be recursive in structure to provide consistent information over time about successive student cohorts, hence, the choice of design for this study.

According to Tinto, attrition among students in postsecondary institutions can be grouped into two general categories, academic dismissal and voluntary departure. Academic dismissal often reflects the inability or unwillingness of a student to meet the minimum academic requirements for college work. A student may not be able to meet these requirements due to individual abilities, poor study skills, or lack of academic preparation. In contrast, voluntary departure is based on daily interactions between the student and others in his environment (Tinto 1993, 2007). Our focus in this study is on academic dismissal, specifically student attrition in entry-level college mathematics courses.

The increase in student attrition at the institutional level is directly affected by student attrition at the course level and in particular student attrition in college-level mathematics courses. As indicated by Bowen, Chingos, and McPherson (2009), there is a serious shortage of students completing degrees in science and engineering. This can be directly attributed to the high attrition rate in college mathematics courses and is reflected in the growing demand for remedial
mathematics courses. According to Pytel (2007, p. 1) colleges have been inundated with students in need of remedial classes in mathematics. The problem has become so overwhelming that colleges are forced to rewrite textbooks, do more reteaching, and force students to take remedial courses without credit. Each semester the University of Alaska Anchorage offers approximately 49 sections of developmental mathematics classes, 7 sections of developmental reading classes, and 33 sections of developmental writing classes. This raises two questions:

- What factors are affecting the poor performance of developmental mathematics students in college-level mathematics courses? and
- What factors will ensure smooth progress of developmental mathematics students to complete required college-level mathematics courses?

To address these, a serious study of the research specifically examining the issue of student attrition and the means of reducing attrition at the institution level via reducing attrition at the course level. A number of the factors affecting student attrition described in the following studies are worthy of exploration in this study to examine their influence on the reduction of attrition in college-level mathematics courses.

**Factors Related to Reduced Student Attrition and Increased Academic Success**

*Demographic Data*

The demographic variables to be discussed are: age, ethnicity, college grade point average and course load.

**Age**

A number of studies confirm that age is a significant predictor when addressing student attrition and academic success. This was the finding in different studies regardless of the type of postsecondary institution, whether a two-year or four-year college or university. As the University of Alaska Anchorage is a ‘hybrid’ institution
incorporating the mission of a community college together with the mission of a university the broad application of age to student attrition and academic success is particularly important.

The most common finding has been that traditional age students (18-24), in particular 18 to 19 year olds, tend to have higher attrition rates in college courses. Whereas, the attrition rate for non-traditional age students (25-60+) is lower. This finding seems reasonable as older students generally attend college with greater purpose and intrinsic motivation. They often have greater academic and personal background knowledge as well as a greater awareness of what is necessary to meet course requirements. These older students frequently enrol in fewer courses per semester and tend to be more focused on their course work.

This was substantiated by the findings in several studies. The first was at William Rainey Harper College, Illinois Institute of Technology, an urban four-year college located in Chicago, Illinois, where a study by Crane, McKay, and Poziemski (2002, p. 11) tracked the cohort of new students to the college in fall 1997 through spring 2001. This study compared the performance of students successfully completing developmental courses with those students who were not successful. It also compared two groups of developmental students with students not required to complete developmental courses. Successful completion was defined as completing the highest level course in a developmental subject area with a grade of at least a C. Information was gathered on 3873 students. The variables considered in the study included: age and ethnicity. The study concluded that students 20 years of age and older did as well if not better than students who were younger in the developmental courses and better than those younger students in the non-developmental classes.

Campbell and Blakey (1996), applied the I-E-O (Input-Environment-Output) model designed by Astin. This model focused on the changes and growth of the student after being exposed to a specific environment. The model acts similar to a ‘value added’ prototype. In application it provides faculty with the ability to identify the
type of environmental conditions that may best facilitate the development of the student’s talents. Campbell and Blakey assessed the impact of early remediation on the persistence and/or the performance of underprepared students at a Midwestern, suburban community college. Using multiple regression analysis, the results indicated the significant predictors of academic performance, success and non-success, of underprepared students based on cumulative GPA were age and ethnicity. Once again the older student was more persistent and earned the higher GPA.

The application of Tinto’s theory (1993) of understanding attrition among college students was empirically tested in several different settings. Halpin (1990) tested Tinto’s theory in a community college setting prior to Tinto’s publication in 1993. His findings revealed that Tinto’s model had predictive validity and that the demographics that determine the reasons and patterns of student departure include race and age.

The findings of Johnson in his 1993 study indicated that age was one of the four variables analysed to find a parsimonious set which could predict academic success in a college level course. Of these, age was identified as one of the two strongest discriminators positively related to academic success. As the student age increases the more likely the student will experience academic success in a college-level mathematics course.

A study conducted by Gary Rice at the University of Alaska Anchorage published in 2002 revealed that traditional age students (18-24) had a higher course attrition rate (42 percent) than the attrition rate (22 percent) for non-traditional aged students (25-60+) (Rice 2003, Table 2 p. 3).
These studies confirm that age is a serious consideration in the study of attrition regardless of the type of postsecondary institution, two year or four year. As the University of Alaska Anchorage is a ‘hybrid’ institution incorporating the mission of a community college together with the mission of a university, age is an essential variable for this study.

**Ethnicity**

The value of equal opportunity for all is engrained in the American ideas of freedom and democracy. A fundamental challenge facing America today is securing equal rights of education for all. Multiple studies have shown that students from minority groups, in particular Black and Hispanic students, are disproportionately at-risk in college, being unprepared for college work (Rowe 2005, p. 2). As a result, ethnicity plays an important role in the study of student attrition. It has been noted as a significant predictor of student attrition in both national and institutional studies, and is clearly an important variable to include in this study.

The national research study, *Crossing the Finish Line: Completing College at America’s Public Universities*, by Bowen, Chingos, and McPherson (2009) followed the progress of students entering four-year public universities in 1999 for a six-year period until graduation, transfer, or withdrawal. Students who withdrew were considered dropouts and thus included in the attrition rate of the institution. In 2006, the college dropout (attrition) rate had reached over 40 percent with fewer than 60 percent of entering students graduating within six years. Their findings show that the United States educational system harbours huge disparities in graduation rates related to race/ethnicity, gender and socioeconomic status. Furthermore, these appear to be growing rather than narrowing. Of particular interest in this study is the disparity in race/ethnicity. The comparable graduation rates of males who graduated within six years of entering a public college or university are 75 percent for Whites, 59 percent for Blacks, 66 percent for Hispanic, 13 percent Native Americans, and 78 percent for Asian/Pacific Islander (Bowen, Chingos, & McPherson 2009, p. 47; Lobo, Talbot, & Morris 2009, pp. 45, 292).
A similar finding was found in an earlier study, *Short-term Enrolment in Postsecondary Education: Student Background and Institutional Differences in Reasons for Early Departure, 1996-1998*, conducted by the National Center for Educational Statistics (NCES) in 2002. This report examined the characteristics and behaviour of freshmen students enrolled in postsecondary institutions in the fall 1996. According to this study one of the most significant factors associated with attrition at public four-year institutions is race/ethnicity. This study examined the fluctuation in minority populations in postsecondary institutions.

Since 1970, the student population in postsecondary institutions has become more diverse with increases in minority groups, of which the largest increases occurred in Hispanic and Asian/Pacific Islander populations. The college attendance rates and college attrition rates vary among these populations. The NCES 2002 study found that Black students who began public four-year colleges were more likely than their White, Asian Pacific Islander, and Hispanic peers to leave within three years (National Center for Education Statistics 2002, p. 36). Some of what accounts for these statistics is the difference in the college enrolment rates between the populations. The rate of college enrolment immediately after high school completion increased from 49 percent in 1972 to 67 percent by 1997. Between 1997 and 2006 the rate has fluctuated between 62 percent and 69 percent. Differences in immediate college enrolment rates among racial/ethnic groups were evident during the period between 1972 and 2006. The enrolment rate for Black high school graduates in 2006 was 13 percentage points lower than for their White counterparts (55 percent versus 69 percent). The gap between Hispanics and Whites high school graduates and their enrolments in college has widened during the period from 1972 to 2006. In the early 1970s the rates were nearly identical. In 2006, the college enrolment rate for Hispanics was 58 percent compared to 69 percent for Whites (National Center for Educational Statistics 2008, p. 39).
Ethnicity was also found to be a contributor to the attrition of students at both a community college (Halpin 1990) and at a four-year Midwestern college, William Rainey Harper College, Illinois Institute of Technology, (Crane, McKay, and Poziemski 2002). At the University of Alaska Anchorage for the total population in Rice’s study (2003), the student attrition course rate for minority students ranged from 35 percent for Hispanic students to 45 percent for Alaska Natives. The average across all minority groups was 40.5 percent while the attrition rate for White students was 26 percent.

Noticeable in these studies is the increased persistence and lower attrition rates of Hispanics among the minority groups as compared to lower persistence and higher attrition rates of Blacks or Alaska Natives. It is uncertain what influence societal roles play in this pattern between minority groups. It is reasonable to assume that some interplay exists and would be an interesting follow-up study.

**College Grade Point Average (GPA)**

College Grade Point Average in this study is defined as the student’s GPA upon completion of the developmental mathematics course, Intermediate Algebra, and prior to entering the college-level mathematics course. It is generally agreed that the student’s overall GPA spanning several semesters is a fair assessment of the student’s academic success in future courses. Although, some institutions and programs set specific limits on the student’s GPA, often 2.5 or 3.0 in a 4.0 system, to ensure a student will be academically successful in the demanding courses within the designated professional program, research does not support a specific GPA for guaranteed academic success in subsequent courses. Although it is worth noting that according to the National Center for Educational Statistics (2002) student GPAs under 2.75 in the first year of college is a significant factor in predicting student attrition. The overall composition of a student’s GPA is significant. Studies by Nobel and Sawyer (1989, p. 351) and Armstrong (2000) have determined that the reliability of a single course grade used to predict student academic success is typically lower than the overall grade point average.
The studies by Crane, McKay, and Poziemski (2002), Rice (2003), and Bowen, Chingos, and McPherson (2009) were conducted at four-year public postsecondary institutions. They examined all courses taken by the students in their study and the grades they received. They also investigated the total number of course withdrawals and the ratio of college credits earned to the number of college credits attempted. The findings identified college GPA as a strong predictor of academic success. This was particularly true when analysing the number of courses dropped. This indicator served as a significant predictor of the successful completion of future courses and degree completion. Grades reflecting poor performance in courses were a strong indicator in Tinto’s (1993) study of student attrition. He indicated that a major cause of student attrition was academic difficulty as reflected in the students’ GPAs.

Related to a student’s overall college GPA are the concepts of ‘overmatching’ and ‘undermatching’ of students with courses, programs and institutions. Generally speaking, educational attainment suffers and students are harmed when two types of sorting errors occur:

- students are ‘overmatched’ by enrolling in courses, programs or institutions for which they are not qualified; or
- students are ‘undermatched’ by failing to enrol in courses, programs or attend colleges or universities where they are appropriately challenged (Bowen, Chingos, & McPherson 2009, p. 227).

The first sorting error of ‘overmatching’ is where students enrol in courses, programs, and institutions for which they are underprepared or unqualified. This error is well-known to produce difficulty for students often leading to poor grades in courses which are then reflected in their overall GPA.

The second sorting error is often ignored in the research and literature. It is the one that deserves more attention than it has received. In this sorting error, ‘undermatching’, students tend to select less demanding courses, programs and...
institutions, and then find themselves less challenged and surrounded by less capable students. Their college GPA suffers. Outcomes of this error include poor course completion rates, lower GPAs, and disappointing graduation rates for these capable students. It is unclear as to whether these students identify themselves with the less capable students and therefore perform poorly or if they are ‘bored’ and lack the drive to improve their grades. The overall affect is that these students were perceived as underprepared. These students may then be placed in even less demanding courses creating a downward spiral often leading to student attrition.

The proper placement of students in both the developmental course and the college-level mathematics courses is important. By providing a means within the first two weeks of the semester to assess the ability of students in the class may be useful. It will help to identify those students who may be ‘undermatched’ for the course having selected the developmental course as a result of the second sorting error. Those students have the ability to switch to a more demanding course.

Students are generally well-advised to enrol in one of the more challenging courses, programs or institutions for which they qualify or have been accepted. It was found that for students who were accepted into demanding programs and courses, they were able to compete successfully. When compared to similar students who elected less demanding courses and less selective institutions, they had higher rates of successful course completions as reflected in their overall college GPA and higher rates of graduation.

Course Load

Course load in this study refers to the number of credit hours a student is taking during the semester in which the student is enrolled in the college-level mathematics course. A full-time student is defined as one whose course load is twelve or more credit hours. A part-time student is a student enrolled in less than twelve credit hours. The research on the relationship of course load to student attrition and academic success is mixed. A number of researchers have found that there is a
higher attrition rate among part-time students versus full-time. While others have suggested that the number of credit hours a student is enrolled in per semester is indirectly related to the student’s academic success.

Related to course load is the number of course withdrawals as well as the number of college credit hours attempted but not completed in a given semester. The change in a student’s number of credit hours within a semester as a result of course withdrawals may change the student’s status from a full-time student to a part-time student. This change can have a direct impact on the student’s academic success and degree completion.

Waycaster (2002), Crane, McKay, and Poziemski (2002), and Rice (2003) have each identified course load as a significant predictor of academic success. In Waycaster’s study fifteen mathematics classes in five colleges were involved. One of the primary variables was course credit hours taken during the semester the students were enrolled in the mathematics classes.

The study by Crane, McKay, and Poziemski tracked the cohort of new students to an urban four-year college in fall 1997 through spring 2001. This study was interested in comparing the performance of students successfully completing developmental courses with those students who were not successful. Information was gathered on 3873 students including:

- number of developmental course withdrawals;
- number of college course withdrawals; and
- ratio of college credits earned to college credits attempted.

Rice’s (2003) study included student enrolments at the University of Alaska Anchorage during the period from 2000 to 2002. These averaged approximately 16,500 students in the fall semester, 16,000 students in spring semester and 6500
students in the summer semester each year. The ratio of full-time to part-time students is 33 percent full-time students to 67 percent part-time students. The attrition rate ranged from a low of 10 percent in summer 2000 to a high of 32 percent in fall 2001. Overall, of the number of students who were considered ‘attritors’, 41 percent were full-time students enrolled in 12 or more credit hours and 22 percent were part-time students enrolled in less than 12 credit hours. The attrition rate among full-time students is just over 2 course sections per semester as compared to 1.5 sections among part-time students. As the actual number of full-time and part-time students who are considered ‘attritors’ is nearly equal (2446 full-time and 2261 part-time), a difference of .5 section per person becomes significant. If the attrition rates could be lowered, part-time students would be likely to progress more rapidly toward their degree goals. As a result of attrition, students end the semester with 48 percent of their starting student credit hours. This is a reduction in their course load of more than 50 percent over the course of the semester. This could have a profound effect on their progress toward a degree. For some students this also changes their status from full-time student to part-time student (Rice 2003, p. 4).

After examining the ratio of college credits earned to college credits attempted, Rice (2003) reported that the greater the number of credit hours attempted the greater the likelihood of attrition occurring. Moreover, with each additional credit hour added to the student’s course load, the complexities, pressure and potential conflicts related to time management and course requirements also increased.

Reviewing these statistics and conclusions, it would appear that students who carry heavier course loads have a higher proportion of course attrition. This is reflected in the finding that the fewer the number of credit hours in which a student is enrolled and the fewer number of courses dropped are significant predictors of academic success and degree completion (Rice 2003, p. 5).
But there is more to this issue of course load. Tinto (1993, p. 20; 2007) has stated that the proportion of students in four-year institutions attending part-time has been steadily increasing. At the University of Alaska Anchorage the percent of part-time students averages 66 percent.

Part-time students take more time to reach their degree goal. Bowen, Chingos, and McPherson (2009, p. 67) find that the time-to-degree matters. The time-to-degree for students carries with it a high cost for both the student and the postsecondary institution. Those students generally taking six years or longer to complete their degree are found to have more courses with failing grades and are at risk of student attrition in subsequent courses. These students are more likely to have delayed their postsecondary enrolment which according to the National Center for Educational Statistics (2002) is one of the most significant factors associated with attrition at public four-year institutions.

In many respects, part-time students feel marginal to the mainstream of institutional life. Often they have different values and are subject to external demands. These students are more likely to be married, to have children at home, to live off campus, and to be employed while attending college. These demands may constrain their interaction with other members of the college and create low academic integration especially their first year which is a significant factor associated with student attrition (National Center for Educational Statistics 2002).

With these distractions, part-time students may find their commitment to their academic goal waning, placing their academic success in jeopardy. Tinto (1993, p. 44) states that students with sufficiently high goal commitment to the completion of their college degree are willing to ‘stick it out’ even in unsatisfactory circumstances, thus remaining in classes they find difficult. Conversely, students whose commitment is weak may, at the first sign of difficulty, withdraw from a course. If the commitment is sufficiently low this withdrawal from classes may later result in permanent withdrawal from higher education.
These differing conclusions regarding the effect of course load on student attrition and academic success warrant the inclusion of this variable in the study.

**‘Stopping-out’ Factors**

The ‘stopping-out’ variables to be discussed are: duration of ‘stop-out’ and developmental attempts.

The basis for students electing to ‘stop-out’ has not been well documented in the literature. Prior to the work of Vincent Tinto, the primary motivations thought to cause a student to ‘stop-out’ between courses or to leave the institution were work related problems, family emergencies, financial pressures, or lack of academic preparedness.

Hertzog (2005) and Tinto (1993) explored the reasons for students leaving college, the causes of student attrition. These motives may well apply to students ‘stopping-out’ between courses and not completing a given sequence of classes, in particular, mathematics courses. They discovered that when students enter an institution they bring with them a variety of background attributes and experiences that establish their college goals and contribute to their commitment to the institution. These factors influence the way students integrate into the academic and social systems of the institution. Students who have strong coping skills and are able to adjust to changes in lifestyle and to increased academic demands are more likely to persist at college.

Those students who feel welcome at an institution are more likely to remain and do well academically. Student-faculty contact plays an important role in a student’s persistence and desire to remain in college (Tinto 1993, p. 56; 2006-2007). According to a number of studies, (Pascarella and Terenzini 1977; Maggio, et al. 2005; Barefoot 2000; Keup 2006) the stronger and more frequent the contact between student and faculty member the more likely the student is to persist,
especially if these encounters go beyond the mere formalities of academic work to include broader intellectual and social issues. In contrast, the absence of faculty contact or contact that includes only formal conversations limited to the confines of course work, the more likely the student will voluntarily ‘stop-out’ or withdraw from his classes and the institution.

As important, is faculty behaviour inside the classroom. Classroom behaviours influence the students’ perception of the faculty member’s receptivity outside the classroom. Those faculty members, who initiate interactions with students and show that they are genuinely interested in the students, improve the students’ chances of remaining at the institution and continuing with the prescribed sequence of courses.

The research by Carini et al. (2006), Barefoot (2004), and Tinto (1993) reveals that the interactions between faculty members and their students play a major role in determining whether or not a student will elect to ‘stop-out’ between courses or from the institution. The behaviour of faculty members and other staff members at an institution may be more important than previously named reasons for ‘stopping-out’.

Although the behaviour of individual faculty members has been shown to be an important factor when evaluating ‘stopping-out’, the design of this research study did not attempt to measure or evaluate the effects of these behaviours or their influences on instruction. By the very nature of college instructional programs, there are a series of faculty members teaching different sections of the same course using a variety of teaching methods and introducing different personalities in to the classroom setting, creating different classroom and learning environments. As a result, the behaviour of the individual teacher creates a serious threat to the validity of this study.
Duration of ‘Stop-out’

The duration of ‘stop-out’ refers to the time between enrolments. In this study it is number of semesters, including summers, between the last enrolment in the developmental mathematics course and the first enrolment in the college-level course.

Four research studies, Doucette and Hughes (1990), Rives (1992), Johnson (1993), and Barrett (2004), evaluated the effects of the Duration of ‘Stop-out’ on student attrition and the Academic Success of students completing a college-level course. The designs of these studies as well as their findings were mixed.

To begin, Doucette and Hughes (1990) state in their study *Assessing Institutional Effectiveness in Community Colleges*, in the section ‘Guide to assessing basic skills and developmental education’, that it is difficult to determine whether students who had completed developmental courses were continuing on to enrol in and succeed at the next level of education in postsecondary programs. Their reason for arriving at this conclusion is described in the following quotation:

> Because underprepared students often follow intermittent enrollment patterns, longitudinal follow-up studies will require a data base and research design that extends at least five years from initial enrollment. Long-term longitudinal follow up is particularly important for underprepared students because their initial goals might not include enrollment in the next level of education, or they may not enroll in a postsecondary program immediately upon attaining basic skills competencies. (Doucette & Hughes 1990, p. 25)

Doucette and Hughes recognized the need for more in-depth studies regarding the effects of the phenomenon of ‘stopping-out’. They suggested that longitudinal follow-up studies be conducted for no less than five years. Their awareness of the need to study the effects of student intermittent enrolment patterns and their impact on student success in subsequent courses set the stage for future research studies.
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Three of these research studies are described: Rives (1992), Johnson (1993), and Barrett (2004). These studies analyse the effect of intermittent enrolment patterns of students. They were conducted for shorter periods of time than the five years suggested by Doucette and Hughes. Despite the difference in the length of time used in each of the studies, it is important to review their findings.

Barbara Rives’ study, *A Structural Model of Factors Relating to Success in Calculus, College Algebra, and Developmental Mathematics (Student Success)*, was completed in 1992. This study was conducted on three campuses of two Texas universities. Data were collected from 1550 students enrolled in developmental, college algebra, and calculus classes. Three instruments were used to collect the data; Rotter Locus of Control Survey, Aiken-Dreger Revised Mathematics Attitude Scale, and Rives Demographic and Math Preparation Scale. The testing of the participants was conducted by faculty members administering the instruments during their regularly scheduled classes in fall 1991. Data related to ‘stopping-out’ included a single question, ‘The last time I took a math class was…’, where students could select from choices beginning with only one or two semesters up to 9 or more years (Rives 1992, pp. 159-160). Rives’ research was not designed as a longitudinal study. The data gathered were the reactions of students to a single question at one specific moment in time.

Upon collecting this information, Rives evaluated the effect of ‘stopping-out’ between completing the current mathematics course and the previous mathematics course by designing a coding system where a higher score represented a shorter length of time between courses and a lower score represented a longer period of time. Interestingly, in this study, the length of time since the last mathematics course and the success in the current course were inversely related. This meant that the longer the student had been away from mathematics classes the more successful the student’s performance in the latter course. Rives found her results puzzling, especially since Padzar (1990) stated that the more time since a student had
practiced a skill or had thought about it in a prescribed way; the more difficult it was to be successful. Rives concluded that further study of ‘stopping-out’ was needed.

In 1993, Laurence Johnson completed his study, Developmental Performance as a Predictor of Academic Success in Entry-level College Mathematics. This study analysed the effects of ‘stopping-out’ between the completion of the developmental course, Elementary Algebra, and the enrolment in the college-level course, Intermediate Algebra. He conducted a longitudinal follow-up study for a period of three years from fall 1989 to summer 1992. The population of his study was composed of 1998 community college students in Austin, Texas. Johnson (1993, p. 167) concluded that the length of time a student allowed to pass between exiting a developmental prerequisite course and enrolling in the subsequent college-level course negatively impacted the grade in the subsequent college-level class. Therefore, the more time that elapsed between completing the prerequisite course and entering the college-level course, the more likely the student would receive a Non-Success grade in the college-level course.

A number of differences exist between this researcher’s study and the study conducted by Johnson (1993). In comparison, Johnson considered Intermediate Algebra a college-level course while this research considered it a developmental course. Johnson’s findings were based on the effects of the variables on the academic success achieved in one college-level mathematics class, while in this researcher’s study three college-level courses were included, College Algebra, Applied Finite Mathematics, and Elementary Statistics. Moreover, Johnson’s study followed the students for a period of three years as opposed to a five year period used in this researcher’s study, as suggested by Doucette and Hughes.

The study by Diane Barrett (2004), Pre-college Level Mathematics Courses in Higher Education: Predicting Student Placement was conducted in California. This study, completed in 2003, explored the factors that influenced the placement of students entering a four-year college into pre-college level mathematics courses
rather than college-level mathematics courses. Barrett similar to Rives based her findings regarding the Duration of ‘Stop-out’ on the responses of students to a single question prior to registration at the college.

According to her research, the length of time since the previous mathematics course was the primary reason in deciding whether a student was ready for college-level courses or required pre-college level classes. Again, as in Johnson’s study, the length of time a student allowed to pass between a prerequisite course and entering a subsequent course negatively impacted the placement of a student into college-level classes. Barrett concluded that the more time that elapsed since a student had practiced a skill or thought about the skill in a prescribed way; the more difficult it was to be successful in performing that skill. Neither the Rives (1992) study nor the Barrett (2004) study employed a longitudinal design.

As noted earlier, the findings from these studies were mixed. Johnson (1993) and Barrett (2004) studies concluded that the more time that elapsed between exiting the prerequisite course or learning a skill and entering the subsequent course or building on the learned skill, the less likely and more difficult it was to be successful. Contrary to these findings, Rives (1992) concluded that the longer a student was away from the prerequisite course the more successful the student’s performance was in the subsequent course.

Analysis of these studies suggests there are several factors that could account for the differences in their findings. Each study determining the effects of ‘stop-out’ was conducted with a different set of students at three different types of postsecondary institutions in three separate locations. Two of the studies based their conclusions on the answer to a single question on a given day in the life of the student. Only Johnson’s study was conducted over a period of time, three-years. It is understandable that the results from these studies might be different.
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Rives’ findings varied most from the other studies. As she based her conclusions on the response to a single question and made no attempt to verify the information given by the students, it is conceivable that the data she received were inaccurate. Moreover, if these students had been asked the same question at another point in time, their response may have been different based on their perceptions at that time. Or as Rives admits herself, the coding for the data may have been misleading. She designed a coding system where a higher score represented a shorter length of time between courses and a lower score represented a longer period of time. Given this coding system, the results could easily be misinterpreted.

As each of these studies failed to adhere to the guideline set down by Doucette and Hughes (1990), that a longitudinal study be conducted for no less than five years, the research is far from complete on this topic. This thesis provides further study on this topic incorporating the ‘stopping-out’ variable.

**Developmental Attempts**

Developmental Attempts refers to the number of enrolments in the developmental mathematics course. The measure of this variable is the number of attempts a student made to complete the developmental course. Although there seems to be a void in the literature specifically addressing the relationship of the number of attempts of the same developmental course and academic success in the college-level course, the accepted belief is that the more repetitions a student has in a particular course, the less likely that student will successfully complete the developmental course when taken after the second try. Common wisdom would suggest that the lack of success in the developmental course after several tries would lead to a similar situation in the subsequent college-level course. Experience often bears this out, particularly when students do not take steps to improve their background by either reviewing prerequisite material or re-enrolling in the prerequisite course prior to attempting the failed class again. As Rives (1992) found in her study, students who have not completed the developmental mathematics
course with a grade of C or better, should not be encouraged to continue on to the next course until the previous course material is mastered.

Supporting this experience are the studies by Bowen, Chingos, and McPherson (2009, pp. 224, 235), Tinto (1993, p. 44, 2007), Pace (1984), and Amos (1990). They recognized that students with a serious commitment to the completion of their program of study or college degree in their current institution are willing to ‘stick it out’ even in unsatisfactory circumstances. In this case the unsatisfactory circumstances could refer to completing classes they find difficult. Conversely, students whose commitment is weak may withdraw at the first sign of difficulty, in this case, from a course. If the commitment is seriously lacking the withdrawal from one class may lead to repeated withdrawals of either the same class or other classes, resulting in either an extended amount of time –to-degree or permanent withdrawal from higher education.

As Pace (1984) concluded in his study, academic outcomes are more closely related to the quality of student effort than either the student’s demographic characteristics or previous academic background. Pace’s basic assumption is that what a student gets out of college depends less on where the student goes to school but more on what the student does once he gets there, the degree and quality of effort the student puts in to his college experience. A follow up study by Tinto, Goodsell, and Russo (1993) demonstrates that the relationship between student effort and gain, student persistence and academic success, is not simply a function of student ability but a reflection of student involvement in the college setting. It is, therefore, important that students become fully involved in the institution in their first year by using the campus facilities including the library, tutor assistance, faculty advising, and counselling assistance. It is also important for students to link up with other students. These opportunities are available to enhance the student’s degree and quality of effort.
A number of studies have shown that the successful completion of introductory courses is critical for first-year students. Typical failure rates in these courses contribute to the attrition rates in subsequent courses and in the institution between the first and second year (Twigg 2005, Rice 2003, Bowen, Chingos, and McPherson 2009, and Tinto 1993, 2007). Most often, these introductory courses are developmental in nature. In comprehensive universities the non-success rate, that of receiving a grade of D, F or W, ranges between 22 percent and 45 percent. These introductory courses generate approximately a third of student enrolments in four-year institutions (Twigg 2005, p. 3).

Worthy of note is the pattern of attrition in the developmental classes at the University of Alaska Anchorage. The attrition rate for first-time freshman in developmental classes is approximately the same as the attrition rate for first-time freshmen in all of their courses (25 percent). However, as the number of total credits earned increases so does the attrition rate in the developmental courses. On the surface this appears somewhat counterintuitive. One would expect that as students have more experience in a collegiate learning environment that they would be more likely to be successful in all of their coursework. This appears to be the case when one observes the increasing GPA mean for students who have successfully completed developmental courses as their student standing increases. However, it appears that juniors and seniors enrolling in developmental courses may be doing so for reasons other than the intended purposes of these courses. This non-alignment of purposes ultimately results in a higher attrition rate for them (Rice 2003, p. 2).

Nearly 10 percent of the enrollees who enter UAA are underprepared students unable to perform in college-level courses. Though research is far from complete on the topic of developmental attempts, identifying the relationship between the number of repetitions of developmental courses and the effect on the academic success of students in college-level courses is of particular importance at UAA, given its population.
Course Performance Measures

The course performance measures suggested for use in this study are the developmental course grade and the college course grade.

Notably absent in many studies are discussions about the meaning and reliability of factors affecting academic success. One such factor is the course grade. At one level, if a course grade is based on the accumulation of points earned on a series of evaluation tasks required as part of a course, then the course grade appears to be an inherent means of measuring academic success and is a ‘unidimensional symbol having multidimensional meanings’ (Pollio, Humphreys, & Milton 1989, pp. 77, 90). The study by Armstrong (2000, p. 691) found that student performance in college including the grade in the last mathematics course taken tended to have a greater effect on the prediction of subsequent course grades than did demographic or situational variables.

Developmental Course Grade

The developmental course grade is defined as a grade of A, B, C, D, F, W, or AU earned in the exit-level developmental mathematics course, Intermediate Algebra. Multiple studies (Crane, McKay, & Poziemski 2002, Johnson 1993, Pytel 2007, Rives 1992, Rice 2003, Waycaster 2002), where a variable is included to determine the success rate of students in a developmental mathematics class, the measurement has consistently been the student’s final course grade. This appears to be the accepted measurement of success or non-success in the given class. As such and to compare results of this study with others, this measurement standard will be used in this study.

College Course Grade

The college course grade is defined as a grade of A, B, C, D, F, W, or AU earned in the selected entry-level college mathematics course. In each of the studies cited above the standard of measurement for success or non-success in the college-level
mathematics course was the end of course grade. Again, for comparative purposes this accepted standard will be used in this study.

**Developmental Education as a Possible Intervention to Reduce Student Attrition and Increase Academic Success**

Examining college and university policies regarding remediation as a means of decreasing student attrition, it is apparent that most assume that simply exposing students to missing academic content will lead to adequate learning and thus reduce student attrition in subsequent courses. This was particularly evident in the 1990s when postsecondary institutions throughout the United States decided to eliminate developmental education programs and remedial courses from their curriculum. The primary reasons given were to reduce costs and increase academic rigor. By 2000 nearly every state in the United States had eliminated these courses from at least one institution. As a result, those students least able to speak up in their own defence were the first to be ‘shut out’ of the very institutions that would provide the means by which they could improve their standing in society. The elimination of these courses occurred at a time when the demand had increased more than two fold (Plucker, Wongsarnpigoon, & Houser 2006, pp. 3-4; Shults 2000, p. 3; Duranczyk & Higbee 2006, p. 22).

The institutions eliminating these programs and courses failed to take into account the tremendous impact these developmental efforts had made on their community and the nation. The result of institutions abandoning developmental efforts can now be seen in the tremendous loss of human capital over the past decade with the number of college graduates in serious decline within the United States over the past decade (Bowen, Chingos, & McPherson 2009, p. 1).

In the institutions continuing to offer developmental classes, the demand for remediation increased particularly in the area of mathematics. By 2007 colleges and universities were overwhelmed by students requiring remedial mathematics classes and the need continued to grow in 2009. The attempt to meet the growing demand at
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the University of Alaska Anchorage resulted in expanding the number of sections of developmental mathematics classes to 49 offered each fall semester and again each spring semester. With the demand continuing to grow, it was still not enough.

Questions remain. When will there be enough developmental sections offered? Is there another strategy to meet the needs of these remedial students? It is troubling to realize that despite the growth in the number of developmental classes, student attrition rates and the number of non-success grades continue to increase in the entry-level college mathematics courses.

A possible intervention to slow down the rise in attrition rates might be the creation of a comprehensive developmental education program. A comprehensive developmental education program is a twofold academic support system designed to promote student success for all students regardless of their academic skill level. This support system includes a series of developmental education courses in reading, composition, mathematics, and study skills together with a network of student support programs. The network of support programs integrates tutoring, workshops, advising and counselling services, learning and computer programs and an early warning grading system (Quirk 2005, pp. 83-92).

What is Developmental Education?

‘If you have built castles in the air, your work need not be lost; that is where they should be. Now put the foundations under them.’ (Thoreau, 1854, p. 243)

Developmental education is a field of knowledge, practice, and inquiry (National Association of Developmental Education 17 May 2008, p. 1). Developmental education promotes the cognitive and affective growth of all postsecondary learners, at all levels of the learning continuum. It promotes the growth of the total person, assisting students to master increasingly more complex tasks, achieve self-direction, and become more socialized. The emphasis is not solely on correcting existing
academic deficiencies but on preparing students to make choices appropriate to their stage of development. The resources of the entire institution are focused on the development of these students (Haig, Bersch, & Easely 1986, p. 1).

**Theoretical Basis of Developmental Education**

Developmental education is a field of practice and research within higher education with a theoretical foundation in developmental psychology and learning theory. Developmental learning theory promotes the mental, emotional, and social development (in increased complexity) of the individual. It focuses on the stages of development of an individual and establishes expectations for learning based on these stages. The field of developmental education focuses on taking students from where they are upon entering the program to as far as they can progress. This is accomplished by using a holistic approach to promote cognitive and affective development. As these students exhibit a wide variety of learning styles, the program accommodates these by providing interdisciplinary teaching combined with student services, including advising, counselling, and academic support. (National Association of Developmental Education 1995, p. 1)

Developmental education gains its strength from its multidisciplinary foundation derived from the disciplines and practitioners of psychology, student development, reading, adult education, and mathematics. The integration of these diverse disciplines is thought to enhance the field by creating an interdisciplinary framework (Casazza 1998, p.14).

Throughout history, theories of learning have been part of the knowledge base which informs the practice of developmental education. Practitioners have been guided by a variety of theories and schools of thought. A number of learning theories have influenced the approaches to learning in the field of developmental education. Among the early influences are:
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- behaviourist theory;
- humanist theory; and
- developmental theory.

Although these three learning theories are derived from outside the field of developmental education, they each impact developmental education in a unique way.

**Behaviourist Theory**

The basic assumption of behaviourists is that individuals respond to external stimuli in their environment. By manipulating the stimuli, through positive or negative reinforcement, it is possible to influence the desired learning outcomes. Skinner (1953, pp. 405-411) viewed education as a means of imparting knowledge and as a means of teaching students to think as well as to observe, organize, and manipulate ideas, materials, and information. The stimuli to encourage learning often consisted of good grades, diplomas, degrees, and awards. These reinforcers were more effective when the individual understood the advantages and rewards of an excellent education.

The behaviourist theory of learning is identified by its clear and measurable objectives. The content is divided into small units of sequential material and provisions are made for immediate feedback. The behaviourist approach influences the delivery of services within the programs. Behaviourists, particularly Skinner, significantly influenced the field of developmental education by creating the basis of several instructional systems including:

- programmed learning (programmed instruction), an individualized approach to the teaching–learning process recognized as one of the first attempts at individualized instruction (Molenda 2008, p. 52);
- computer-assisted instruction, activities offered via the computer that supplement traditional teacher-directed instruction including drill and practice, tutoring, and simulations (Cotton 1991, p. 2);
• mastery learning, a teaching method, beginning with John Carroll and expanded upon by Bloom, based on the principle that all students can learn or master a reasonable amount of material given a sufficient amount of time and the appropriate instruction and support services (Guskey 2007, pp. 12-24); and

• the Keller Plan, a set of educational methods and practices that permit the students to work at their own pace, require students to demonstrate unit-perfection, stress the use of the written word in teacher-student communications, use lectures and demonstrations for motivational purposes only, use tutors and proctors to assist students, and permit students to repeat examinations (Keller 1968, pp. 82-83).

**Humanist Theory**

The humanistic approach affects the overall philosophy of developmental education. The humanist theory emphasizes the worth of the individual and the individual’s natural desire to learn. Similar to the behaviourist, the humanist believes that the environment plays an important role in the learning process. Carl Rogers and others believe that people are naturally motivated to learn. According to Rogers (1959, p. 196), a person has a single, independent motivating predisposition termed the ‘actualizing tendency’. The actualizing tendency is the innate tendency of the individual to develop his capacities to the extent that he is independent of external forces.

In application to classroom instruction, the teacher’s role is to provide a supportive environment that will stimulate the natural learning tendency and provide for open and empathetic communications with each individual, creating the opportunity for acceptance and the free exchange of ideas. According to Cross (1981, p. 228), for developmental programs to implement the humanistic theory, it is essential that the learning environment of these programs provide a variety of learning options, resources, and materials. This will offer students the opportunity to learn in an
environment conducive to their needs, freeing them from dependence on the instructor for information and skill development.

Boylan (1986a, p. 2) states that very few developmental education programs use a complete humanistic approach in either their design or implementation. He attributes this to the nature of the underprepared student. Generally, these students do not take responsibility for their own learning. In response, developmental educational programs are required to be more structured than is suggested by the humanistic approach. Until developmental students become more proficient independent learners, discipline themselves to complete their academic work without constant supervision, and monitor their own progress, the use of a complete humanistic approach is not possible. Still, the humanistic theory has been most useful as a basic philosophy for developmental educators, assisting them in developing instructional methods where students are involved in monitoring their learning progress, developing them into self-directed learners.

**Developmental Theory**

Developmental education courses and programs are most influenced by developmental learning theory. Developmental theory is based on the fundamental assumption that individuals differ in their levels and rates of growth. Students move from one level of knowledge to another at their own pace. Unlike humanists, developmentalists require instructors to take an active role in this growth process. The instructor is required to create a learning environment that is warm, supportive, and encouraging while organizing situations in the environment where content can promote and foster the mental, emotional, and social development of the individual by providing a variety of resources for growth.

Developmental theorists believe that growth is a predetermined, hierarchical process. Individuals interact with their environment and deal with tasks at their own rate of development. An important idea of developmentalists is the concept of the ‘critical period’. It is during this period that an individual is equipped and ready for
experiences that will assist his maturing process. It is therefore important that activities involving the integration of prerequisite skills and innate readiness are made available to the student at this critical time (Roueche & Snow 1977, p. 13). The essence of this theory is central to the foundation and philosophy of the field of developmental education; as such the name developmental education was derived from this learning theory (Boylan 1986b, p. 1).

**Definition of Developmental Education**

Developmental education is a field of study generally depicted as an approach to teaching rather than an academic discipline. As such, the definition of developmental education is given as a description of the elements and techniques incorporated in this holistic teaching style.

In 1995, the National Association for Developmental Education (NADE) established a working definition for developmental education to guide theory, research and practice in the field. This definition focused on a holistic approach to cognitive and affective development of students, acknowledged a wide spectrum of learning styles, and promoted interdisciplinary teaching and incorporated a number of student services.

The National Association of Developmental Education defines developmental education in the following way.

- Developmental education is sensitive and responsive to the individual differences and the special needs of learners.
- Developmental education programs and services commonly address academic preparedness, diagnostic assessment and placement, development of general and discipline-specific learning strategies, and affective barriers to learning (National Association for Developmental Education 1995, p. 1).
Higbee (1991, p. 74) evaluates this definition within the context of cultural pluralism noting that this is a more positive approach for viewing students, in all their complexities, than the negative approach implied in the past by the terms ‘remedial’ and ‘compensatory.’

Goals of Developmental Education

The National Association of Developmental Education established the following goals for the field of developmental education and developmental educators.

- Goal 1: To preserve and make possible educational opportunity for each postsecondary learner.
- Goal 2: To develop in each learner the skills and attitudes necessary for the attainment of academic, career, and life goals.
- Goal 3: To ensure proper placement by assessing each learner's level of preparedness for college course work.
- Goal 4: To maintain academic standards by enabling learners to acquire competencies needed for success in mainstream college courses.
- Goal 5: To enhance the retention of students.
- Goal 6: To promote the continued development and application of cognitive and affective learning theory. (National Association of Developmental Education, 1995, p. 1)

Characteristics of Successful Developmental Education Programs

Creating an environment for student success is the essence of developmental education programs. Donovan (cited in Boylan 2002, p. 19) found that the most successful developmental education programs were those governed by a clearly stated philosophy rooted in the principles of student development and developmental psychology. This philosophy guided the daily delivery of courses and services. The fundamental beliefs of this philosophy are described by Casazza and Silverman:
If we look back at the belief system that many practitioners of developmental education and learning assistance share, we find that one major theme emerges: placing the learner at the center of our practice. Closely aligned with this learner-centred approach is an understanding of the word developmental. The word denotes an educational process that begins with a determination of where learners are, what they want to achieve, and how to help them realize their greatest potential as they work toward their goals. (Casazza & Silverman 1996, p. 260).

**Best Practices of Successful Developmental Education Programs**

According to Spann (1984), ‘developmental education is the application of the best of what we know about learning, teaching, and counselling.’ The elements contributing to a successful developmental education program include elements taken from behaviourists, humanists, and developmental theorists. These include:

- a set of clearly defined goals and objectives for the developmental program and courses;
- an evaluation process to guide design, implementation, and improvement of the program;
- a strong philosophy of learning to guide the writing of goals and objectives and the delivery of services;
- a mandatory assessment and placement process;
- a counselling and advising component specifically integrated into the structure of the program;
- a tutoring program employing well-trained tutors;
- an integration of classroom and laboratory activities;
- a series of courses or workshops on strategic thinking;
- an ongoing student orientation program;
- an integration of critical thinking into the curriculum;
- an institution-wide commitment to developmental education with strong administrative support;
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- a high degree of structure in the courses;
- an implementation of a variety of teaching methods and approaches including mastery learning and Supplemental Instruction;
- a series of classes where student progress is monitored and credit is awarded;
- a set of flexible completion strategies;
- an array of multiple delivery and learning systems including learning communities and paired courses;
- a [teaching] faculty who enjoy teaching in the program;
- an application of sound cognitive theory in the design and delivery of courses;
- a centralized or highly coordinated program;
- a strong interface with subsequent courses including consistency between exit standards of developmental courses and entry standards of college-level courses; and
- a series of training and professional development opportunities for staff and faculty (Boylan 1983, p. 3; Boylan & Saxon 1999, pp. 10-11).

Best Practices in Developmental Mathematics

Among these, according to Duranczyk (2007, p. 3), there are six characteristics that continue to be recommended when discussing the best practices in developmental mathematics education. These are:

- institutional commitment and support;
- professional development for staff and faculty;
- programs created with a theoretical base;
- mandatory assessment and placement;
- comprehensive services; and
- ongoing evaluation.
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**Developmental Interventions**

It is clear from these program characteristics that developmental education is more than remediation for the underprepared student. Developmental education assumes students have the ability to succeed and provides the means for their success in a protective learning environment.

To summarize, the developmental interventions designed to purposely and holistically meet the needs of these students are:

- developmental education courses, taught using a series of learning options, designed to reach a variety of non-traditional students while providing encouragement and strong transitional skills;
- learning communities created within the program to support academic and social development of students;
- tutoring programs;
- learning laboratories (a centralized area where individualized instruction, self-paced learning, workshops, and tutoring functions are provided), generally ancillary to a developmental course or program (Ad Hoc Committee on Basic/Developmental Education 1991, p. 21);
- comprehensive learning centres (an organized, multifaceted, and individualized program where learners, information and facilitators are brought together to assist all students experiencing academic difficulties and all faculty members in the institution, (Christ 1971, p. 39)); and
- academic advising and counselling programs (Boylan, Bliss, & Bonham 1997, p. 2).
Effective Programs

Success Rates of Students

The effectiveness of remedial and developmental education programs is encouraging given that only a few courses are offered and the students are judged to have little or no chance of passing traditional college-level courses without remediation. The effectiveness of these programs can be judged by the progress of students enrolled in them. Students completing developmental programs earn higher grades and persist longer than their non-participating peers (Boylan 1999, p. 1) and (Boylan & Bonham 1992, p. 3).

Students who complete remedial courses are as successful as those who enter college academically prepared (Day & McCabe 1997, p. 4). More than 90 percent of the students who complete developmental writing succeed in freshman composition, while 83 percent of those who complete developmental reading succeed in their initial social science course. The percentage in mathematics is lower but still significant; 77 percent of developmental mathematics students succeed in college mathematics courses (Boylan & Bonham 1992, p. 2). As a result, over 75 percent of the entering underprepared students are retained through the first year with a GPA of 2.0 or higher. It should be noted that developmental students who continue on into the second year often do so at a lower rate than the general college population. According to Boylan (1999, p. 3) these students are more likely to remain at community colleges than four-year institutions. Approximately 40 percent complete a baccalaureate degree. This is close to the national average of 45 percent for traditional, non-developmental students (Boylan 1999, p. 3).

Criteria Used to Determine Effectiveness

Reviews of literature and opinions of experts (Casazza & Silverman 1996, pp. 221-222; Maxwell 1997, pp. 28-32), determined that a remediation program was successful if the program met the following academic criteria:
students were able to complete remedial requirements within a reasonable period of time;

students who successfully completed remedial courses were able to pass college-level courses in the same or similar subject areas;

students who successfully completed remedial courses were able to achieve GPAs comparable to students who were not required to participate in remediation; and

students who took remedial courses were retained over time.

To measure program effectiveness, Weissman, Bulakowski, and Jumisko (1997, pp. 1-2) recommend evaluating the following information:

- course completion success rates;
- percentage of students earning grades of C or better;
- movement of students from remedial to college-level courses;
- successful completion of college-level coursework; and
- student persistence over a three-year period.

These elements are the backdrop for the selection variables used in conducting the study described in this thesis.

Studies have documented a high level of correlation between student success and the following course or program characteristics:

- required entry-level testing;
- mandatory placement into basic skills courses;
- continuous evaluation of the student’s progress;
- curriculum interface between remedial and subsequent college-level courses; and
use of alternative instructional methods including technology (McMillan et al. 1997; Boylan et al. 1997).

Developmental Education Program in Response to Student Attrition

Theoretical Basis

Research investigating student attrition from courses and institutions is generally based on sociological, psychological and educational theories (Marshall 2008). Marshall (2008) identifies the following as the most notable:

- Tinto’s Student Retention Model (1975) that looks at the issues from a sociological standpoint, identifying the importance of integrating the new student into the institution with an emphasis on fostering student and faculty interactions.

- Bean’s Student Attrition Model (1982) that includes a complex set of psychological processes, coping and self-efficacy skills as well as locus of control orientation by which students will determine whether they will continue or withdraw from their studies.

- Astin’s Theory of Involvement (1984), Braxton’s support of active learning (2000), and Chickering’s Student Development Theory (1969) are educational theories. Astin suggests that student involvement is key to retention. Braxton speaks of the value of active rather than passive learning. Chickering classifies student development through the use of ‘vectors’, among these are intellectual competencies (knowledge, critical thinking, analysis, synthesis, and evaluation) and social competencies (interactions and communication skills).

These theories have been studied by numerous researchers as to their effectiveness in assessing and predicting student academic success and student persistence. The findings for successful academic success strategies include developmental education programs that are:
focused on student success and achievement (Tinto 1993; Carini, Kuh, & Klein 2006);

created to be proactive and include pre-enrolment activities, mandatory skill assessment and placement, problem-solving techniques, and academic skill-building activities in all courses (Barefoot 2005; Boylan, Bonham, & White 1999; Kozeracki 2002; Keup 2006); and

designed to improve student integration and academic skill levels by creating learning communities whereby students follow a common block of courses for an entire semester or year, encouraging student interaction with each other and faculty members (Tinto 1993, 2007; Boylan & Saxon 1999; Bean and Eaton 2001; Keup 2006; Barefoot 2004; Carini, Kuh, & Klein 2006).

A number of recommendations are offered in the available literature to reduce student attrition and improve academic success. These include:

- create mandatory placement and skill development programs where academically deficient students, those who have demonstrated skills below the minimum required to succeed in college-level course, are required to enrol in remedial or developmental courses (Moore and Carpenter 1985, p. 103; Perin 2002; Kozeracki 2002; Carini, Kuh, & Klein 2006, p. 23);
- create methods for interfacing between lower and higher skill level courses to provide students with the opportunity for continued success (Tinto 2006-2007, p. 7; Zhao and Kuh 2004);
- employ experienced, full-time faculty to teach in remedial or developmental programs as they are more able to provide student support for improved student retention and academic success. Graduation rates increase when the ratio of full-time faculty to part-time faculty is high (Jacobi 2006);
- monitor attendance and participation in the program. Strong attendance policies improve retention in some cases by as much as 70 percent according to Fowler’s study at Louisiana State University at Eunice (Fowler 2007; Beatty-Guenter 2007; Barefoot 2000);
provide on-going communications between faculty and high risk students and establish an early warning system to alert at-risk students to additional learning assistance and student support services including tutoring, counselling, and study skills sessions (Barefoot 2004; Beck 2001);

evaluate the program to determine if it is meeting the needs of students (Boylan & Saxon 1999, pp. 10-11);

maintain low class enrolments. Small classes tend to increase individual attention and discourage passivity common among at-risk students. Large classes were found to be one of the most significant factors impacting student attrition (Maggio, et al. 2005); and

create a student-centred environment in classes providing active learning experiences that empower students to participate (Keup 2006, pp. 43-44; Barefoot 2000).

When comparing the findings listed above for assessing and predicting reduced student attrition and increased academic success to the best practices for a comprehensive developmental program described earlier, it appears that the components of a comprehensive developmental education program support the findings for reducing student attrition and increasing academic success. The components are linked in the following fashion:

- focus of achievement and success is seen in the a strong philosophy of learning in the goals and objectives of the program, an application of sound cognitive theory in the design and delivery of courses, and structured courses taught by full-time faculty interested in teaching these courses using a variety of teaching techniques and student support service and providing flexible completion strategies;

- a proactive program is seen in a mandatory assessment and placement process, courses and workshops on strategic thinking, well-trained tutors to assist with classes, study skills and counselling components, and an ongoing college orientation program; and

When comparing the findings listed above for assessing and predicting reduced student attrition and increased academic success to the best practices for a comprehensive developmental program described earlier, it appears that the components of a comprehensive developmental education program support the findings for reducing student attrition and increasing academic success. The components are linked in the following fashion:

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- a proactive program is seen in a mandatory assessment and placement process, courses and workshops on strategic thinking, well-trained tutors to assist with classes, study skills and counselling components, and an ongoing college orientation program; and
student integration is seen in the establishment of a learning cohort or community accomplished by enrolling students in a block of courses taught using an interdisciplinary team-teaching approach to several disciplines including reading, writing, and mathematics and by a strong interface with subsequent courses to ensure consistency in standards and seamless streaming between the courses.

Overall, research supports the role of developmental education in reducing student attrition. In a recent study, Moss, and Yeaton (2006) found when examining data from over 1400 students that developmental students had a higher rate of B and C grades and had a lower rate of failures than non-developmental students. In Herzog’s study (2005) comparing a number of factors to dropout, ‘stop-out’, transfer, and reenrolment found that developmental students were more likely to reenrol. A further study by Bettinger and Long (2005) reports that developmental students are more likely to complete a bachelor’s degree within four years than students with similar backgrounds who did not participate in a developmental education program.

These studies lend credence to the possibility that a comprehensive developmental education program may be a viable intervention for reducing student attrition and improving student academic success.

**A Successful Comprehensive Developmental Educational Program**

An example of a comprehensive developmental education program was one designed in 1982 at Anchorage Community College. Within a year of its inception, in 1983, this program was cited as an Exemplary Developmental Education Program by the National Center for Developmental Education at Appalachian State University in Boone, North Carolina and later appeared in *The National Directory of Exemplary Programs.*
In the mid-1980s, while the developmental education program and its faculty and staff members were enjoying national and regional recognition, the State of Alaska was experiencing serious fiscal problems as the result of declining oil prices. By 1986, state revenues had reached an all-time low. Budget cuts were inevitable for all state agencies including the University of Alaska System. In fall 1986, a restructuring plan for the University of Alaska was implemented to cope with the declining revenues. Twelve of the original thirteen community colleges were absorbed into the three existing universities. Duplicate programs, services and staff were eliminated.

The existing exemplary developmental program housed in the Developmental Studies/Learning Resources Division, was split apart. The Learning Resources Center became a separate entity with a different reporting structure from the Developmental Studies Department. The Developmental Studies Department, after restructuring, continued to offer courses in the areas of reading, writing, study skills and mathematics. However the conditions that promoted the success of the original Developmental Education Program no longer existed. The vast array of teaching methodologies and techniques were no longer available. Instead the ‘new’ program reverted back to its remedial roots were the primary teaching method was lecturing.

This new developmental education program was no longer comprehensive in scope or definition. The support services, materials, tutoring programs, and workshops offered through the Learning Resources Center were no longer linked to the specific needs of the students enrolled in the developmental courses offered through the Developmental Studies Department. Also lost in the reconfiguration was the faculty and staff development component, critical to the training of faculty and the creation of innovative materials and courses. The result was a significant decrease in student retention rates in developmental courses. The student retention rates for the original developmental courses program were greater than 85 percent. After restructuring, the retention rates ranged from 40 to 60 percent.
The original developmental education program designed in 1982 prior to restructuring is described in the following paragraphs.

**Description**

The mission of the original developmental education program was to assist underprepared and ‘at risk’ students to succeed in a college setting using a holistic approach that was assessment and advisement-driven. It was designed to assist students in achieving their stated academic goals. The program addressed the needs of a diverse student population from all academic levels, not just those requiring remediation.

This comprehensive developmental education program is presented in outline form in Appendix A, *Program Overview, Developmental Education Model* (Haig 1984a) and in Appendix B, *Looking to the Future, Developmental Education* (Haig 1984b). The *Program Overview* identifies developmental education as a method of teaching unrelated to the level of content of the material taught. This is an important difference between developmental and remedial programs. The chart in Appendix A describes the basic components, delivery methods and populations served by a comprehensive developmental program.

As described in Appendix A, the developmental education program designed in 1982 was divided into three distinct sections. The first section consisted of a developmental learning system for addressing the needs of students with serious learning and skill deficiencies. This section, corrective area, consisted of the a variety of academic courses taught incorporating various methodologies together with a series of student support services including tutoring, counselling and the establishment of learning communities. A second section of the program was devoted to the needs of students requiring fewer skill remedies but in need of counselling and learning assistance. The last section was dedicated to the needs of faculty and staff members. This portion of the program provided staff development seminars, training sessions and informational material to faculty and staff member
from all disciplines throughout the university concerning the educational philosophy and techniques used in developmental education.

The result of these efforts was a significant reduction in student attrition in each of the developmental courses including those in the area of mathematics. The student attrition rate for the developmental classes was less than 15 percent as compared to the same classes taught using more traditional methods. The traditionally-taught classes had attrition rates ranging from 40 to 70 percent.

Components

The individual components integrated into the developmental education program are described in detail in Appendix B. These components served students and faculty from each of the sections described in Appendix A.

Summary

This chapter has provided a broad examination of the literature relevant to this study. The key factors related to student attrition and academic success have been touched on and comparisons drawn in relation to this study. Moreover, a possible academic intervention has been proposed and examined in light of the existing research. The current slowdown in the growth of educational attainment evident in recent decades, due to high student attrition in public four-year institutions in particular within the last decade, poses a serious risk to the economic leadership of the United States (Goldin and Katz 2008).

Some of the studies referenced in this chapter are dated, beginning as early as the mid-1970s. These studies remain relevant today due to the nature of the topics discussed.
Developmental education was introduced as a topic of national importance in the mid-1970s. The definition, goals, and components of successful programs were cited in the literature at that time through the 1980s. Although research continues in this area in relation to student attrition and academic success, the focus now is on applications of former definitions and procedures developed in previous decades.

Studies on student attrition have been ongoing since the early 1970s. Many of the current studies including this one continue to refer back to Tinto’s original groundbreaking study and student retention model in 1975. Subsequent studies have built upon that model. The lasting impact of Tinto’s study of 1975 is the way in which it brought major attention to student attrition at postsecondary institutions. In 1993 with his new book, *Leaving College, Rethinking the Causes and Cures of Student Attrition*, renewed interest was sparked in this area. In 2009 with the publication of Bowen, Chingos, and McPherson’s book *Crossing the Finish Line, Completing College at America’s Public Universities*, issues concerning student attrition are once again at the forefront of attention in colleges and universities throughout the United States. These early studies have become the foundation for the work that has followed and as such continue to remain relevant.
Chapter 4: Research Methodology and Design: Investigating the academic performance of developmental mathematics students in college-level mathematics courses at the University of Alaska Anchorage from summer 2001 through spring 2006

Overview

In this chapter methodology and design of the study are discussed. Methodology is defined as the flexible and continually changing structure of a study that specifies the procedures used in the collection of data and the means used to analyse it (Leedy 1993, p. 9). Several aspects of methodology discussed in this chapter include:

- the selection of the appropriate methodology;
- the research design, identifying the Population and the Sample as well as the method used to select the participants;
- the procedures used to collect and organize the components of the data sets;
- the treatment applied, the Intermediate Algebra course at the University of Alaska Anchorage;
- the research questions, describing the statistical analysis used for each of these questions and identifying the null hypotheses, the dependent variable, the independent and control variables; and
- the validity of the study and its limitations.

Selecting an Appropriate Methodology and Research Design

A Quantitative Approach

This study will examine the relationship between student academic performance in an exit-level developmental mathematics course and subsequent academic performance in one of three entry-level college mathematics courses at the University of Alaska Anchorage during the time interval from 2001 through 2006. It will provide a predictive model of academic success in introductory college-level mathematics comprised of factors from three sets of variables: Demographic,
‘Stopping-out’, and Course Performance. Using these variable sets, an attempt will be made to explain the variance that currently exists in the academic performance of students enrolled in the three college-level mathematics courses: College Algebra, Applied Finite Mathematics, and Elementary Statistics.

A review of research methods reveals that this study lends itself to the use of quantitative research methods. Stainback and Stainback (1984, p. 402) describe quantitative research methods as those which:

- attempt to arrive at an understanding of facts from an outsider’s perspective, retaining an objective view;
- focus on the accumulation of facts and causes of behaviour;
- use structured procedures to verify or disprove predetermined hypotheses; and
- focus on objective data apart from the feelings and thoughts of the individuals collected under controlled conditions.

Research design describes the study’s general plan and the means for collecting data. Robson and Ball (2001, p. 33) note that the choice of a specific research design is dependent upon a number of factors, among these are:

- the purpose of the research; and
- the generally agreed upon methods used in the field.

As described, the purpose of this study is concerned with the measurement, quantification, and statistical analysis of student data in an unbiased manner. The information is viewed as impersonal and objective. Accordingly, the quantitative research design approach is selected for this study.
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*Ex Post Facto Design*

The specific empiricist research design to be used is the *ex post facto* design, given the reliance on previously collected data. *Ex post facto* design or causal-comparative design is used when the data has been previously collected and the possible causes have already occurred. In this design the researcher begins with the effect and by working backwards attempts to identify the cause. As a rule, this statistical design is based on the same principles as experimental designs, except the treatment has already occurred and is not subject to manipulation. *Ex post facto* designs are subject to the same threats to validity as other experimental designs. Hopkins (1980, p. 347) states that to conclude when the independent variable, X, is the cause of differences in the dependent variable, Y, three conditions must be met:

- a statistical relationship must exist between the variables;
- the independent variable, X, must have occurred prior to the dependent variable, Y; and
- the dependent variable, Y, was not influenced by other variables.

Through the use of statistical analysis, an element of control can be incorporated into an *ex post facto* design to compensate for the limitations of this method of study.

*Ex post facto* analyses, despite their limitations, are often the only design available for a study of student outcomes. Often, experimental or even quasi-experimental designs are not appropriate for studies using historical data. The application of the *ex post facto* design to this study is described in detail in the next chapter. A complete explanation of the research design follows.

**Research Design**

This study will examine the relationship between student academic performance in an exit-level developmental mathematics course and subsequent academic performance in a college-level mathematics course at the University of Alaska.
Anchorage. A predictive model of academic success in introductory college-level mathematics will be developed. The model will include three sets of data: student Demographics, ‘Stopping-out’ related measures, and Course Performance measures (grades) in the exit-level developmental course, Intermediate Algebra. With the use of these variable sets, an attempt will be made to explain the academic performance of a student enrolled in one of the following subsequent college-level mathematics courses: College Algebra, Applied Finite Mathematics, and Elementary Statistics.

The use of previously collected, historical data in this study compels the use of an *ex post facto* design. The historical data allows for a longitudinal approach to control for the ‘stopping-out’ phenomenon common among developmental students (Doucette & Hughes 1990, p. 25). Developmental students are not alone in this practice. This is often a common practice among all levels of students: successful, unsuccessful, lower division as well as upper division. These students allow several semesters to pass before enrolling in the subsequent course in the sequence, a frequent occurrence in mathematics courses. It is essential that this phenomenon be included in an examination of the effects developmental performance has on later coursework. The research questions for this study are related to academic success of former developmental mathematics students in the college-level mathematics courses. The data analysis used and the specific research questions are detailed later in this chapter. The process of selecting participants for this study is described in the next section.

**Participant Selection**

The Sample for this study was drawn from the Population consisting of all undergraduate students enrolled at the University of Alaska Anchorage during the five year period from summer 2001 through spring 2006 and who completed the developmental course, Intermediate Algebra, and one of the three college-level mathematics courses listed earlier. Those who met these criteria numbered 2010 students. Among these students, 1858 students received either an Academic Success or a Non-success grade in all courses taken. The students in the Population receiving
an Incomplete (I) grade in either course were eliminated. Thus, the Sample of 1858 students was used in the model for this study.

The information regarding the students included in the Sample was obtained through the information management system at UAA. The University of Alaska System of colleges and universities including the University of Alaska Anchorage maintains an information management system at each university site as a condition of accreditation. This information is located on a mainframe computer using BANNER 2000, a single database designed to support enrollment management, student financial aid, finance, human resources, and advancement systems. BANNER, created by Systems and Computer Technology Corporation, a branch of SunGard Higher Education, manages the information in the files on students enrolled at UAA. The information contained in these files includes demographic data collected during the registration process, course listings, and grades. The data in the files is updated each semester. The information concerning the members of the Student Population was compiled in a format compatible with SPSS for Windows, 2005 edition.

There are approximately twenty-two sections of Intermediate Algebra, MATH A105, offered each fall semester and again each spring semester with sixteen on-campus sections, five off-campus sections, and one taught as a WEB course via the internet. During the summer semesters there are approximately six sections offered at different locations, depending on the year and room availability. Generally one or two sections are taught on-campus and four or five are held off-campus.

In June 2007 the data profiling the students meeting the criteria for this study was compiled from Banner and the UAA Office of Institutional Planning, Research and Assessment (OPRA) Data Warehouse. Although the data includes more than 40 separate variable descriptions only nineteen of these were of interest in this study.
Profiles of the Population and Sample

A brief description of the data collected profiling the Population and the Sample is provided in this section.

Description of the Population

The Population consists of 2010 undergraduate students with the following characteristics:

- 1275 Females and 735 Males;
- 1388 White, 192 Alaska Native, 24 American Indian, 74 African American, 114 Hispanic, 134 Asian/Pacific Islander, and 84 Other;
- average age of 24.1 years, ranging from 14 to 56 years;
- 184 students, fewer than ten percent of the population, reported a high school GPA. Of those students reporting their GPA, the mean was 2.8;
- 1705 Degree Seeking students, 305 Non-Degree Seeking students; and
- 1255 Full-Time students, 755 Part-Time students.

Description of the Sample

The Sample consists of 1858 undergraduate students with the following characteristics:

- 1168 Females and 690 Males;
- 1282 White, 182 Alaska Native, 3 American Indian, 60 African American, 106 Hispanic, 124 Asian/Pacific Islander, 101 Other;
- Average age of 23.9 years, ranging from 14 to 56 years;
- 161 students, less than 9 percent of the population, reported a high school GPA, with a mean of 2.9;
- 1574 Degree Seeking students, 284 Non-Degree Seeking students; and
- 1175 Full-Time students, 683 Part-Time students.
As this is an *ex post facto* study where archival information is used, participants will not be recruited. Only anonymous archival enrolment data and other information will be analysed. The participants selected from the archival data are those students who have taken Intermediate Algebra and one of the three college-level mathematics courses, College Algebra, Applied Finite Mathematics, or Elementary Statistics during the period from 2001 to 2006. All students who met the criteria from the Population are included in the Sample for the study. There is no intention of excluding anyone from the Sample who meets the criteria from the Population.

The participants in this study are members of at least three distinct but overlapping groups of students. A comparison between these groups of students is illustrated in Table 1. The groups are:

- all students enrolled at the University of Alaska Anchorage during the five year period from 2001 to 2006 (N = 166,652);
- all students who enrolled in the Intermediate Algebra course during the five year period (N = 6839);
- all students who persisted in Intermediate Algebra, completing the course within the five year period and who continued on to complete one of the three college-level mathematics courses (N = 2010), the Population; and
- those students who completed the Intermediate Algebra class with an Academic Success grade equivalent of 2.0, 3.0, or 4.0 (C, B, or A) or a Non-success grade of a D, F, W, or AU and completed one of the three college-level mathematics courses (N = 1858), the Sample.

When examining Table 1, the groups of students enrolled in Intermediate Algebra (All Intermediate Algebra students, the students in the Population, and the students in the Sample) appear to have similar characteristics with regard to Age, Gender and Ethnicity. The mean age of all students attending UAA (30.8) during the five year period in question is somewhat higher than the age of the students enrolled in all Intermediate Algebra classes (26.4), and those who completed Intermediate Algebra
within the five year period (24.1), as well as those who persisted and received Academic Success and Non-success grades in the Intermediate Algebra course (23.9).

The difference in the mean ages between the general population of UAA and the Intermediate Algebra population is expected. The majority of the students requiring the Intermediate Algebra course are often recent high school graduates; many completing only the required basic mathematics courses to graduate. The State of Alaska requires Elementary Algebra as the terminal mathematics course for high school graduation. As a result, Intermediate Algebra, the subsequent course in the mathematics sequence following Elementary Algebra, is the single most sought after mathematics course offered at UAA. The interest in this class is defined by the numerous sections offered that are subsequently filled each semester during the registration process. There are more sections of this course than any other mathematics course.
Table 1. Comparison of Age, Gender, and Ethnicity Between the UAA Population, Intermediate Algebra Population, Population of Study and the Sample

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Age</th>
<th>Gender %</th>
<th>Ethnic %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>S.D</td>
<td>Male</td>
</tr>
<tr>
<td>UAA Population (All)</td>
<td>166,652</td>
<td>30.8</td>
<td>NA</td>
<td>39</td>
</tr>
<tr>
<td>Intermediate Algebra Population</td>
<td>6839</td>
<td>26.4</td>
<td>8.9</td>
<td>40</td>
</tr>
<tr>
<td>Population Of Study (Persistent 105 Math Students)</td>
<td>2010</td>
<td>24.1</td>
<td>8</td>
<td>36.6</td>
</tr>
<tr>
<td>Sample (Grades: A, B, C, D, F, W, or AU)</td>
<td>1858</td>
<td>23.9</td>
<td>7.7</td>
<td>37</td>
</tr>
</tbody>
</table>
Although the gender proportions are similar for all groups, the proportion of females enrolled in the Intermediate Algebra classes is slightly lower (1 percent) than in the general student body. The proportion of female students in the Sample who persisted in the Intermediate Algebra course and continued on enrolling in one of the three college-level mathematics courses is higher (3 percent) than the proportion of female students in the Intermediate Algebra classes.

The ethnic proportion of Alaska Natives, Hispanics, and Blacks is higher among those enrolled in Intermediate Algebra than the general population of students attending UAA. The proportion of Alaska Natives, Hispanics, and Asian/Pacific Islander is higher among the persistent students in the Population. Moreover, for Alaska Native students and Asian/Pacific Islander students, the proportion is higher still among the persistent students, those in the Sample who are continuing on to the college-level mathematics courses.

A comparison between the Population (size 2010) and the Sample (size 1858) reveals that these groups are substantially the same in all categories. There are only minor differences in the area of ethnicity between the two groups. The Sample is composed of a higher percentage of Alaska Native students and a lower percentage of Black students as compared to the Population. Overall, the percentages are substantially the same, suggesting that the Sample is representative of the Population for the purpose of this study.

**Procedures for Collecting Data**

This study relied on archival student information compiled from the enrolment management system maintained by the University of Alaska Anchorage using the BANNER 2000 database. The individual participants had no personal contact with the researcher. The identification of all participants was by random number, untraceable back to the individual once the demographic or academic information
was collected. The archival information was collected electronically for each participant.

The data set was assembled from two sources:

- student demographic information and
- course grade records.

This data set was analysed to identify which characteristics or combination of characteristics best predicts success in the entry-level college mathematics courses.

The demographic data is routinely collected at the time of admission to the University of Alaska Anchorage and at each semester during the registration process. The information collected includes student contact information, date of birth, ethnicity, gender, degree status (degree or non-degree), major, course load (exact number of credits), class standing (total number of credit hours to date), first-time freshman (yes or no), and high school GPA. This information is then entered into the university’s computer system indexed by the student’s identification number. Prior to 2005, the student identification number was the student’s social security number. After 2005, students were assigned a randomly generated number for identification purposes.

The course grade records are managed by the BANNER database. Student transcript records are maintained for each student and include the courses taken with the grades received. Faculty members are required to complete the grade record sheets by hand at the end of each semester, specifying the grade earned by each enrolled student. The grade record sheets identify the course number, section number, instructor’s name and the students enrolled at the end of the third week of class. The students are listed by their university identification numbers. The completed grade sheets are submitted to the department secretary, sent on to the Dean’s office, and finally to the Registrar’s Office where a staff member enters the grades into the BANNER database. At each office, the grade forms are checked for accuracy. To
ensure the grading process is accomplished in a timely fashion, the faculty member’s final pay check is withheld until the process is complete.

Use of Cohort Groups

Gary Rice, Associate Vice Provost of Institutional Research, Office of Institutional Planning, Research, and Assessment (OPRA) at UAA developed a strategy for tracking the progress of all students attending UAA. This model of data collection and analysis tracks students for ten years beginning at the semester they enter the institution. The model was created to link the institution’s accountability to its mission by assessing how successful the institution has been in providing learning support to students attempting to reach their goals.

This model creates the unique opportunity of taking a ‘snapshot’ of a group of students for a specified period of time. This group can be divided up into a series of cohorts using one or more student characteristics. Among the characteristics used are age, gender, enrolment status, ethnicity, class standing, class load, high school GPA, and declared major. Using this model to create specific cohorts enables a researcher, faculty member, or university staff member to follow the academic life of a student or group of students from a specified starting date at UAA to a specified completion date. The current model follows these students for a maximum of ten years. The participants in this study formed a cohort for the period, 2001 to 2006 with the select characteristics listed earlier in Chapter 3.

Through the use of the cohort process, appropriate data for this study was gathered. The process began by using a file management system to create a list of UAA students who had enrolled and completed the Intermediate Algebra course and one of the three college-level mathematics courses: College Algebra, Applied Finite Mathematics, and Elementary Statistics during the period from summer 2001 to spring 2006. If a student had multiple enrolments in the Intermediate Algebra course, only the most recent enrolment grade was used. A tally identifying the number of times the student enrolled in the Intermediate Algebra course was
maintained for later use in the study. For a student with multiple enrolments in the
college-level mathematics courses, the first enrolment score was used.
Demographic, course, grade, and enrolment information collected from BANNER
through OPRA was appended to each student file. As described previously, the
student’s anonymity was protected throughout the study by assigning to each student
in the Sample a randomly generated number. The data set was then stored in
OPRA’s Warehouse where it was later accessed.

**Intermediate Algebra, the Developmental Course**

The relationship of academic performance in a developmental mathematics course to
the success in one of three college-level mathematics courses is the focus of this
study. The developmental mathematics course in this study is the Intermediate
Algebra course at the University of Alaska Anchorage during the period from 2001
to 2006.

**Description**

At the University of Alaska Anchorage courses numbering A100 to A199 are
considered freshman-level, lower division courses. Among these courses, MATH
A105 (Intermediate Algebra) is the most frequently offered mathematics course,
averaging 22 sections a semester in the fall and spring with enrolments ranging from
25 to 40 students per section. The high enrolment in this course is a result of several
factors. Among these are:

- an increase in the number of younger students, between the ages of 20 and
  24;
- an increase in the number of more mature students, over the age of 50;
- an increase in the number of underprepared mathematics students required to
  complete advanced mathematics courses for their major; and
- an increase in the number of Associate of Arts degree programs requiring
  Intermediate Algebra as a required and often terminal mathematics course.
During the period from 2001 to 2006 there was a steady decline in the average age of students attending UAA. It declined from 31.3 in 2001 to an average age of 30.3 in 2006. The rise in the number of students between the ages of 20 to 24 accounted for this change. In the fall of 2001 only 4486 students, 24.8 percent of the undergraduate students were in this age range while in fall 2006 the number rose to 6244 students, 32 percent of the undergraduates.

The drop in the average age of undergraduate students suggests that the majority of students enrolling at UAA are recent high school graduates. In Alaska, high school students are required to complete Elementary Algebra to graduate. If high school students are not encouraged to complete more advanced mathematics classes prior to entering college, the subsequent mathematics course in the sequence is Intermediate Algebra. The net result is that a significant number of students entering college are required to enrol in Intermediate Algebra prior to registering for college-level mathematics courses or prior to completing their Associate of Arts or Associate of Science degree program.

A separate population of students enrolling in Intermediate Algebra are the more mature students, those over the age of 50. The percentage of these students also increased during this five-year period but to a lesser degree than the 20-24 year-old group. In 2001, the percent of undergraduates over the age of 50 was 10.5 percent. By 2006 it had increased to 10.9 percent. These older students tend to be more conservative in their assessment of their academic skills, specifically in the area of mathematics. As a result, these students often begin their college career by enrolling in developmental courses including Intermediate Algebra to refresh their academic skills.

**Course Prerequisites**

The designated course prerequisites for MATH A105 (Intermediate Algebra) are to complete MATH A055 (Elementary Algebra), or MATH A060 (Essential Mathematics) with at least a grade of C. The requirements for enrolling in
Intermediate Algebra without completing one of these courses has varied and been modified during the period of this study. Between summer 2001 and summer 2004, students were able to enrol in Intermediate Algebra if they had earned a score of 18-21 out of 36 on the ACT exam, a score of 480-519 out of 800 on the SAT exam, 49+ out of 100 on the ASSET mathematics exam, or a passing score on the placement exam designed by the faculty members in the Department of Mathematical Sciences at UAA.

Standardized exams including SAT, ACT, and ASSET have been available for many years and have been used by postsecondary institutions to determine whether a student is eligible for acceptance into the institution or to determine whether a student is ready for a specific course. The SAT Reasoning Test (formerly Scholastic Aptitude Test and Scholastic Assessment Test) was introduced in 1901 as a standardized test for college admissions in the United States. The SAT is owned and distributed by The College Board, a division of the Educational Testing Service. In 1959 the ACT, a standardized achievement exam, was administered as a competitor of the SAT. It was discovered that some students who did poorly on the SAT did better on the ACT and vice versa. The ASSET Student Success System is a testing and advising program used as a recruiting, course placement, and retention tool. This program includes a series of placement tests including those in the area of mathematics. The ACT and ASSET exams are owned and distributed by the American Testing Corporation.

Beginning in fall of 2004 and continuing through spring 2006, the ASSET exam and the Department of Mathematical Sciences placement exam were replaced with ACCUPLACER, a standardized placement exam designed by The College Board. This exam was composed of two separate tests, the Elementary Algebra exam and the College Level Mathematics (CLM) exam. Students would be eligible to register for Intermediate Algebra if they received a score greater than 70 on the Elementary Algebra test or received a score between 0 and 50 on the College-Level Mathematics test. The College-Level Mathematics test assessed students’ skills from Intermediate
Algebra through Precalculus. A student scoring higher than 50 on the CLM would be eligible to take a college-level mathematics course and would not need to enrol in the developmental course, Intermediate Algebra. ACCUPLACER is an untimed, computer adaptive, placement test that measures skills in math. The questions are selected for the student on the basis of responses to previous questions. This technique selects questions based on the student’s ability level. Students, therefore, must answer every question on the test. This test was developed, standardized, and validated by The College Board.

Although these entry requirements exist at UAA, the current registration process conducted through BANNER is unable to check automatically for the completion of course prerequisites or the results of placement exams prior to or during registration. As a result, students are able to self-select courses without advice from a counsellor or faculty member. Often, students select courses for which they are unprepared and enrol in classes without having the proper academic background. The responsibility for checking each student’s preparation for the course lies with the instructor who conducts a prerequisite check during the first week of the class. If the instructor does not check the student’s eligibility for registration in the course, students are able to remain in the class without the proper mathematics skills or knowledge, often leading to unnecessary student failures or withdrawals.

**Grade Descriptions**

Students who have taken the proper placement exams or have completed the prerequisite course may, also, find themselves ill-prepared for the registered course. For those students and for those who have self-selected a course for which they are unprepared, the university has created an Add and Drop period during the first two weeks of a semester. At that time a student may add or drop a course without grade penalty and without the instructor’s signature. If a student drops a course during this period, it will not appear on the student’s transcript. For those students electing to remain in the class, discovering after the first two weeks that they are not able to master the material, a Withdrawal from the class is possible. This grade, though non-
punitive, will appear on the student’s transcript as a W. Students may withdraw during the 3rd week through the 12th week of the semester without penalty and without the instructor’s approval. After week 12, withdrawals are no longer permitted. Instructors may withdraw a student for non-performance or non-attendance without notifying the student through the 12th week of the semester.

Two additional non-punitive grades are part of the University of Alaska Anchorage grading system. These are the Audit (AU) grade and the Incomplete (I) grade. These grades have specific requirements which must be met prior to assignment. The Audit (AU) grade indicates enrolment in a course for information only; no credit is assigned or received by the student. Students may enrol in the course as an audit student or may elect to change their grade option from credit to audit between the 3rd week and 12th week of the semester.

The Incomplete (I) grade is a temporary grade assignment indicating that the student has made satisfactory progress in the majority of the work in the course. Aside from unavoidable absences or other conditions beyond the control of the student, the student would have successfully completed the course. An Incomplete Grade Contract is filed, detailing the required work that must be completed by the student to receive a permanent final grade. This contract is signed by the student and the faculty member and maintained in the dean’s office for a period of a year. If the course work is not completed within a year from the contract date then the Incomplete (I) grade becomes the permanent grade. Thus, the Incomplete (I) grade could become, at a future date, an Academic Success grade of an A, B, or C; a Non-success grade of a D or F; or the permanent grade of I. As the final outcome of an Incomplete (I) grade is not known when it appears on a transcript, the Incomplete (I) grade has been omitted from the grade options in this study.
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Contact Time

Intermediate Algebra is a 3 contact-hour, 3 credit-hour course. One contact hour is defined as 50 minutes of contact time. This course typically meets either two days or three days per week during the fall and spring semesters for a total of two and half hours per week. In the summer semesters classes meet four days a week for two hours a day for five weeks or four days a week, one and a quarter hours per day for ten weeks. Intermediate Algebra, a developmental course, is taught predominately using the traditional lecture method. Some sections augment the classroom teaching with small group or individualized instruction. Tutoring is available on campus for all Intermediate Algebra students in the two mathematics laboratories, on a first-come, first-serve basis. The number of assignments given and the credit assigned vary with the instructor. Typically, four instructor-designed exams are given during the semester together with a final exam.

Course Location

MATH A105 (Intermediate Algebra), is offered at both on-campus and off-campus locations. Among the 22 sections available for student enrolment each fall and spring, 5 sections, 23 percent, are offered off-campus, 16 sections, 73 percent, are on-campus offerings, and one section, 4 percent of the offerings, is an internet (WEB) course. Student enrolments vary significantly among these sections from 25 students in the WEB course to 40 students in the more traditionally-taught sections offered by the Mathematics Department. During the summer semesters five sections are generally offered, four of the five are off-campus and one on-campus. The enrolments in each of these sections are limited to 30 students.

Teaching Faculty

Full-time and adjunct faculty teach the Intermediate Algebra classes. During the fall and spring semesters, 6 of the 22 sections, 27 percent, are taught by full-time faculty while the remaining 16 sections, 73 percent, are taught by adjunct faculty. In the summers, often all sections are taught by adjuncts.
Anchorage is a mobile community with families employed by the military and the oil industry. The Anchorage School District is constantly in need of new full-time faculty members to teach their mathematics and science courses. For these reasons few adjunct faculty members remain employed at UAA for an extended period of time. To provide uniform course delivery in all sections of Intermediate Algebra, the Department of Mathematical Sciences provides each adjunct faculty member with a course mentor and a course content guide containing the course description, goals and objectives for each assigned course. The course mentor is a full-time faculty member in the Department of Mathematical Sciences who has had considerable experience teaching the course.

Course content and learning objectives for Intermediate Algebra are consistent university-wide. The Department of Mathematical Sciences is responsible for the curriculum and course content. The textbook for the course is a standardized textbook selected by faculty members in the Department of Mathematical Sciences and is used in all sections of the course offered by the department. Instructors are provided with the supplemental materials supplied by the publisher of the textbook including the instructor’s teaching manual, instructor’s solutions manual and bank of pre-printed tests. While faculty members of the Department of Developmental Education also offer several sections of the Intermediate Algebra course and are able to select their own textbook, they must follow the course content guide listing the course objectives developed by the Department of Mathematical Sciences. This guide is updated periodically to ensure consistency within UAA’s mathematics sequence.

The qualifications for teaching each mathematics class offered at the University of Alaska Anchorage are established by the faculty in the Department of Mathematical Sciences. To teach MATH A105 (Intermediate Algebra), full-time faculty members must have a Ph.D. or Master’s Degree in Mathematics, Mathematics Education or related field. A Master’s Degree in Mathematics or a closely related field is the preferred qualification for all adjunct faculty members. If this qualification is not
met, the adjunct faculty member must have completed eighteen credit hours of graduate study in mathematics with a GPA of at least a 3.0 on a 4.0 scale. These eighteen mathematics credits must include 12 semester credits of Calculus and two, three-credit, upper division courses in mathematics.

Teaching experience varies among the adjuncts from no experience in either teaching or tutoring to extensive teaching experience with full control of the class. To preserve the integrity of the course, each adjunct is observed while teaching and evaluated each semester. The first two semesters of adjunct teaching are considered a probationary period.

On the Anchorage campus, for an adjunct faculty member to continue teaching beyond two semesters, the following criteria outlined by the Department of Mathematical Sciences are considered:

- teaching evaluations;
- observation of the adjunct faculty member in a class by a designated tenure-track faculty member from the department. If the observer deems that a second observation is needed, it will be completed by a member of the adjunct faculty committee;
- absences. The Department Chair/Secretary must document all absences of the adjunct faculty member; and
- course information including syllabi, tests and final grades, all of which must be made available to the adjunct faculty committee for review (Department of Mathematical Sciences, University of Alaska Anchorage 2005, pp. 1-2).

The mentor for the course and the members of the adjunct faculty committee are responsible for recommending the continued appointment of the adjunct faculty member after the probationary period. In all circumstances, the final decision lies with the Department Chair.
Despite the efforts of the Department of Mathematical Sciences’ policies to provide uniform instruction for all Intermediate Algebra sections, it is difficult to measure and ensure that the same quality of teaching occurs in each section. Measuring the educational outcomes for a program or course can be complicated by the diversity in teaching styles, individuals, and settings used in the course. Waycaster (2001, p. 413), found that success rates within a course appear to be independent of the type of instruction used; lecture/laboratory or individualized and independent of the faculty member’s rank. Thus, the diversity among adjunct and full-time faculty is not expected to affect the outcomes of this study.

Research Study

Student attrition levels at UAA were on the rise during the 1990s. By fall 2001 the average attrition rate for all courses at UAA, undergraduate and graduate together, was 19.1 percent (Rice 2003, p. II). In the area of mathematics the rate was as high as 41 percent. UAA’s reputation was suffering. Students growing up in Alaska were electing to go ‘outside’ to college rather than attend an ‘in-state’ school. In fall 2001 nearly 75 percent of the students enrolled at UAA were from outside the state. Given these conditions, it was clear that UAA’s enrolment might soon be on the decline. In 2002, UAA’s Chancellor announced that student success was one of the institution’s highest priorities. The institution’s administration was supporting research activities and studies aimed at improving student success and at reducing student attrition. This was the opportune time to begin this study and contribute to the development of this university and other postsecondary institutions.

In response to this need, this research design was developed. This research study examined the relationship between student academic performance in an exit-level, pre-college, developmental mathematics course in conjunction with other performance factors and student academic performance in subsequent, entry-level college mathematics courses. An Academic Success model was developed in an attempt to explain the differences which exist in the Academic Success of students who enrolled in College Algebra, Elementary Statistics, or Applied Finite
Mathematics upon completing the developmental mathematics course, Intermediate Algebra.

The population of the study consisted of students who successfully completed Intermediate Algebra, the exit-level developmental mathematics course, and who subsequently enrolled in one of the following three entry-level college mathematics courses: College Algebra, Elementary Statistics, or Applied Finite Mathematics while attending UAA during the five year period from 2001 to 2006.

**Variables Used in the Study**

The measure used in the analyses was the College Course Grade in the college-level course classified in one of two levels, Academic Success and Non-success. Academic Success was defined as a grade of 2.0, 3.0 or 4.0, (C, B, or A). Non-success was defined as not receiving a numerical grade of 2.0 or higher (a grade of D, F, AU, or W). An explanation discussing the grouping of the Audit (AU) grade with the Non-success grades is given in the section *General Definition of Terms* in Chapter 2 of this thesis.

The independent variable sets consisted of Demographic, ‘Stopping-out’, and Course Performance information related to student performance as cited in the literature. The Demographic set included: Age, Gender, Ethnicity, College GPA (Grade Point Average), and Course Load (number of credit hours).

The ‘Stopping-out’ set included the Duration of ‘Stop-out’ representing the number of semesters between the enrolment in the developmental course and the last enrolment in the college-level course; the lapse between the successive enrolments in the sequential courses. The remaining variable in this set, Developmental Attempts, was the number of repeat enrolments in the developmental course.
Chapter 4: Research Methodology and Design — 103

The Course Performance variable set included three variables. The first, Developmental Course Grade, was the independent variable defined as the final grade received in the last enrolment of the developmental course. The second variable, College Course Grade, was the course grade for the college-level course. This was the dependent or criterion variable for the study.

The statistical controls in the design were the independent variables included in the study. Two approaches were used in the analysis of Academic Success. The first approach employed a stricter method of control. This method entered several independent variable sets into the discriminant functions one at a time, prior to finally entering the variable to be tested in an attempt to isolate the effects of the tested variable. The second approach allowed the variables to enter in any order using a forward selection stepwise procedure. The purpose of this approach was to create a parsimonious model. In this way, the control variables not significantly contributing to the discriminant function could be identified and removed with a backward elimination procedure. These procedures and the research questions are detailed in the next section.

**Statistical Procedure and Research Questions**

Discriminant function analysis, the primary statistical approach used in this study, is a form of regression analysis. There are several purposes for discriminant analysis. These include:

- to classify cases into groups using a discriminant prediction equation;
- to investigate differences between and among groups;
- to determine the most parsimonious way to distinguish among groups; and
- to assess the relative importance of the independent variables in classifying the dependent variable.
This approach is useful in building a predictive model when the criterion, independent variable is used to sort the sample into discrete groups. This is possible through the generation of a discriminant function or equation based on linear combinations of the predictor or dependent variables. With this statistical approach, it is possible to determine if the predictor variables correctly classify individuals in the sample into discrete groups and which variables render the greatest contribution to the group membership (Smith & Glass 1987, p. 216). Although there are other methods that could have been used such as multiple regression, this method lends itself to the creation of a predictor model, a fundamental outcome of this study.

With the assistance of Dr. Cora Neal, the SPSS program was used for this analysis (SPSS 2005). The analysis included the use of the Demographic, ‘Stopping-out’ and Course Performance variable sets described in the previous section to create an Academic Success Model for the entry-level college mathematics course.

**Research Question 1**: Does the Duration of ‘Stop-out’, the length of time between successive enrolments in the exit-level developmental course and the entry-level college course in the mathematics sequence, predict Academic Success in the college-level mathematics course when the effects of the Demographic and the Course Performance variables (Age, Ethnicity, College GPA, Course Load, Developmental Attempts, and Developmental Course Grade) are controlled?

**Null Hypothesis**: The Duration of ‘Stop-out’, the length of time between successive enrolments in the exit-level developmental course and the entry-level college course in the mathematics sequence, does not predict Academic Success in the college-level mathematics course when the effects of the Demographic and the Course Performance variables are controlled.
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A discriminant function analysis was performed using SPSS to answer this question. The dependent variable in the analysis was College Course Grade, classified as Academic Success (A, B, or C grades, grade level between 2.0 and 4.0) and Non-success (D, F, W, or AU grades). The subcommand ANALYSIS within SPSS was used to perform multiple discriminant analyses while controlling the entry order of the variables (SPSS, 2005, p. 456). The Demographic variables and the Course Performance variables were each entered into the analysis as a distinct set. Only then was the Duration of ‘Stop-out’ variable allowed to enter the analysis. The net effect of this approach was to control for the effects of the Demographic and Course Performance variable sets, thus isolating the effect of ‘Stopping-out’ on college-level Academic Success.

**Research Question 2:** Does the Developmental Course Grade predict Academic Success in entry-level college mathematics when the effects of the Demographic, ‘Stopping-out’, and Course Performance variables (Age, Ethnicity, College GPA, Course Load, Developmental Attempts, and Duration of ‘Stop-out’) are controlled?

**Null Hypothesis:** The Developmental Course Grade does not predict Academic Success in entry-level college mathematics when the effects of the Demographic and ‘Stopping-out’ variables are controlled.

The same approach used to answer the first research question was applied in answering the second question. A discriminant function analysis was performed where the dependent variable in the analysis was College Course Grade, sorted in two levels: Academic Success (A, B, or C grades, numerical values ranging from 2.0 to 4.0) and Non-success (D, F, W, or AU grades). SPSS was used with the subcommand ANALYSIS to perform multiple discriminant analyses while controlling the order in which the variables are entered (SPSS 2005, p. 456). The Demographic variables were entered first into the equation as a set followed by the ‘Stopping-out’ variables also entered as a set. At that point, the Course Performance variable, Developmental Course Grade, final grade for the developmental
mathematics course was allowed to enter the analysis. The net effect of this approach was to strictly control for the effects of the Demographic and ‘Stopping-out’ variable sets, thus isolating the effect of the Developmental Course Grade on college-level success.

**Research Question 3**: Which combination of the Demographic, Course Performance, and ‘Stopping-out’ factors (Age, Ethnicity, College GPA, Course Load, Developmental Attempts, Duration of ‘Stop-out’, and Developmental Course Grade) best predicts which entry college-level mathematics students will achieve Academic Success.

**Null Hypothesis**: A unique parsimonious combination of the factors (Age, Ethnicity, College GPA, Course Load, Developmental Attempts, Duration of ‘Stop-out’, and Developmental Course Grade) that will predict which entry college-level mathematics students will achieve Academic Success does not exist.

Although the variable set used in the analysis for this question was identical to the set used in both the first and second research question, here the purpose was not to isolate the effects of performance in the developmental course but to identify a parsimonious set of variables which would predict Academic Success in the college-level mathematics courses. The discriminant analysis stepwise method combining the features of forward selection and backward elimination was employed to permit the variables to enter the classification analysis. The statistic selected for entering or removing variables from the set, the entry criteria, was the minimization of Wilks’ lambda, a variable selection method that selected the variables for entry into the discriminant analysis equation based on how much the variables lower the Wilks’ lambda. The variable, at each step, that minimizes the overall Wilks’ lambda was entered into the equation.
Using the MATRIX subcommand, a correlation matrix of all the pairwise Pearson correlations between the independent variables was created. This matrix was evaluated for the presence of multicollinearity, the undesirable situation when one independent variable is a linear function of other independent variables. Unique solutions in stepwise discriminant function analysis are not possible when linear relationships between the independent variables are present (Smith & Glass 1987, pp. 216-217).

**Ethical Issues**

Due to the nature of an *ex post facto* study where the data is archival and anonymously accessed, the research poses no threat or risk to the participants or subjects. The stress or burden of the research will not affect any participant as there is no contact between the researcher and the participants. Prior to the release of any demographic or academic information on the participants by UAA’s Office of Institutional Planning, Research, and Assessment, a number indicator or code was assigned to each participant. This effectively removed any identifying information about the participant and any link between the researcher and the participants. By eliminating the opportunity for personal contact with the students, either those participating or not participating in the study, the possibility of either posing a risk to or coercing the student subjects has been avoided.

The electronic data will be stored on the hard drive of the Student/Principal Investigator and the hard copies of data will be stored in a locked file at the home address of the Student/Principal Investigator. Student/Principal Investigator and the student’s principal supervisor will have access to the complete gathered data. Upon completion of the study and at the appropriate time, the electronic data will be destroyed by erasing it from the Principle Investigator’s hard drive, and all hard copies will be shredded.
A clear, concise and accurate explanation of the application of the results of the study will be provided. The presentation of the results is critical to its application. As the implementation of the results of the study will be broad based, it is important that the faculty and university advisors understand its meaning prior to advising students to prevent inaccurate advisement of students prior to enrolling in entry-level college mathematics courses.

**Validity and Limitations of the Study**

According to Trochim (2006, ‘Philosophy of Research’, p. 1) validity is ‘the best available approximation to the truth of a given proposition, inference, or conclusion.’ Research arrives at conclusions based on the quality of the measurements used in the study. Validity of research refers to the conclusions reached about the quality of the research methodology. Trochim (2006, ‘Philosophy of Research’, p. 3) states that there are four types of validity:

- conclusion validity;
- internal validity;
- construct validity; and
- external validity.

Each type of validity addresses a specific question. These questions are cumulative. To begin, conclusion validity examines whether there is a relationship between the variables in the study. Assuming there is a relationship, internal validity determines if the relationship is causal. Assuming that there was a causal relationship in the study, construct validity asks if the implemented study was the one intended to be executed (construct of the study) and if the measured outcomes were the ones intended to be measured (construct of the measure). The last type is external validity. Assuming that there is a causal relationship in the study between the constructs of the cause and effect; external validity asks if it is possible to generalize this effect to other situations, people, places or times.
Conclusion Validity

Conclusion validity (statistical conclusion validity) is concerned with whether relationships exist between the data and to what degree the conclusions reached about these relationships are reasonable. This validity is obtained by the appropriate use of statistics. There are several threats to conclusion validity, factors that can lead to reaching incorrect conclusions.

Among these are:

- having low statistical power;
- performing numerous statistical tests to obtain statistically significant findings;
- using measures with low reliability;
- implementing treatments with low reliability;
- performing treatments in settings with other distractions; and
- failing to standardize the administration of the treatment (Parker 1990, 616).

These often create difficulties in identifying a Type I error, falsely rejecting the null hypothesis or a Type II error, failing to reject a false null hypothesis. These threats can lead to one of the following incorrect conclusions:

- there is no relationship when there is one; or
- there is a relationship when one does not exist.

To improve conclusion validity, Trochim (2006, ‘Improving Conclusion Validity’, p. 1) suggests including procedures in the study that will foster:

- standardized implementation of treatment;
- high reliability of measures; and
good statistical power, greater than 0.8, (statistical power improves as the sample size increases).

There are several threats to conclusion validity inherent in this study. One is alpha inflation which can occur when several statistical tests are applied to the same sample. The rate of alpha inflation has been known to accelerate as additional tests are performed (Parker 1990, p. 616). The possibility of a false result can occur when several tests are performed on the sample. Minimizing the possibility of this threat is the use of the multivariate discriminant functions analysis and the application of a lower alpha level. Inherent in this study are the effects of diverse teaching styles and materials. While this complication can be minimized by following the standardized learning objectives listed in the course content guides, ordering common textbooks, and assigning senior faculty members in the Department of Mathematical Sciences to mentor adjunct faculty members. The reliability of the presentation of the material in the Intermediate Algebra course is not consistent; dependent in large part on whether the faculty member follows these guidelines and uses these services. Parker (1990, p. 616) observed that the threat of low reliability increased when different individuals and different settings were used to administer the treatment, in this case the Intermediate Algebra course.

**Internal Validity**

Internal validity for causal studies is the most important type of validity (Parker 1990, p. 613). Internal validity means there is evidence that what was done in the study caused what was observed. Researchers, at times, employ flawed designs that lead to obtaining evidence supporting their research hypotheses, when, in fact, these findings may be explained by other situations rather than the research hypotheses. Several threats to internal validity can be grouped into three categories (Trochim 2006, ‘Internal Validity’, p. 2). The first is the single group threat which occurs when only a single group receives the treatment. The second is the multiple group threat when several groups are used in the study. Finally, there are the social threats to internal validity where the research is happening in a real world setting where
people are reacting not to the effects of the study but to what is happening around them. The third type of threat, the social threat, is a chief concern in this study. There is the possibility of unknown extraneous events occurring during the same period of the study that could affect a student’s performance in the college-level mathematics class. These include:

- crisis within the family;
- problems with friends;
- difficulties at work;
- health concerns;
- financial demands;
- college pressures resulting from the courses the student is taking; and
- other predicaments the student is facing, external to the college-level mathematics course, could interfere with the student’s success in the course.

Several techniques can be used to reduce these threats and control extraneous and error variance. According to Parker (1990, p. 614) the most well-known techniques are:

- random assignment of subjects to treatment and control groups,
- limiting the range or holding constant the extraneous variables,
- including the extraneous or contaminating variables in the research and measuring their effects,
- using statistical control procedures, and
- matching subjects on contaminating or extraneous variables.

The middle three techniques listed above are applicable to this study while the first and the last are not. Since the design of this study is *ex post facto*, not an experimental or quasi-experimental design, there is no control group. The three techniques that do apply are:
restricting the extraneous variable,

including extraneous variables into the research design, and

using statistical control procedures. For unknown extraneous events that could have occurred during the period of the study and that may have affected a student’s performance in the college-level mathematics course, no attempt was made to identify or control for these events in the study. Other changes including maturation and developmental changes most likely have taken place during this same period. Although these are unrelated to the variables in the study, there is no doubt that they have affected the performance of the students. However, no attempt was made to list, measure, or determine the influence of these changes on the student performance of those in the Sample.

Construct Validity

Construct validity involves generalizing from the measures in a study to the concept of these measures (Trochim 2006, ‘Construct Validity’, p. 1). With regard to an individual variable, construct validity refers to whether or not the variable is adequately defined and accurately measured. A number of threats to construct validity exist. Among these are:

- inadequate preoperational explanations of constructs (did not do a good job of defining (operationally) the meaning of the construct);

- mono-operational bias, mono-method bias;

- hypothesis-guessing;

- researcher’s expectations;

- confounding levels of constructs;

- generalizing across time; and

- interaction of procedures and treatments (Parker 1990, p. 617).
The threat of mono-operation bias, where the study is performed on a single population at a specific time and place, is particularly true for *ex post facto* studies (Trochim 2006, ‘Threats to Construct Validity’, p. 1). In these studies there is a dependence on pre-defined variables and existing data. The threat occurs when the reliance on these might under-represent the supporting constructs or contributes to the extraneous variance. In this study several of the independent variables have multiple levels, presenting a threat of confounding levels of constructs.

**External Validity**

External validity is concerned with generalizing the conclusions of this study to other people, places and time frames. To generalize across time and places it is necessary to administer the procedures in the study at different times and in different locations. To generalize across people, it is important to have the sample for the study be a representative group of the entire population. Threats to external validity include formulating poor generalizations across people, places, or times. Two methods for improving external validity are:

- using random selection to obtain the Sample and protect against high dropout rates; and
- providing an extensive amount of data describing the degree of similarity between groups of people, places, and time periods (Parker 1990, p. 615).

It is obvious that the best method to use to strengthen the external validity of a study is to replicate it in a variety of places, with different populations, and at different times.

In this study, the most apparent threat to the external validity is the use of the Sample from UAA as a representative sample of university students in general or of all developmental students, or even of developmental Intermediate Algebra students at UAA at a different time, whether past or future. One primary purpose of this study is to provide a model which faculty and staff at UAA and other universities and colleges might use to evaluate their academic, developmental, or college-level
programs. Several other threats to the external validity exist in this study as a result of the nature of the study, the methods used and the findings. Among these threats is the use of different categories of faculty to teach the Intermediate Algebra course.

College instructional programs involve the efforts of numerous teachers from a variety of backgrounds including: full-time, part-time, novice, experienced, etc. These teachers bring to the classroom different teaching styles, personalities, and evaluation environments which will undoubtedly influence the delivery of the Intermediate Algebra course. Affecting the study are the other courses the students are taking during the same semester. The population for this study consists primarily of full-time students with a course load of at least 12 credit hours per semester. Therefore, most if not all students in the Sample are enrolled in other courses at the same time as they are taking the developmental course and the college-level mathematics course. The material taught in these other courses and the methodologies used will undoubtedly influence these students. This research does not attempt to isolate or measure the effects of these influences.

The discussion in this chapter has taken a critical look at the method and design of the research study. An examination of the ‘ex-post facto approach, the procedures for data collection and organizing the data sets, and the use of the discriminate function analysis approach to the research questions was detailed. The chapter concluded with a look at the types of validity and limitations of the study to be considered.
Chapter 5: Results

Overview

The purpose of this study is to identify factors to facilitate the smooth progress of developmental mathematics students to complete successfully required college-level mathematics courses. The relationship between student academic performance in an exit-level developmental mathematics course and the academic performance in one of three subsequent college-level mathematics courses taken at the University of Alaska Anchorage between 2001 and 2006 will be examined in an attempt to identify these factors. The predictive model of Academic Success for the entry-level college mathematics courses, College Algebra, Elementary Statistics, and Applied Finite Mathematics will feature Demographic, ‘Stopping-out’, and Course Performance variables.

The findings of the discriminant function analyses used to evaluate the hypotheses are described in detail. The topics discussed include statistical power, effect size, and reliability. Featured are the descriptive measures of the variables and the correlations between them. This data is presented in Table 2 through Table 14.

Statistical Power and Effect Size

Two types of statistical errors are addressed in the discussion of statistical power and effect size, a Type I error and a Type II error. A Type I error is the act of rejecting the null hypothesis when it is true. The probability of a Type I error occurring is denoted by $\alpha$. A Type II error is the act of accepting the null hypothesis when it is not true. The probability of a Type II error occurring is denoted by $\beta$. While both errors are important and a balance must be achieved between them, Stevens (1996, p. 172) suggests that more attention should be paid to the Type II error as this is the basis for the power of the statistical test. Statistical power, $1 - \beta$, is the probability of rejecting the null hypothesis when it is false.
According to Parker (1990, p. 616), the power of a statistical test is a function of three factors: the alpha level, the sample size, and the effect size; where effect size refers to how much of a difference the treatment makes or the degree to which changes occur in the dependent variable as a result of changes in the independent variables. An increase in statistical power will result by increasing any or all of the three factors. Although each of these is important, Stevens (1999, p. 174) states that power is heavily dependent on sample size. For any given effect size and alpha level, increasing the sample size will increase the power. He suggests that the operational definition for the power of a large group is at least .80. The optimal sample size is one that provides for this power. According to Stevens (1996, p. 174), when the sample size is large, greater than 100, power is not an issue.

In this study, the Population consisted of 2010 students who have taken the developmental mathematics course, Intermediate Algebra, and persisted completing one of the three targeted, entry-level college mathematics courses, College Algebra, Applied Finite Mathematics, or Elementary Statistics. Of these, 1858 students completed the Intermediate Algebra course and one of the college-level mathematics courses earning Academic Success or Non-success grades in each of the courses, grades other than the Incomplete (I) grade. This latter group composed of 1858 students became the sample for the study. The sample size for this Sample far exceeded the 100 suggested for high power.

**Reliability**

Discriminant function analysis is a mathematical maximization process which was originally developed in 1936 by R. A. Fisher. It is a classic method of classification, a procedure for identifying relationships between quantitative criterion variables and quantitative predictor variables. In this study, where the purpose is the classification of characteristics into groups on the basis of a predictor variable, discriminant function scores can be used to predict membership in a particular group. In discriminant function analysis, a discriminant function is developed using a weighted combination of predictor variable values to classify an object into one of
the criterion variable groups. It is constructed in such a way that the items’ scores separate or discriminate those items in the different categories of the criterion variable.

Reliability is based on the quality of measurement. In research, according to Trochim (2006, ‘Theory of Reliability’, p. 1) reliability refers to the consistency of results when a study is carried out repeatedly. Hence, a measure is reliable if it gives the same result repeatedly. Although reliability cannot be computed directly, an estimate of reliability can be made as a correlation between two observations on the same measure.

According to Stevens (1996, p. 265), two studies in Monte Carlo have shown that when using discriminant function analysis it is essential that the ratio of the sample size relative to the number of variables be large; otherwise the standardized coefficients and the correlations are unstable. When this ratio is low, the results from one sample may not be replicated by a different sample. To avoid this problem and achieve consistent and reliable results from the discriminant function analysis, Stevens suggests that the population include a minimum of 20 participants per variable.

The Population consists of 2010 students who received either an Academic Success or Non-success grade in the Intermediate Algebra course and one of the three college-level mathematics courses. The Sample with 1858 students is composed of 92.4 percent of the 2010 students in the Population. The Sample is arrived at by eliminating those students from the Population who received an Incomplete (I) grade in either of the two completed courses.

To determine the reliability of this study, a ratio of the size of the sample to the number of variables was computed. The Sample used in the models for this study was 1858. The total number of variables in the study is 13, including 12
independent variables and 1 criterion variable (Academic Success in the college-level mathematics course as measured by College Course Grade). The ratio of the number of participants or subjects, 1858, to the number of variables, 13, revealed there were 143 participants per variable, far exceeding the minimum of 20 suggested by Stevens for consistent and reliable results from discriminant function analysis.

A comparison was made between the Population and the Sample to determine whether these two populations were similar. This comparison is illustrated in Table 2 through Table 4. As the Sample is composed of a high percentage of the Population (92.4 percent) and the data in Tables 2 through 4 reveal similarities between these populations in the Demographic, Stopping-out, and Course Performance Variable Sets, it can be seen that the two populations are equivalent. It is, therefore, reasonable to assume the Sample is representative of the Population.
Table 2. Descriptive Statistics for Developmental Variable Set [all groups of Intermediate Algebra (developmental mathematics) students]

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Age</th>
<th>Ethnic</th>
<th>College GPA</th>
<th>Course Load</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>S.D.</td>
<td>Mean S. D.</td>
<td>FT (≥ 12 Cr. Hrs.)</td>
</tr>
<tr>
<td>Intermediate Algebra UAA (All)</td>
<td>6839</td>
<td>26.4</td>
<td>8.9</td>
<td>N/A N/A</td>
<td>45</td>
</tr>
<tr>
<td>Population Of Study (Persistent Students)</td>
<td>2010</td>
<td>24.1</td>
<td>8</td>
<td>2.72 0.82</td>
<td>62.4</td>
</tr>
<tr>
<td>Sample (Grades: A, B, C, D, F, W, AU)</td>
<td>1858</td>
<td>23.9</td>
<td>7.7</td>
<td>2.75 0.82</td>
<td>63.2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Age</th>
<th>Ethnic %</th>
<th>College GPA</th>
<th>Course Load</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Sample (Grades: A, B, C, D, F, W, AU)</td>
<td>1858</td>
<td>23.9</td>
<td>7.7</td>
<td>5.6</td>
<td>63.2</td>
</tr>
</tbody>
</table>
Chapter 5: Results —120

Table 2 represents the descriptive statistics for the Demographic Variable Set for three groups: all Intermediate Algebra students, the Population of the study, and the Sample. The Intermediate Algebra group consists of 6839 students. These students enrolled in the Intermediate Algebra course during the five year period between 2001 and 2006 and remained in a class through the third week of the semester. Only 2010 students of the 6839 students completed Intermediate Algebra and continued on to enrol in one of the following college-level courses: College Algebra, Applied Finite Mathematics, and Elementary Statistics. Those students who continued on and enrolled in one of the college-level courses constituted the Population. The Sample was comprised of 1858 students from the Population receiving either Academic Success or Non-success grades, not a grade of Incomplete (I), in the Intermediate Algebra course and in the selected college-level mathematics course.

Comparing the Intermediate Algebra population and the Sample as detailed in Table 2, there are some significant differences. The one area where the Sample, the Population and all students enrolled in Intermediate Algebra are similar is in the overall GPA. The overall GPA for the students in the Sample is the highest, 2.75. The Population GPA is slightly less at 2.72 while the overall GPA for all students enrolled in Intermediate Algebra is 2.70. This is understandable as some of the members of the larger group of all Intermediate Algebra students will receive Incomplete (I) grades affecting the overall GPA as well as their decision to persist onto a college-level mathematics course.

According to Rojstaczer (2009, p. 1), the average college GPA is 3.07 for all colleges and universities, public and private, in the United States. Clearly, the Intermediate Algebra students at UAA fall far below this mark. This difference may be a function of the mission and open admission policy of UAA. At the University of Alaska Anchorage, students are accepted into the university regardless of their previous academic record and enrol in courses of their choosing if they meet the prerequisites. For students to be accepted into a professional program of study quite
the opposite is the case. Students must complete specific prerequisites and meet strict academic standards prior to acceptance and entry into these programs.

The finding from a study conducted by the National Center for Educational Statistics (2002) is of great concern. It states that a significant factor in predicting student attrition is if a student’s GPA falls below 2.75 in the first year of college. The average GPA in each group of students enrolled in Intermediate Algebra at UAA is either at the 2.75 GPA or below. Clearly not all students enrolled in Intermediate Algebra are freshmen. However, the low average GPA may be a significant reason for a high attrition rate not only in the mathematics courses but in the institution overall.

The Sample is significantly younger, with more students in each of the following groups: Female, Full-Time (enrolled in 12 or more credits), AK Native, Hispanic, and Asian/Pacific Islander, while including fewer White and Black students. The Sample cannot be considered representative of all students enrolled in Intermediate Algebra classes.

Conversely, the Sample is virtually identical to the Population. These populations vary by merely a tenth of a percentage point in the areas of Age, Gender, all Ethnic groups, and College GPA. The area of greatest difference is Course Load. The difference is nearly a percentage point, revealing more Full-Time students are in the Sample than the Population.
### Table 3. Descriptive Statistics for 'Stopping-Out' Variable Set

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Developmental Attempts</th>
<th>Duration of 'Stop-out'</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>S.D.</td>
</tr>
<tr>
<td>Population (persistent students)</td>
<td>2010</td>
<td>1.18</td>
<td>0.496</td>
</tr>
<tr>
<td>Sample (Grades: A, B, C, D, F, W, AU)</td>
<td>1858</td>
<td>1.17</td>
<td>0.475</td>
</tr>
</tbody>
</table>

Table 3 compares the means and the standard deviations of the Population and the Sample for each of the two ‘Stopping-out’ variables, the Developmental Attempts and the Duration of ‘Stop-out’. Developmental Attempts refers to the number of times a student has been listed as enrolled in the developmental course after the third week of the semester. The number of times the student has repeated the developmental course prior to enrolling in the college-level mathematics course. Some students have had as many as 6 repetitions.

Duration of ‘stop-out’ refers to the number of semesters between the last enrolment in the developmental mathematics course and the first enrolment in the subsequent college-level mathematics course. A duration value of one indicates that the student enrolled in the subsequent college-level mathematics course immediately, the very next semester after completing the developmental course. Examining the data files, 802 students of the 1858 students, 43 percent of the Sample, ‘stop-out’ at least one semester before enrolling in the college-level mathematics course. The Duration of ‘stop-out’ for those students who ‘stop-out’ at least one semester before enrolling in the college-level course is 3.14 semesters. However, a number of students ‘stop-out’ more than 6 semesters and some students ‘stop-out’ as many as 14 semesters between the two courses.
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For the variable, Duration of ‘Stop-out’, the means and standard deviations of the two populations, the Sample and the Population, are nearly identical, separated by only a hundredth of a point. In conclusion, the Sample is an accurate representation of the Population.

Table 4. Descriptive Statistics for Developmental Course Variable Set

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Developmental Course Grade</th>
<th>College-level Course Grade (%) (Academic Success in Groups)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>S.D.</td>
</tr>
<tr>
<td>Population (persistent students)</td>
<td>2010</td>
<td>2.69</td>
<td>0.843</td>
</tr>
<tr>
<td>Sample (Grades: A, B, C, D, F, W, AU)</td>
<td>1858</td>
<td>2.84</td>
<td>0.843</td>
</tr>
</tbody>
</table>

*Prior probability of success in the population is 65%

Table 4 features two population groups, the Population (2010) and the Sample (1858) comparing the Developmental Course Grade statistics of mean and standard deviation for each population. The Table 4 also compares the Academic Success of students in each of these groups, where Academic Success is defined as the number and percentage of students receiving a success grade of an A, B, or C in the entry-level college mathematics course.

The comparison of the Developmental Course Grade between the two populations reveals that the mean grade of 2.84 for the Sample is considerably higher than that for the Population, 2.69. This may be a reflection of the fact that those students who have received an Incomplete (I) grade in Intermediate Algebra, the developmental course, were removed from the Population to form the Sample. Although the Incomplete (I) grade is a non-punitive grade when computing a student’s GPA, it creates a penalizing effect when calculating the mean grade for an entire set of
grades. The Incomplete (I) grades in the set of scores are not assigned a point value, thus not contributing to the total accumulation of points. The number of students producing the grades, however, has increased; causing the mean GPA to be lower than the computed GPA when the Incomplete (I) grades are not included in the computation.

Comparing the percent of academically successful students in each population reveals that the Sample has a higher percentage than the Population (65 percent versus 63 percent). The Population includes students who have received an Incomplete (I) grade in Intermediate Algebra. Of those students receiving an Incomplete (I) grade in the developmental course and continuing on to the entry-level college course, many would not have the academic background to earn a success grade of an A, B, or C in the college mathematics course, essentially lowering the percentage of academically successful students.
### Table 5. Sample Model--Correlation Matrix (p < .05, N = 1858)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Academic Success</th>
<th>Age</th>
<th>College GPA</th>
<th>Course Load</th>
<th>Develop. Attempts</th>
<th>Duration of Stop-out</th>
<th>Developmental Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.867</td>
<td>1</td>
<td>0.165</td>
<td>-0.297</td>
<td>0.017</td>
<td>-0.018</td>
<td>0.076</td>
</tr>
<tr>
<td>White (Dummy Variable)</td>
<td>0.156</td>
<td>0.078</td>
<td>0.096</td>
<td>-0.026</td>
<td>-0.009</td>
<td>-0.001</td>
<td>0.031</td>
</tr>
<tr>
<td>Black (Dummy Variable)</td>
<td>-0.046</td>
<td>0.027</td>
<td>-0.047</td>
<td>-0.001</td>
<td>0.054</td>
<td>-0.036</td>
<td>-0.059</td>
</tr>
<tr>
<td>AK Native (Dummy Variable)</td>
<td>-0.145</td>
<td>-0.037</td>
<td>-0.021</td>
<td>0.069</td>
<td>0.007</td>
<td>0.013</td>
<td>0.029</td>
</tr>
<tr>
<td>Hispanic (Dummy Variable)</td>
<td>-0.023</td>
<td>0.003</td>
<td>-0.032</td>
<td>-0.026</td>
<td>0.001</td>
<td>-0.024</td>
<td>-0.029</td>
</tr>
<tr>
<td>Asian/P I. (Dummy Variable)</td>
<td>-0.041</td>
<td>-0.091</td>
<td>-0.057</td>
<td>-0.011</td>
<td>-0.014</td>
<td>0.004</td>
<td>-0.012</td>
</tr>
<tr>
<td>College GPA</td>
<td>0.867</td>
<td>0.165</td>
<td>1</td>
<td>-0.034</td>
<td>-0.294</td>
<td>-0.053</td>
<td>0.514</td>
</tr>
<tr>
<td>Course Load</td>
<td>-0.201</td>
<td>-0.297</td>
<td>-0.034</td>
<td>1</td>
<td>-0.026</td>
<td>-0.063</td>
<td>-0.081</td>
</tr>
<tr>
<td>Developmental Attempts</td>
<td>-0.205</td>
<td>0.017</td>
<td>-0.294</td>
<td>-0.026</td>
<td>1</td>
<td>-0.006</td>
<td>-0.074</td>
</tr>
<tr>
<td>Duration of Stop-out</td>
<td>-0.034</td>
<td>-0.018</td>
<td>-0.053</td>
<td>-0.063</td>
<td>-0.006</td>
<td>1</td>
<td>-0.13</td>
</tr>
<tr>
<td>Developmental Course Grade</td>
<td>0.746</td>
<td>0.076</td>
<td>0.514</td>
<td>-0.081</td>
<td>-0.074</td>
<td>-0.13</td>
<td>1</td>
</tr>
</tbody>
</table>
Correlation Matrix for the Sample Academic Success Model

The correlation matrix presented in Table 5 lists the significant Pearson pair-wise product moment coefficients of correlations ($p < .05$. N = 1858) among the 17 independent variables included in the Academic Success Model for the Sample. Academic Success was defined to be a numerical value equivalent to one of the following grades, A, B, or C, achieved in the college-level mathematics course. Included in this model of 12 variables were 5 ‘dummy’ variables representing each of the ethnic groups: White, Black, Alaska Native, Hispanic, and Asian/Pacific Islander.

Meaningful relationships exist between the remaining independent variables represented in Table 5. The strongest significant correlations were between the following pairings. Those with positive correlations are:

- Academic Success and Age ($r = 0.867$);
- Academic Success and College GPA ($r = 0.867$);
- Academic Success and Developmental Course Grade ($r = 0.746$); and
- Developmental Course Grade and College GPA ($r = 0.514$).

Those with negative correlations are:

- Academic Success and Developmental Attempts ($r = -0.205$) and
- Academic Success and Course Load ($r = -0.201$).

The variables significantly correlated to the criterion variable of Academic Success measured as a grade level between 2.0 and 4.0, C, B, or A in the college-level mathematics course are:

- Age ($r = 0.867$);
- College GPA ($r = 0.867$);
- Developmental Course Grade ($r = 0.746$);
- White ($r = 0.156$), ‘dummy’ ethnic variable;
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- Developmental Attempts ($r = -0.205$);
- Course Load ($r = -0.201$); and
- AK Native ($r = -0.145$), ‘dummy’ ethnic variable.

College GPA ($r = 0.514$) is the only independent variable significantly correlated with Developmental Course Grade. College GPA is also the only variable positively correlated to Academic Success and Developmental Course Grade.

The independent variables named in the ‘Stopping-out’ set, specifically Duration of ‘Stop-out’ and Developmental Attempts are not significantly correlated with either Academic Success or Developmental Course Grade.

Test of Hypotheses

The primary statistical approach used in these analyses was discriminant function analysis. Each of the three analyses conducted can be considered Academic Success models, as the dependent or criterion variable was Academic Success, the grade received in one of the three college-level mathematics courses. The sample of 1858 cases was used to establish classification functions which were used to answer the three research questions. Wilks’ lambda was used to test the significance of the discrimination function with $\alpha = 0.05$, the rate of significance compared to chance given the prior probabilities derived from the data set. The results from each of the tests will be described later in this chapter. The specifics of each analysis are described according to the individual research question.

Research Question 1: ‘Stopping-out’ Time

In this section Research Question 1 is analysed. The Demographic, ‘Stopping-out’, and Course Performance variable sets were used to model Academic Success in the college-level course. A discriminant function analysis was performed on the Sample using forced entry of the variables by set. The criterion or dependent variable,
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College Course Grade, is described in two categories: Academic Success, defined as a numerical value equivalent to a grade of A, B, or C; and Non-success, defined as not receiving a numerical value equivalent to one of the above grades instead receiving a grade of D, F, W, or AU.

**Research Question 1:** Does the Duration of ‘Stop-out’, length of time between successive enrolments in the exit-level developmental course and the entry-level college course in the mathematics sequence, predict Academic Success in the college-level mathematics course when the effects of the Demographic and Course Performance variables are controlled?

**Null Hypothesis:** The Duration of ‘Stop-out’, length of time between successive enrolments in the exit-level developmental course and the entry-level college course in the mathematics sequence, does not predict Academic Success in the college-level mathematics course when the effects of the Demographic and Course Performance variables are controlled.

To answer this question, SPSS was used with the subcommand ANALYSIS to perform multiple discriminant analyses while controlling the order in which the variables were entered (SPSS 2005, p. 456). The Demographic variables were entered first into the equation as a set followed by the Course Performance variable (final grade) for the developmental mathematics course, Developmental Course Grade, and the number of repeated enrolments in the developmental course, Developmental Attempts. At that point, the ‘Stopping-out’ variable, Duration of ‘Stop-out’, the number of semesters between completing the developmental mathematics course and enrolling in the entry-level college mathematics course was allowed to enter the analysis. The net effect of this approach was to control strictly for the effects of the Demographic and Course Performance variable sets, thus isolating the effect of ‘Stopping-out’ on college-level Academic Success.
According to Klecka (1980, p. 23) two methods are often used to interpret discriminant function analyses. These are:

- examination of the standardized coefficients, used to determine which of the variables are redundant, or
- examine the discriminant function, variable correlations.

These methods suggest which variables are most closely aligned with the canonical variable, represented by the discriminant function. In either case, the largest absolute values of the coefficients or correlations are used for interpretation. The standard coefficients and the discriminant function-variable correlations for the first research question are presented in Table 6.
Table 6. Hypothesis 1: Duration of 'Stop-out'

Standardized Canonical Discriminant Function Coefficients and Pooled-Within-Groups Correlations Between Discriminating Variables and Canonical Discriminant Function

<table>
<thead>
<tr>
<th>Variables</th>
<th>Standardized Canonical Coefficients</th>
<th>Pooled-Within-Groups Correlations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.105</td>
<td>0.289</td>
</tr>
<tr>
<td>College GPA</td>
<td>0.57</td>
<td>0.85</td>
</tr>
<tr>
<td>Course Load</td>
<td>-0.137</td>
<td>-0.197</td>
</tr>
<tr>
<td>Developmental Attempts</td>
<td>-0.07</td>
<td>-0.258</td>
</tr>
<tr>
<td>Developmental Course Grade</td>
<td>0.456</td>
<td>0.731</td>
</tr>
<tr>
<td>Duration of 'Stop-out'</td>
<td>0.005</td>
<td>-0.044</td>
</tr>
<tr>
<td>White (Dummy Variable)</td>
<td>0.08</td>
<td>0.194</td>
</tr>
<tr>
<td>Black (Dummy Variable)</td>
<td>0.054</td>
<td>-0.011</td>
</tr>
<tr>
<td>AK Native (Dummy Variable)</td>
<td>-0.085</td>
<td>-0.142</td>
</tr>
<tr>
<td>Hispanic (Dummy Variable)</td>
<td>0.002</td>
<td>-0.059</td>
</tr>
<tr>
<td>Asian/P. I. (Dummy Variable)</td>
<td>0.01</td>
<td>-0.074</td>
</tr>
</tbody>
</table>
Four variables were found to make the strongest contribution to the prediction of Academic Success in the college-level course. These variables, listed with their standardized canonical coefficients, include:

- College GPA (0.570);
- Developmental Course Grade (0.456);
- Course Load (-0.137); and
- Age (0.105).

Reviewing the data in Table 6, it is clear that even after controlling for the effects of Age, Ethnicity, Developmental Attempts, Course Load, and College GPA, College GPA is the most powerful predictor. This is borne out by the high correlation of College GPA with the discriminant function, 0.850. The variable Developmental Course Grade is a very strong predictor as well. This is supported by the high correlation of the Developmental Course Grade with the discriminant function, 0.731.

Examination of the pooled-within-groups correlations of the variables with the discriminant function reveal that there are four variables strongly correlated with this discriminant function. These are:

- College GPA (0.850);
- Developmental Course Grade (0.731);
- Age (0.289); and
- Developmental Attempts (-0.258).
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According to this data, a student’s possibility of success in the college-level mathematics course increases as:

- College GPA increases;
- Developmental Course Grade improves;
- Age increases; and
- Number of Developmental Attempts decreases.

These findings also reveal that the variable Duration of ‘Stop-out’, with its small negative value, has virtually no effect on Academic Success in the college-level course.

Table 7. Hypothesis 1: Duration of 'Stop-out'

<table>
<thead>
<tr>
<th>Description of Canonical Discriminant Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
</tr>
<tr>
<td>----------</td>
</tr>
<tr>
<td>1</td>
</tr>
</tbody>
</table>

(a) First 1 canonical discriminant function was used in this analysis.

A test of significance was performed to evaluate the significance of the discriminant function. Table 7 lists the eigenvalues, canonical correlation of the variables, taken together with the discriminant function, and the values of Wilks’ lambda and Chi Square, and the associated significance level. The null hypothesis for testing Wilks’ lambda is that the canonical correlation is zero; the variables do not discriminate between the levels of the criterion variable. As Table 7 illustrates, the value for the Wilks’ lambda, \( \Lambda \), 0.851, indicates that the discriminant function is significant at the \( p < .05 \) level.
The discriminant function for the variable Duration of ‘Stop-out’ proved to be significant. The Duration of ‘Stop-out’ variable was found not to contribute to the prediction of Academic Success in entry-level college mathematics after controlling for Age, Gender, Ethnicity, College GPA, Course Load, DevelopmentalAttempts to complete the developmental course, and Developmental Course Grade. The conclusion is that there is not enough evidence to reject the Null Hypothesis for Research Question 1. Therefore, it appears that the length of time between the completion of the developmental course and the enrolment in the college-level course has little effect on the successful completion of the college-level mathematics course. This result indicates that the effects of ‘stopping-out’ may require further investigation.

Table 8. Hypothesis 1: Duration of 'Stop-out'

Classification Results for the Sample (N=1858)

<table>
<thead>
<tr>
<th>Actual Group</th>
<th>N</th>
<th>Predicted Group Membership</th>
</tr>
</thead>
<tbody>
<tr>
<td>Success</td>
<td>1210</td>
<td>820 (67.8%) 390 (32.2%)</td>
</tr>
<tr>
<td>Non-success</td>
<td>648</td>
<td>212 (32.7%) 436 (67.3%)</td>
</tr>
</tbody>
</table>

Percent of ‘grouped’ cases classified correctly: 67.6%

The classification results for the Sample (1858) are presented in Table 8. The model correctly classified successful and non-successful students 67.6 percent of the time. This represents an improvement over chance by 4 percent [(0.6760/.65) – 1], as the prior probability of success in the population was 65 percent, the percent of students from the original population of 1858 who received a success grade in the college-level course. The classification result is slightly better than chance.
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**Research Question 2: Developmental Mathematics Course Grade**

An analysis of Research Question 2 is presented in this section. The Demographic, ‘Stopping-out’, and Course Performance variable sets were used to model Academic Success in the college-level mathematics course. The criterion College Course Grade is described in two categories: Academic Success, defined as a numerical grade equivalent to an A, B, or C; and Non-success, defined as a grade of D, F, W, or AU. The procedures used in this analysis are similar to those used in the analysis of Research Question 1.

**Research Question 2**: Does the Developmental Course Grade predict Academic Success in entry-level college mathematics, when the effects of the Demographic, ‘Stopping-out’, and Course Performance variables are controlled?

**Null Hypothesis**: The Developmental Course Grade does not predict Academic Success in entry-level college mathematics when the effects of the Demographic, the ‘Stopping-out’, and Course Performance variables are controlled.

A discriminant function analysis was performed on the Sample using forced entry of the variables by set. The dependent variable in this analysis was the College Course Grade. The same analysis procedures used with Research Question 1 were used to analyse this question. The subcommand ANALYSIS SPSS was used to perform multiple discriminant analyses while controlling the order in which the variables were entered (SPSS 2005, p. 456). For Research Question 2, the Demographic variables were entered first into the equation as a set followed by the ‘Stopping-out’ variables also entered as a set. At that point, the Course Performance variable (final grade) for the developmental mathematics course was allowed to enter the analysis. The net effect of this approach was to strictly control for the effects of the Demographic and ‘Stopping-out’ variable sets, thus isolating the effect of the Developmental Course Grade on college-level Academic Success.
### Table 9. Hypothesis 2: Developmental Course Grade

Standardized Canonical Discriminant Function Coefficients and Pooled-Within-Groups Correlations Between the Discriminating Variables and the Canonical Discriminant Function

<table>
<thead>
<tr>
<th>Variables</th>
<th>Standardized Canonical Coefficients</th>
<th>Pooled-Within-Groups Correlations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.105</td>
<td>0.289</td>
</tr>
<tr>
<td>College GPA</td>
<td>0.57</td>
<td>0.85</td>
</tr>
<tr>
<td>Course Load</td>
<td>-0.137</td>
<td>-0.197</td>
</tr>
<tr>
<td>Developmental Attempts</td>
<td>-0.07</td>
<td>-0.258</td>
</tr>
<tr>
<td>Developmental Course Grade</td>
<td>0.457</td>
<td>0.731</td>
</tr>
<tr>
<td>Duration of 'Stop-out'</td>
<td>0.005</td>
<td>-0.039</td>
</tr>
<tr>
<td>White (Dummy Variable)</td>
<td>0.08</td>
<td>0.194</td>
</tr>
<tr>
<td>Black (Dummy Variable)</td>
<td>0.054</td>
<td>-0.011</td>
</tr>
<tr>
<td>AK Native (Dummy Variable)</td>
<td>-0.085</td>
<td>-0.142</td>
</tr>
<tr>
<td>Hispanic (Dummy Variable)</td>
<td>0.002</td>
<td>-0.059</td>
</tr>
<tr>
<td>Asian/P. I. (Dummy Variable)</td>
<td>0.01</td>
<td>-0.074</td>
</tr>
</tbody>
</table>
As stated earlier, the methods used to interpret discriminant function analyses are:

- to examine the standardized coefficients, which were used to determine which of the variables were redundant, or

- to examine the discriminant function, variable correlations.

These methods indicate which variables are most closely aligned with the unobserved trait which the canonical variate (discriminant function) represents. The largest absolute values of the coefficients or correlations are used for interpretation. The standard coefficients and the discriminant function-variable correlations for the second research question are presented in Table 9.

Four variables were found to make the strongest contribution to the prediction of Academic Success. These, listed with their canonical coefficients, were:

- College GPA (0.570);  
- Developmental Course Grade (0.457);  
- Course Load (0.137); and  
- Age (0.105).

It appears from this data that College GPA and Developmental Course Grade are the strongest predictors of success in the college-level mathematics course. This is substantiated by the very high correlation of College GPA with the discriminate function of 0.85 and the high correlation of Developmental Course Grade with the discriminant function of 0.731.

An examination of the pooled-within-groups correlations of the variables with the discrimination function reveals there are four variables strongly correlated with the discriminant function. These are:

- College GPA (0.850);  
- Developmental Course Grade (0.731);  
- Age (0.289); and
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- Developmental Attempts (-0.258).

According to this data, a student’s possibility of success in the college-level mathematics course increases as:

- College GPA increases;
- Developmental Course Grade improves;
- Age increases; and
- Number of Developmental Attempts decreases.

Once again, the Duration of ‘Stop-out’ had a very small negative effect on Academic Success in the college-level mathematics course.

A separate test of significance was performed to evaluate the significance of the discriminant function. Table 10 lists the eigenvalues, canonical correlation of the variables, taken together with the discriminant function, and the values of Wilks’ lambda and Chi Square, and the associated significance level. The null hypothesis for testing Wilks’ lambda is that the canonical correlation is zero; the variables do not discriminate between the levels of the criterion variable. As Table 10 illustrates, the value for the Wilks’ lambda, \( \Lambda \), of 0.851 indicates that the discriminant function is significant at the \( p < .05 \) level.
Tables 10. Hypothesis 2: Developmental Course Grade

Description of the Canonical Discriminant Function

<table>
<thead>
<tr>
<th>Function</th>
<th>Eigenvalue</th>
<th>% of Variance</th>
<th>Canonical Correlation</th>
<th>Wilks' Lambda</th>
<th>Chi Square</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.175 (a)</td>
<td>100</td>
<td>0.386</td>
<td>0.851</td>
<td>298.2</td>
<td>0.00</td>
</tr>
</tbody>
</table>

(a) First 1 canonical discriminant function was used in the analysis

As the discriminant function proved to be significant and the Developmental Course Grade variable was found to strongly contribute to the prediction of Academic Success in entry-level college mathematics when controlling for Age, Ethnicity, College GPA, Course Load, Developmental Attempts to complete the developmental course, and Duration of ‘Stop-out’; the null hypothesis for Research Question 2 was rejected.

The classification results for the Sample (1858) are presented in Table 11. The model correctly classified successful and non-successful students 67.6 percent of the time. This represents an improvement over chance by 4 percent as the prior probability of success in the population was 65 percent. The classification result is slightly better than chance.
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Table 11. Hypothesis 2: Developmental Course Grade

Classification Results for the Sample (N = 1858)

<table>
<thead>
<tr>
<th>Actual Group</th>
<th>N</th>
<th>Predicted Group Membership</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Success</td>
</tr>
<tr>
<td>Success</td>
<td>1210</td>
<td>821 (67.9%)</td>
</tr>
<tr>
<td>Non-success</td>
<td>648</td>
<td>213 (32.9%)</td>
</tr>
</tbody>
</table>

Percent of 'grouped' cases classified correctly: 67.6 %

_Research Question 3: Creating an Academic Success Model for College-level Mathematics_

The third and final analysis was to answer Research Question 3. In this analysis the variable set was identical to the two used to complete the analysis for the first and second research questions. This time, instead of isolating the effect of ‘Stopping-out’, as in Research Question 1, or isolating the effect of Developmental Course Grade, as was the case in Research Question 2, the purpose of this analysis was to find a parsimonious set of variables which could be used to predict Academic Success in the college-level courses.

_Research Question 3:_ Which combination of the Demographic factors (Age, Ethnicity, Course Load and College GPA), the ‘Stopping-out’ factors (Developmental Attempts of the developmental mathematics course and Duration of ‘Stop-out’, time between enrolments), and the Course Performance factor (Developmental Course Grade) best predicts student Academic Success in an entry-level college mathematics course.
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**Null Hypothesis**: A unique parsimonious combination of the factors Age, Ethnicity, Course Load, College GPA, Developmental Attempts, Duration of ‘Stop-out’, and Developmental Course Grade that will predict student Academic Success in an entry-level college mathematics course does not exist.

To answer this question a stepwise discriminant function analysis was used, combining the elements of both forward selection and backward elimination to permit the variables to enter the classification analysis. The entry criterion was the minimization of Wilks’ lambda. The correlation matrix, Table 5, of all pair-wise Pearson correlations between the independent variables was created to test for the presence of multicollinearity. There were several variables significantly correlated with Developmental Course Grade; the highest correlation was with College GPA (0.514). All other correlations with the Developmental Course Grade were less than $r = 0.130$.

Four variables met the Wilks’ minimization criteria for entry into the analysis. Their standardized discriminant function coefficients and correlations with the discriminant function are listed in Table 12. These variables, listed with their standardized coefficients, were:

- College GPA (0.638);
- Developmental Course Grade (0.448);
- Course Load (-0.139); and
- AK Native (-0.129), the dummy ethnic variable.

The first two variables with the largest (absolute value) coefficients on this list are also the same two variables in the analyses of Research Question (Hypothesis) 1 and Research Question (Hypothesis) 2.
Table 12. Hypothesis 3: Predictive Model for Academic Success

Standardized Canonical Discriminant Function Coefficients and Pooled-Within-Groups Correlations Between Discriminating Variables and Canonical Discriminant Function

<table>
<thead>
<tr>
<th>Variables (met Wilks' minimum criteria)</th>
<th>Standardized Canonical Coefficients</th>
<th>Pooled-Within-Groups Correlations</th>
</tr>
</thead>
<tbody>
<tr>
<td>AK Native</td>
<td>-0.129</td>
<td>-0.145</td>
</tr>
<tr>
<td>College GPA</td>
<td>0.638</td>
<td>0.868</td>
</tr>
<tr>
<td>Course Load</td>
<td>-0.139</td>
<td>-0.205</td>
</tr>
<tr>
<td>Developmental Course Grade</td>
<td>0.448</td>
<td>0.746</td>
</tr>
</tbody>
</table>

An examination of the pooled-within-groups correlations of the variables with the discriminant function shows that the College GPA (0.868) variable had the strongest correlation with the discriminant function. The Developmental Course Grade (0.746) had a high correlation with the discriminant function. Course Load (-0.205) had a solid correlation with the discriminant function.

A separate test of significance was performed to evaluate the significance of the discriminant function. Table 13 identified the eigenvalues, canonical correlation of the variables when they are taken together with the discriminant function. Table also includes the Wilks’ lambda value, the chi square value, and the associated significance level. The null hypothesis for testing the Wilks’ lambda was that the canonical correlation is zero; the variables do not discriminate between the levels of the criterion variable. Table 13 showed that the value for Wilks’ lambda is 0.856 and the canonical correlation is 0.380, indicating the discriminant function is significant at the p < .05 level.
Table 13. Hypothesis 3: Predictive Model for Academic Success

Description of the Canonical Discriminant Function

<table>
<thead>
<tr>
<th>Function</th>
<th>Eigenvalue</th>
<th>% of Variance</th>
<th>Canonical Correlation</th>
<th>Wilks’ Lambda</th>
<th>Chi Square</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.168 (a)</td>
<td>100</td>
<td>0.38</td>
<td>0.856</td>
<td>288.358</td>
<td>0.00</td>
</tr>
</tbody>
</table>

(a) First 1 canonical discriminant function was used in this analysis.

The classification results for the calibration Sample, N = 1858, is presented in Table 14. This table shows that the model correctly classified successful and non-successful students 67.9 percent of the time. This represents an improvement over chance by 4.46 percent, approximately 4.5 percent, ([.6790 / .65] – 1), given that the prior probability for success in the population as indicated in Table 4 is 65 percent. This rate is better than chance and an improvement on the rates in the prior two analyses.

Since the discriminant function proved to be significant it can be concluded that a unique parsimonious combination of the factors exists. The combination of factors produced a classification rate of approximately 4.5 percent better than chance on the calibrated population causing the null hypothesis for Research Question 3 to be rejected.
Table 14. Hypothesis 3: Predicative Model for Academic Success

Classification Results for the Sample Population (N = 1858)

<table>
<thead>
<tr>
<th>Actual Group</th>
<th>N</th>
<th>Predicted Group Membership</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Success</td>
</tr>
<tr>
<td>Success</td>
<td>1210</td>
<td>831 (68.7%)</td>
</tr>
<tr>
<td>Non-success</td>
<td>648</td>
<td>217 (33.5%)</td>
</tr>
</tbody>
</table>

Percent of 'grouped' cases classified correctly: 67.9%

In summary, the most significant predictors of success for a student enrolling in one of the three entry-level college mathematics courses (College Algebra, Applied Finite Mathematics, and Elementary Statistics) after completing the developmental mathematics course (Intermediate Algebra) at the University of Alaska Anchorage during the period from summer 2001 and spring 2006 are the student’s:

- College GPA, the cumulative GPA of all courses taken just prior to enrolling in the college-level mathematics course; and
- Developmental Course Grade, the final grade received in the Intermediate Algebra course.

The effect of the Duration of ‘Stop-out’, the number of semesters between the completion of the developmental course and the enrolment in the entry-level college mathematics course, appears not to be significant when determining student Academic Success in the one of the college-level mathematics courses, College Algebra, Applied Finite Mathematics, and Elementary Statistics.
Chapter 6: Findings, Conclusions, and Recommendations

Overview

The discussions in this final chapter of the study will focus on the research questions and the statistical findings uncovered in the previous chapter. Special attention will be given to:

- detailing significant conclusions and possible applications;
- comparing the findings of this study with the findings of other studies, specifically, those conducted by the researchers described in Chapter 3, Literature Review; and
- identifying questions guiding recommendations for further research.

To interpret accurately the findings, conclusions, and recommendations listed in this chapter, it is important to recall that the purpose of this study was to identify factors that facilitate the smooth progress of developmental mathematics students to successfully complete required college-level mathematics courses. The technique used was to explore the relationship between the student’s academic performance in an exit-level developmental mathematics course, Intermediate Algebra, and the student’s academic performance in one of three entry-level college mathematics courses, College Algebra, Applied Finite Mathematics, and Elementary Statistics. The study focused on the influence of three sets of factors:

- Demographic variables;
- ‘Stopping-out’ measures; and
- Course Performance variables.
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**Discussion of the Findings**

Prior to this study, in the late 1990s, postsecondary institutions throughout the United States were faced with dramatic increases in the number of students failing to complete their degrees. In response, according to the National Center for Educational Statistics (2003, p. iii), 98 percent of public community colleges and 76 percent of all postsecondary institutions in the United States offered remedial or developmental courses.

In Alaska, the situation was more acute, beginning with high school students. More than 33 percent of the students entering high school as freshman in the year 2000 failed to graduate. Of the students who did graduate, less than one-third attended a postsecondary institution. Nearly two-thirds of the students attending a postsecondary institution in Alaska, namely branches of the University of Alaska, were unprepared for college-level mathematics and English courses (Kassier & Hill 2008, p. 2).

In response to the rising attrition rate and falling retention rate among students at UAA, Gary Rice, Associate Vice Provost of Institutional Research, Office of Institutional Planning, Research and Assessment (OPRA) at the University of Alaska Anchorage, published *Increasing Student Success: Focus on Attrition*.

After the publication of *Increasing Student Success: Focus on Attrition*, the challenge was to move beyond these initial findings to the next level of research. The intent of this study was to build upon the data found in Rice’s report to address specific questions and concerns, namely which factors or student characteristics could best predict academic success for students enrolled in one of three basic GER, college-level mathematics courses, namely College Algebra, Applied Finite Mathematics, or Elementary Statistics upon their successful completion of the developmental mathematics course, Intermediate Algebra.
Discussion of the Problem: Purpose of the Study

In an attempt to identify the factors that would predict Academic Success in a college-level mathematics course, a review of the findings from the report, *Increasing Student Success: Focus on Attrition*, was made. Examining the list of findings, it became quite clear that the highest student attrition rates occur in the GER courses in the areas of quantitative skills and the natural science. Mathematics courses were ranked highest where the average attrition rate was 41 percent. The intent of this study was to provide conclusive findings, identifying those factors that would predict Academic Success for students enrolling in GER, college-level mathematics courses. The time frame for this study was selected to coincide with the ending date of the first cohort of students Rice used in his model and then described in his attrition report, published in 2003. The group of students examined for Rice’s report were those enrolled at UAA from fall 1999 through spring 2001. The students in the cohort selected for this current study were enrolled at UAA from summer 2001 through spring 2006. Only those students who had completed Intermediate Algebra and one of the GER mathematics classes, namely College Algebra, Applied Finite Mathematics, or Elementary Statistics with an Academic Success or Non-success grade were included in the study. The purpose of this study was to provide currently unknown information about those factors leading to the Academic Success of students enrolled in GER, college-level mathematics courses.

Research Questions on Academic Success

This study addressed three research questions and conducted related analyses. The three variable sets of Demographic information, ‘Stopping-out’ factors, and Course Performance were used to model Academic Success in the college-level mathematics courses. The criterion, College Course Grade, had two levels of results: Academic Success, defined as a numerical grade equivalent to an A, B, or C; and Non-success, defined as a grade of D, F, W (Withdrawal), or AU (Audit).
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**Research Question 1:** Does the Duration of ‘Stop-out’, length of time between successive enrolments in the exit-level developmental course and the entry-level college course in the mathematics sequence, predict Academic Success in the college-level mathematics course when the effects of the Demographic and the Course Performance variables (Age, Ethnicity, College GPA, Developmental Attempts, and Developmental Course Grade) are controlled?

**Null Hypothesis:** The Duration of ‘Stop-out’, length of time between successive enrolments in the exit-level developmental course and the entry-level college course in the mathematics sequence does not predict Academic Success in the college-level mathematics course when the effects of the Demographic and Course Performance variables are controlled.

To answer this question, a discriminant function analysis was performed on the Sample using forced entry of the variables by set. The dependent variable in the analysis was College Course Grade, classified as Academic Success (numerical grade equivalent to an A, B, or C grade) and Non-success (D, F, W, or AU grades). The Demographic variables and the Course Performance variables were each entered into the analysis as a distinct set. Only then, was the Duration of ‘Stop-out’ variable allowed to enter the analysis. The net effect of this approach was to control for the effects of the Demographic and Course Performance variable sets, thus isolating the effect of ‘Stopping-out’ on college-level Academic Success.

The finding for this question was that there was not enough evidence to reject the Null Hypothesis for Research Question 1. Duration of ‘Stop-out’ variable was inconclusive in determining Academic Success in entry-level college mathematics after controlling for Age, Ethnicity, College GPA, Developmental Attempts, and Developmental Course Grade.
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The analysis of Research Question 1 used a set-wise approach to enter the Demographic set first, followed by the Course Performance set, and then by the ‘Stopping-out’ set, specifically the Duration of ‘Stop-out’. The model correctly classified successful and non-successful students 67.6 percent of the time in the Sample. These correct classification rates exceeded the rate expected by chance, by 4 percent \[\frac{(0.6760/0.65) - 1}{1}\]. The rate expected by chance was the prior probability of Academic Success, 65 percent. This is the percent of students from the original population of 1858 who received an Academic Success grade in the college-level course. The model was a reasonable discriminating tool predicting successful students approximately 68 percent of the time and discriminating between both groups of students at least 67.5 percent of the time. The predictability of classifying both Academic Success students and Non-success students was less than 70 percent.

Four variables were found to make the strongest contribution to the prediction of Academic Success. These variables, listed with their standardized canonical coefficients, included:

- College GPA (0.570);
- Developmental Course Grade (0.456);
- Course Load (-0.137); and
- Age (0.105).

Reviewing this data, it is clear that even after controlling for the effects of Age, Ethnicity, College GPA, Developmental Attempts, and Developmental Course Grade; College GPA was the most powerful predictor. This was borne out by the high correlation of College GPA with the discriminant function, 0.850. It should be noted that the variable Developmental Course Grade was also a very strong predictor, supported by the high correlation of the Developmental Course Grade with the discriminant function, 0.731.
Examination of the pooled-within-groups correlations of the variables with the
discriminant function revealed four variables strongly correlated with this
discriminant function. These are:

- College GPA (0.850);
- Developmental Course Grade (0.731);
- Age (0.289); and
- Developmental Attempts (-0.258).

According to this data, a student’s possibility of Academic Success in the college-
level mathematics course increases as:

- College GPA increases;
- Developmental Course Grade improves;
- Age increases; and
- Number of Developmental Attempts decreases.

The result from these findings was that, with its small negative value, the effect of
the variable Duration of ‘Stop-out’ on Academic Success proved to be inconclusive.

**Research Question 2:** Does the Developmental Course Grade predict Academic
Success in entry-level college mathematics when the effects of the Demographic,
‘Stopping-out’, and Course Performance variables (Age, Ethnicity, College GPA,
Developmental Attempts, and Duration of ‘Stop-out’) are controlled?

**Null Hypothesis:** The Developmental Course Grade does not predict Academic
Success in entry-level college mathematics when the effects of the Demographic and
‘Stopping-out’ variables are controlled.
To answer this question, a discriminant function analysis was performed on the Sample using forced entry of the variables by set. The variable sets for this analysis were identical to those used for the first research question. The purpose of this analysis was not to isolate the effect of the Duration of ‘Stop-out’ but rather to isolate the effect of developmental performance, measured as Developmental Course Grade. The Demographic variables as a set were forced to enter the equation first followed by the ‘Stopping-out’ variable set. After these variables were entered, the Developmental Course Grade in the Intermediate Algebra class was allowed to enter the analysis. The net effect as in the previous analysis was to control for the effects of those variable sets entered first in the analysis, thereby, isolating the effect of the last entry, namely the Developmental Course Grade, on Academic Success in the college-level course.

The analysis of Research Question 2 included a prediction model as did the analysis for Research Question 1. The model correctly classified successful and non-successful students from the Sample (1858) 67.6 percent of the time. This represented an improvement over chance by 4 percent \([(.6760/.65) – 1]\), as the prior probability of success in the population was 65 percent. The classification result was slightly better than chance. Once again, the predictability in both cases was less than 70 percent.

Four variables were found to make the strongest contribution to the prediction of Academic Success. These, listed with their canonical coefficients, were:

- College GPA (0.570);
- Developmental Course Grade (0.457);
- Course Load (0.137); and
- Age (0.105).

This data reveals that College GPA and Developmental Course Grade are the strongest predictors of success in the college-level mathematics course. This is
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substantiated by the very high correlation of College GPA with the discriminate function of 0.850 and the high correlation of Developmental Course Grade with the discriminant function of 0.731.

An examination of the pooled-within-groups correlations of the variables with the discrimination function revealed there were four variables strongly correlated with the discriminant function. These were:

- College GPA (0.850);
- Developmental Course Grade (0.731);
- Age (0.289); and
- Developmental Attempts (-0.258).

According to this data, a student’s possibility of success in the college-level mathematics course increases as:

- College GPA increases;
- Developmental Course Grade improves;
- Age increases; and
- Number of Developmental Attempts decreases.

Once again, the Duration of ‘Stop-out’ had a very small negative effect on Academic Success in the college-level mathematics course.

It is clear from this study that the Developmental Course Grade variable was found to contribute strongly to the prediction of Academic Success in entry-level college mathematics when controlling for Age, Ethnicity, College GPA, Developmental Attempts, and Duration of ‘Stop-out’.
Research Question 3: Which combination of the Demographic, Course Performance and ‘Stopping-out’ factors (Age, Ethnicity, College GPA, Developmental Attempts, Duration of ‘Stop-out’, and Developmental Course Grade) best predicts which students, enrolled in entry college-level mathematics courses, will achieve Academic Success.

Null Hypothesis: A unique parsimonious combination of the factors (Age, Ethnicity, College GPA, Developmental Attempts, Duration of ‘Stop-out’, and Developmental Course Grade) that will predict which entry college-level mathematics students will achieve Academic Success does not exist.

To answer this question, a stepwise discriminant function analysis was used, combining the elements of both forward selection and backward elimination to permit the variables to enter the classification analysis. The entry criterion was the minimization of Wilks’ lambda. Based on this criterion, several variables significantly correlated with Developmental Course Grade, the highest correlation was with College GPA (0.514).

Three variables met the Wilks’ minimization criteria for entry into the analysis. These variables, listed with their standardized coefficients, were:

- College GPA (0.638);
- Developmental Course Grade (0.448); and
- AK Native (-0.129), the dummy ethnic variable.

The first two variables with the largest (absolute value) coefficients are also the same two variables that appeared in the findings of the analyses of Research Question 1 and Research Question 2.

An examination of the pooled-within-groups correlations of the variables with the discriminant function shows that the College GPA (0.868) variable had the strongest
correlation with the discriminant function. The Developmental Course Grade (0.746) had a high correlation with the discriminant function.

The classification results for the Sample, N = 1858, showed that the model correctly classified successful and non-successful students 67.9 percent of the time. This represented an improvement over chance by 4.46 percent, approximately 4.5 percent, \([(0.6790 / 0.65) – 1]\), given that the prior probability for predicting Academic Success in the college-level course was 65 percent. This rate was better than chance.

In summary, the purpose of this study was to identify a set of variables to predict Academic Success in college-level mathematics courses. The most significant predictors of success for students enrolling in one of the three entry-level college mathematics courses of College Algebra, Applied Finite Mathematics, and Elementary Statistics after completing the developmental mathematics course, Intermediate Algebra, at the University of Alaska Anchorage, during the period from summer 2001 and spring 2006, were found to be the student’s:

- College GPA, the cumulative GPA of all courses taken just prior to enrolling in the college-level mathematics course; and
- Developmental Course Grade, the final grade received in the Intermediate Algebra course.

The findings related to the effect of the Duration of ‘Stop-out’ variable, the number of semesters between the completion of the developmental course and the enrolment in the entry-level college mathematics course, were inconclusive in determining student Academic Success in one of the college-level mathematics courses, College Algebra, Applied Finite Mathematics, and Elementary Statistics.
Comparisons with Findings from Other Studies

The findings of this study will be compared to the findings of other studies, specifically, those conducted by the researchers described in Chapter 3, Literature Review. The areas of comparison are findings regarding the effects of ‘Stopping-out’ and Course Performance on Academic Success, specifically the Developmental Course Grade and College GPA.

‘Stopping-Out’

A primary focus of this study was to evaluate the effects of the variable set ‘Stopping-out’ on Academic Success in the college-level mathematics course. ‘Stopping-out’ occurs when students allow two or more semesters to pass between completing a prerequisite developmental mathematics course prior to enrolling in the subsequent college-level mathematics course in a prescribed sequence of classes. Duration of ‘Stop-out’ is defined as the number of semesters between the last enrolment in the developmental course and the first enrolment in the college-level course. As previously mentioned in this study, the effects of ‘Stopping-out’ have not been extensively researched.

Description of Findings

Four studies evaluating the effects of the Duration of ‘Stop-out’ on the Academic Success of students completing a college-level course were described in Chapter 3, Literature Review. These research studies were conducted by Doucette and Hughes (1990), Rives (1992), Johnson (1993), and Barrett (2004).

To begin, Doucette and Hughes (1990, p. 25) in their study Assessing Institutional Effectiveness in Community Colleges, recognized that it was difficult to determine whether students who had completed developmental courses were continuing on to enrol in and succeed at the next level of education in postsecondary programs. Their reason for arriving at this conclusion is described in the following quote.
Because underprepared students often follow intermittent enrollment patterns, longitudinal follow-up studies will require a data base and research design that extends at least five years from initial enrollment. Long-term longitudinal follow up is particularly important for underprepared students because their initial goals might not include enrollment in the next level of education, or they may not enroll in a postsecondary program immediately upon attaining basic skills competencies. (Doucette & Hughes 1990, p. 25)

They determined that there was a need for more in-depth studies regarding the effects of the phenomenon of ‘stopping-out’, suggesting longitudinal follow-up studies be conducted for no less than five years. This set the stage for future research studies. Three of these studies are described here, Rives (1992), Johnson (1993), and Barrett (2004). These research studies analysing the effect of intermittent enrolment patterns of students were conducted. However, each study used a different time frame for analysis and each was for shorter periods of time than the five years suggested by Doucette and Hughes.

The findings from these studies were mixed. Johnson (1993) and Barrett (2004) studies concluded that the more time that elapsed between exiting the prerequisite course or learning a skill and entering the subsequent course or building on the learned skill, the less likely and more difficult it was to be successful. Contrary to these findings, Rives (1992) learned that the longer the student was away from the prerequisite course the more successful the student’s performance was in the subsequent course.

The research findings in this study determined that the effect of the length of time between the completion of the developmental, prerequisite mathematics course and the enrolment in the college-level mathematics course, Duration of ‘Stop-out’ on student Academic Success in one of the college-level mathematics courses, College Algebra, Applied Finite Mathematics, and Elementary Statistics was inconclusive. This finding, different from the findings of the other studies listed above, suggests that there are opportunities for further study of the phenomenon of ‘stopping-out’.
Conclusions

The results of this study regarding the Duration of ‘Stop-out’ is notably different from the previous studies and significantly different from what would have been expected. In general, advisors and faculty members encourage students to continue their mathematics studies once they have commenced, rather than waiting one or more semesters between courses. However, the results of this study suggest that students waiting to continue their mathematics studies may be just as successful as those who continue immediately with their enrolment in the subsequent mathematics courses the following semester.

Several reasons may account for the findings in this study and the difference between these results as compared to the results of the previous studies. The reasons accounting for these findings may include:

- the design of the study; and
- the location and characteristics of the population used in the study.

Design of the Study

The design of this study was significantly different from the designs used in the studies conducted by Rives (1992) and Barrett (2004). Neither of these researchers conducted longitudinal studies. To study ‘stopping-out’, Rives collected data during a single semester at two universities in Texas from students enrolled in three different levels of mathematics courses. On the questionnaire she administered to the students, she asked one question regarding the length of time between the completion of the student’s last mathematics course and their enrolment in the current course. Rives concluded that the longer the period of ‘stop-out’ the more successful the student would be in the subsequent course.

Barrett (2004) examined students entering a four-year college for the purpose of placement into pre-college level mathematics courses rather than college-level mathematics courses. She, too, in her study examined only one question when
evaluating ‘stopping-out’, the length of time since the student’s last mathematics
course prior to entering college. According to her research, the length of time since
the previous mathematics course was the primary reason in deciding whether a
student was ready for college-level courses or required pre-college level classes.

Johnson (1993) conducted an in-depth longitudinal study examining the pattern of
enrolments for students attending a community college in Austin, Texas for a period
of three years. The students examined were those completing Elementary Algebra
and then enrolling in Intermediate Algebra. Johnson’s conclusion was that students
would be less likely to succeed in the subsequent college-level mathematics course
the longer the students waited to continue in the mathematics sequence.

The designs of these studies are quite different from this researcher’s study. First,
not one of the studies described above included a longitudinal follow-up study for a
period of at least five years, as suggested by Doucette and Hughes. The longest
period of follow-up was for three years in the Johnson study. In the case of the
current study, this researcher conducted a longitudinal follow-up study monitoring
the progress of students for a five year period from 2001 through 2006.

Second, aside from Johnson’s study, the others based their analysis on the students’
response to a single question. Johnson, in contrast, followed students for three years
tracking their enrolment patterns in the developmental course, Elementary Algebra,
and the college-level course, Intermediate Algebra.

The third difference between the studies was in the selection of mathematics
courses. In Johnson’s design, most aligned with this researcher’s design, he selected
the developmental course as Elementary Algebra and the college-level course as
Intermediate Algebra. This was an appropriate selection for his study, as his research
was conducted at a community college. In this researcher’s study, the selection of
the developmental course was Intermediate Algebra and the comparison college-
level courses included College Algebra, Applied Finite Mathematics, and Elementary Statistics. The number of students evaluated in the study varied significantly. In Johnson’s study, he analysed the enrolment patterns of 824 community college students during the period from fall 1989 to summer 1992. This researcher analysed the enrolment patterns of 1858 university students during the period from summer 2001 through spring 2006.

The different approaches used to evaluate ‘stopping-out’ in each of the studies might account in part for the differences in the findings regarding the Duration of ‘Stop-out’. Two of the researchers described above discovered that the more time between the classes the less successful students were in the subsequent class. One researcher, Rives, discovered that the more time between classes the more successful the students were in the subsequent course. Contrary to each of these results, this researcher discovered that the amount of time between the courses was not significant in predicting success in the college-level courses.

*Location and Characteristics of the Sample*

The location and characteristics of the students in the Sample may contribute to the vastly different findings regarding 'stopping-out.’ The location of this study was in Anchorage, Alaska at the University of Alaska Anchorage. Anchorage is similar to the locations of the other studies conducted in Texas and California; each is a large urban centre with a population composed of individuals from a variety of age, gender, income, and ethnic groups. Anchorage differs from the other locations owing to the remoteness of the State. Alaska’s isolated location with respect to the contiguous 48 states in the U. S. contributes to the difference in the characteristics of the people living in Anchorage and attending University of Alaska Anchorage as compared to those living in the Lower 48 and attending the other postsecondary institutions described in similar studies, thereby impacting the results of this study.
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Anchorage, as compared to the U.S. in general, has:

- a high percentage of both civilian and active military personnel;
- a much higher percentage of individuals who were born outside of the state, migrating to Alaska;
- nearly half of all Alaska Natives in the state of Alaska;
- several industries where employees are routinely rotated to other locations in the U.S. and worldwide, including oil companies and related subsidiaries; and
- nearly 18 percent of the households in the city relocated outside of the state in the last 5 years.

It is clear that the population of Anchorage is very mobile, more mobile than the average city within the U.S.

This mobility factor affects the student population of UAA and is a possible cause for the high level of ‘stop-outs’. Those students with a greater potential of ‘stopping-out’ include students who are:

- in the military or a member of a military family;
- unable to cope with the ‘harsh’ conditions in Alaska and decide to relocate to another location outside the state. Individuals often have a difficult time dealing with isolation from extended family members, the long winters with extended periods of darkness, or the cold weather that can linger for long periods of time;
- working for a company that routinely rotates personnel, creating a variable work schedule such as two weeks on the job, away from Anchorage, and two weeks off;
- employed in a position that requires extensive travel throughout Alaska or out of the state;
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- relocated based on employment to another city either within the state or out of Alaska; or

- Alaska Native students, returning home to their villages.

Considering these factors, it is understandable that within the Sample of this study composed of 1858 students, there are 802 students, 43 percent of the population, who have ‘stopped-out’ more than one semester after completing the developmental mathematics course and before enrolling in the college-level mathematics course. These students have an average Duration of ‘Stop-out’ of 3.1 semesters. The overall volume of ‘stopping-out’ for these students creates an environment where the Duration of ‘Stop-out’ has little effect on Academic Success in the college-level course.

Another contributor to the findings regarding ‘stopping-out’ may be students who are unprepared for college. As described earlier, the challenge that exists within Alaska is that only one-third of the high school students graduate from high school and then enrol in college. Of those graduating, only about one-third are prepared to do college work (Kassier & Hill 2008, p. 2). With so many underprepared students attending the University of Alaska, in particular those students from the Alaska Native communities, it is not unexpected that students at UAA wait as long as possible to enrol in their required mathematics courses, possibly fearful that they may fail.

These factors have significantly influenced the overall characteristics of the student population at UAA including how the Duration of ‘Stop-out’ affects the success rate in the college-level course. In this case, Academic Success is unaffected by the length of time between the prerequisite, Intermediate Algebra and the subsequent college-level courses. A more stable population base including fewer underprepared students might create a different set of findings. More study is required to determine whether the location of the postsecondary institution, the characteristics of the
students, or the mobility of the population significantly influences the effect
Duration of ‘Stop-out’ has on Academic Success in the college-level course.

**Course Performance: Developmental Course Grade and College GPA**

A prime objective of this study was to determine which combination of variables
best predicts student Academic Success in a college-level mathematics course. The
two Course Performance variables, consistently identified as having the highest
correlation with Academic Success in all three analyses, were Developmental
Course Grade and College GPA. Academic Success in this study was defined as the
numerical equivalent (2.0 to 4.0) of the grades of C, B, or A earned in the selected
college-level mathematics course. The Developmental Course Grade was the final
grade received in the exit-level developmental mathematics course, Intermediate
Algebra. College GPA was the cumulative grade point average of all courses taken
by a student just prior to enrolling in the selected college-level mathematics course.

**Description of Findings**

The predictive power of a student’s previous academic performance and preparation
has been researched over the years. Studies have been conducted by Armstrong
(2000); Barrett (2004); Bettinger and Long (2005); Campbell and Blakey (1996);
Crane, McKay, and Poziemski (2002); Halpin (1990); Hertzog (2005); Johnson

In the earlier studies, namely those conducted by Astin (1982), Halpin (1990), and
Lunneborg and Lunneborg (1986), the authors used high school grade point
averages as the quality measure of academic preparation and the criterion for
success was described as the performance in all college work and in particular
freshman college work. Astin (1982) concluded that the single most relevant
predictor of college grade point average was the quality of the student’s academic
preparation prior to college entry, namely the student’s high school grade point
average. This conclusion was the same regardless of the student’s racial or ethnic background.

Later studies, Campbell and Blakey (1996); Crane, McKay, and Poziemski (2002); Hertzog (2005); Johnson (1993); and Rives (1992) concluded that the most significant predictor of success in a college-level course was the student’s performance in the prerequisite course or the prior developmental or remedial course. Armstrong (2000) and Nobel and Sawyer (1989) determined that the reliability of using a single course grade to predict future success was lower than the student’s overall college grade point average just prior to enrolling in the college-level course.

While it was important to consider all possible factors that might predict success in college-level courses, it was determined early on in the process of collecting data for this study that few students reported their high school grade point averages, less than ten percent of the total Sample. Thus, the data point of high school grade point averages was not included in the variable sets. The average age of the student population of this study was 24 where high school grades and grade point averages would be less meaningful than for a group of students where the average age was 18 or 19. It would seem reasonable that for older students either the developmental course grade or the overall college grade point average would be better predictors of success in college-level courses than high school grade point averages.

In response to the concerns voiced by Nobel and Sawyer (1989) and Armstrong (2000) that a single course grade is less reliable than an overall grade point average in predicting success in subsequent courses, this study included two measures:

- the measure of a student’s background knowledge, the developmental course grade; and
- the measure of the student’s overall college grade point average, computed just prior to enrolment in the college-level course.
Conclusions

An outcome of this study was the creation of a prediction model for Academic Success that included all of the variables from each of the three variable sets. To create this model a step-wise approach was used to enter the Demographic Variable Set, then the ‘Stopping-out’ Variable Set, followed by the Course Performance Variable Set. The created model correctly classified successful and non-successful students in the Sample 67.9 percent of the time. This correct classification rate exceeded the prior probability of Academic Success (65 percent), the rate expected by chance, by 4.5 percent, \[\frac{0.6790}{0.65} - 1\]. The model correctly predicted successful students approximately 69 percent of the time and discriminated between the two groups of students at least 67.9 percent of the time.

The results of the analysis of this predictive model indicated that there were four variables that were highly correlated with Academic Success. These variables along with their standardized coefficients were:

- College GPA (0.638);
- Developmental Course Grade (0.448);
- Course Load (-0.139); and
- AK Native (-0.129), the dummy ethnic variable.

According to this data, a student’s possibility of success in the college-level mathematics course improves as:

- College GPA increases; and
- Developmental Course Grade improves.

College GPA and Developmental Course Grade are the two strongest discriminators as corroborated by the findings from other analyses completed in the study.
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This model of discriminators is less applicable as a screening devise for intervention strategies. Instead, the real value of the model is as a means of understanding the nature of academic success. The model, while useful in evaluating student performance in entry-level mathematics courses, offers a glimpse at the complexity of academic success. The insights from this study provide only a portion of an explanation for the variance in Academic Success. The studies that follow present other explanations.

The study by Rives (1992) assessed the impact of both cognitive and affective factors on academic success. She found that mathematics attitude was directly and positively related to success. Gender was also related. All other factors being equal, women tended to be more successful than men. In the study by Crane, McKay, and Poziemski (2002), they found that consecutive semester attendance and the fewer courses dropped were significant predictors of academic success. Waycaster (2001) found that neither teaching style nor method of teaching had a significant impact on academic success. However, gender of both the student and teacher was significant.

The findings in these studies together with the results of this study provide the opportunity to improve the study of academic success by expanding the existing variable sets to include affective factors.

**Limitations**

A combination of Demographic, ‘Stopping-out’, and Course Performance variables emerged that would aid in the prediction of Academic Success for students enrolling in one of three entry-level college mathematics students, College Algebra, Applied Finite Mathematics, and Elementary Statistics. The two most significant predictors of Academic Success were found to be College GPA and Developmental Course Grade.
While conducting this study, limitations or threats to the validity of the study may have occurred. The possibility exists that some of the students participating in this study may have experienced events, unknown to the researcher, which might affect their performance in the college-level course, events including work related problems, family emergencies, financial pressures, lack of academic support or the lack of interest or understanding on the part of an instructor. These events pose threats to the internal validity of the study. No attempt was made to identify or control for the impact of these events on academic performance within the design of this study.

Moreover, it is possible that the students in the Sample experienced changes unrelated to the variables included in study during the five year period from 2001 to 2006. Among the possible changes that could have occurred include development both physically and emotionally, modification of career and college goals, or an altered family or work situation. The design did not attempt to include or measure the effects of these changes on academic performance. Another possible threat to the validity of the study is that of confounding levels of constructs. This occurs when there are the multiple levels to several of the independent variables used in the study.

Summary of Findings and Conclusions

Findings

The findings of this study form the basis for the conclusions and decisions that will influence future research and practice. These findings include:

- Developmental Course Performance, specifically Developmental Course Grade, is a significant discriminator of Academic Success in entry-level college mathematics courses, namely College Algebra, Applied Finite Mathematics, and Elementary Statistics, even when the effects of Age, Ethnicity, College GPA, Developmental Attempts, and Duration of ‘Stop-out’ were controlled;
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- Developmental Course Grade, College GPA, Age, Elementary Statistics, Applied Finite Math, and the ethnic variable White are positively correlated discriminators of Academic Success;

- Developmental Attempts, and the ethnic variable Alaska Native are negatively correlated discriminators of Academic Success; and

- Duration of ‘Stop-out’ (the length of time a student allows to pass between exiting the developmental mathematics course, Intermediate Algebra, and entering one of the college-level mathematics courses, College Algebra, Applied Finite Math, and Elementary Statistics) is not a discriminator of Academic Success in the entry-level college mathematics course as the results of the analysis proved inconclusive.

To summarize, the essential characteristics of students expecting to succeed in a college-level mathematics course include:

- maintaining a high College GPA;

- earning an Academic Success grade (A, B, or C) in the developmental prerequisite course, Intermediate Algebra; and

- being a mature student (25 years of age or older).

The student who received Non-success grades (D, F, W, or AU) in the college-level mathematics course tended to:

- have numerous Developmental Attempts, repeated enrolments in Intermediate Algebra, as many as six times for some students, before successfully completing the course;

- earn a Non-success grade in Intermediate Algebra; and

- be younger (18 to 24 years of age).

Of particular concern are the academic success rates of Alaska Native students.
Conclusions and Applications

The findings of this study gave rise to a series of conclusions that may be helpful to faculty advisors, college administrators, and college counsellors. The conclusions address each of the following findings:

- Developmental Course Grade and the College GPA were found to be the two most powerful discriminators in the model for Academic Success;
- Age is positively correlated to Academic Success;
- Duration of ‘Stop-out’ proved inconclusive when predicting Academic Success;
- Developmental Attempts was negatively correlated with Academic Success
- Ethnic variable of Alaska Native was negatively correlated with Academic Success; and
- A comprehensive Developmental Education Program be created as an intervention strategy to reduce student attrition and increase Academic Success.

To begin, the Developmental Course Grade and the College GPA were found to be the two most powerful discriminators in the model for Academic Success. Other researchers found similar results in their studies, namely Armstrong (2000); Barefoot (2000); Barrett (2004); Campbell and Blakey (1996); Crane, McKay, and Poziemski (2002); Halpin (1990); Johnson (1993); Keup (2006); Moss and Yeaton (2006); and Rives (1992). The measures of educational background and academic performance used by each of these authors were shown to be the most powerful predictors in their models, as Developmental Course Grade and College GPA were in this study. These findings suggest that Developmental Course Grade and College GPA may be useful alternatives for predicting success in college-level mathematics courses than either high school grade point averages or placement exams, particularly for older students in postsecondary institutions.
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A second finding is that Age is positively correlated to Academic Success. This result suggests that younger developmental students, those directly out of high school, might be more ‘at risk’ for completing the college-level mathematics course with a Non-success grade than students who are older. Special attention should be given to the younger students to assist them in adjusting to the work required in college which is often significantly different than the work required in high school. This can be achieved by providing student support groups, supplemental instruction sessions, and tutors or mentors who are upperclassmen.

The finding for the variable Duration of ‘Stop-out’ in this study was contrary to the findings in the studies cited earlier. The results from this study suggested that the amount of time a student allowed to pass between the two courses had little or no affect on the student’s grade in the college-level course. There is a lack of consistency in the findings and the analysis of the effect the variable Duration of ‘Stop-out’ has on Academic Success in the college-level mathematics course. These inconsistencies raise a number of questions, some of which are listed under Recommendations for Further Study.

Although the finding for the Duration of ‘Stop-out’ in this study suggests that a student’s academic success in the college-level mathematics course is unaffected by the amount of time that passes between exiting the developmental course and entering the college-level course, faculty members and advisors are strongly urged to encourage developmental mathematics students to enrol in the subsequent college-level mathematics course immediately after completing the developmental course.

The importance of a welcoming atmosphere within the institution including interested and understanding faculty on the student persistence has been emphasised in a number of studies. Barefoot (2004), Beck (2001), and Tinto (1993) maintain that those students who feel welcome at an institution are more likely to persist and do well academically. They state emphatically that student-faculty contact plays an
important role in a student’s persistence and desire to remain in college. The stronger and more frequent the contact between student and faculty member the more likely the student is to persist and increase academic success, especially if these encounters go beyond the mere formalities of academic work to include broader intellectual and social issues. In contrast, the absence of faculty contact or contact that includes only formal conversations limited to the confines of course work, the more likely the student will voluntarily ‘stop-out’ or withdraw from his classes and the institution.

The importance of a faculty member’s actions in relationship to his students is often overlooked as a reason for students ‘stopping-out’. As noted by Jacoby (2006), dedicated professors are often focused on the academic area with little emphasis on the personal touch needed by students. In an effort to improve interactions between students and faculty members, workshops and mentoring opportunities should be provided to assist faculty members in personalizing their role with students.

A faculty member’s behaviour inside the classroom influences the students’ perception of the faculty member’s receptivity outside the classroom. Those faculty members who initiate interactions with students and show that they are interested improve the students’ chances of continuing with the prescribed sequence of courses and remaining at the institution.

Students often overestimate their ability to manage the demands of family, friends, work, and school. They may elect to enrol in more courses than is feasible to complete successfully in a given semester. Course Load, the number of credit hours taken in a given semester, was found to be a negatively correlated discriminator of Academic Success. To promote student success, it is essential that faculty advisors and college counsellors encourage developmental students to maintain a reasonable course load, generally no more than 12 credit hours, especially during the semester when they enrol in a college-level mathematics course.
In the case of Developmental Attempts, non-success breeds non-success. The more often a student earns a Non-success grade in the developmental course, Intermediate Algebra, the more likely he is to be unsuccessful in the college-level mathematics course. Faculty advisors, in particular, should monitor these repeated enrolments and provide interventions when a student is experiencing difficulty with the developmental course. Repeated enrolments in the developmental course have a negative effect on the student’s GPA, the student’s self-esteem, and the student’s attitude toward mathematics. As Rives (1992) found in her study, a student’s mathematics attitude is positively correlated to Academic Success in subsequent courses. Similarly, students who have not completed the developmental mathematics course with a grade of C or better, should not be encouraged to continue on to the subsequent course until the previous course material is mastered.

This research identifies the importance of students enrolling in the appropriate course at a time when the student is adequately prepared. One method to prevent a student from enrolling in a course before the student is ready is to establish an effective course registration process. By identifying a series of predictors that influence student Academic Success in the entry-level college mathematics courses, a registration process may be implemented that will automatically perform checks of those predictors to assist students in registering for courses that will increase their Academic Success in current and subsequent classes.

One process would be to implement a prerequisite check prior to permitting the student to register. The prerequisite may consist of a passing grade in the prerequisite course, a passing mark on a placement exam, a passing grade in a transfer course from another institution, a high rating on an Advance Placement examination at the end of a high school course, or an appropriate score on one of several standardized college entrance exams, including the SAT, ACT, or ASSET. Without a comprehensive registration and advising system in place, students are able to enrol in classes for which they are unprepared, setting themselves up for failure. This often results in multiple repetitions of the same course.
The finding that the ethnic variable Alaska Native is negatively correlated with Academic Success offers a unique opportunity for UAA to provide additional assistance to these students. Assistance can be provided through a support program to promote student academic success. One possibility is to establish a centre for Alaska Native students that would provide a comfortable setting where students can meet and assist each other with coursework. In addition this centre can offer a series of student services for Alaska Native students including a tutoring program; a series of mathematics workshops; and a mentoring program, pairing Alaska Native students with other students in their classes or upperclassmen who could assist with questions about courses, faculty, and other services at the university.

The final conclusion in this section is based on an observation made while analysing the data presented in this study. Although not directly related to a specific finding in the study, it is worth serious consideration, especially at institutions where a separate Developmental Education Program exists apart from the traditional academic disciplines.

It became obvious while reviewing the Developmental Course Grade data that students in the Sample completed their Intermediate Algebra course in one of two departments at the University of Alaska Anchorage. Students were enrolled in the Intermediate Algebra course taught through either the Department of Mathematical Sciences or through the Department of Developmental Education. The current Developmental Education Program, however, was not the same Developmental Education Program designed in the early 1980s. Instead, the program today is a return to the more traditional remedial education programs where few student support services are integrated into the program and the courses are focused on filling in the gaps and spaces in the course material rather than assisting students to become more accomplished learners. These programs were unsuccessful when offered at colleges and universities prior to the developmental education movement in the 1970s.
As a result, it is understandable that when comparing the attrition rates of the students enrolled in all sections of Intermediate Algebra, the attrition rates in those sections taught in the current Department of Developmental Education were as high as the attrition rates in the sections taught in the Department of Mathematical Sciences. The highest attrition rate among all disciplines at UAA is in the area of mathematics at 41 percent. It was discouraging to realize that the attrition rate for the sections of mathematics classes taught in the Department of Developmental Education, a department designed to assist ‘at risk’ students, was no lower than the attrition rate in the more traditional sections of the same courses. Further investigation revealed that the ‘in class’ meeting times and the teaching methods used in the Department of Developmental Education were no different than those used in the more traditional classes offered by the Department of Mathematical Sciences. Thus, the students enrolled in the classes offered by the Department of Developmental Education were no more successful in the Intermediate Algebra course than those in the traditional Mathematical Sciences Department.

The recommendation of this researcher is to create a comprehensive developmental education program similar to the one described in the Developmental Education as a Possible Intervention to Reduce Student Attrition and Increase Academic Success section of Chapter 3, Literature Review. It is expected that this program would reduce student attrition rates significantly from the current 40 to 50 percent to less than 20 percent. In the program students would:

- be members of a learning community where they would take a series of developmental courses as a group;
- receive nearly twice as much ‘in class’ instruction time as a traditional class;
- be taught by caring faculty members employing a variety of teaching methods using competency-based evaluation measurements;
- meet with three faculty members and a college counsellor on a continual basis to discuss their academic progress and other issues that might interfere with their success in the courses;
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- be taught study skills and learning techniques as part of the academic courses,
- receive supplemental instruction and tutoring outside of class, and
- be encouraged to form learning cohorts consisting of study and support groups.

The students in a comprehensive program would be able to apply the study skills and learning techniques mastered in the developmental mathematics course to subsequent mathematics courses, enabling them to succeed in other classes. The close relationships formed between students in the developmental class often carries over to subsequent courses where the students continued to enrol in these classes together, creating a built-in support system.

As faculty advisors and counsellors become familiar with the findings of this study and encourage students to enrol in appropriate courses in a timely manner, an increase in student retention will result. Other student benefits will occur as well including improved grade point averages (GPA), fewer course repetitions, an increase in student retention, and a reduction in the amount of time required to complete a degree. Reduced attrition rates will positively affect the institution by reducing the costs associated with student attrition and new recruitments, improving the institution’s reputation within the community and among its peer institutions, and will create opportunities for more students to enter the institution by reducing the time-to-degree. Expanding the educational attainment in the United States will have a profound effect on the country’s growth and economic leadership by providing the human capital needed to satisfy the economic, social and political needs of America (Bowen, Chingos, & McPherson 2009).
Recommendations for Further Research

The results of this study suggest a number of possibilities for further research and analysis. Several of these recommendations are described here.

To verify the findings in this study, the study could be replicated by using other statistical analyses including multiple regression or binary logistic regression.

To determine the degree to which the Academic Success model can be generalized to student populations at other postsecondary institutions, it is important that this current study be replicated. If the analyses of these replicated studies corroborate the results of the current study, a strong case exists to support the broader use of the Academic Success model.

The contradictory results identified in three separate studies evaluating the effects of the variable Duration of ‘Stop-out’ on Academic Success demands that studies be conducted evaluating the effects of this variable. A research study focused specifically on the factors that determine when ‘stopping-out’, the variable that represents the time between the prerequisite mathematics course and the subsequent college-level mathematics course, influences student academic success. It is important for the study on ‘stopping-out’ to include a variety of postsecondary institutions including both two-year and four-year colleges and universities from a series of different locations with different populations of students. These populations need to include populations where ‘stopping-out’ is a frequent occurrence among the students and other populations where ‘stopping-out’ is less frequent or rare occurrence.

This study has examined a number of factors related to success in college mathematics. These are not the sole factors linked to academic success. A separate research analysis expanding the current study to include a series of other variables is recommended. Variables to be considered in an expanded study and examined as to
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their effect on student Academic Success are grouped into three distinct sets. These variable sets are:

- affective variables to include: level of self-esteem, locus of control (whether a student believes his academic results are under his control or are a result of external forces such as chance or luck), mathematics attitude, motivation level, self-perception, student anxiety levels, and student persistence (Barrett 2004, Copley 1991, Padzar 1990, and Rives 1992);

- personal or family characteristics to include: number of dependents, cultural characteristics or influences, personal support from family and friends, education level of parents, employment status (number of hours worked per week), and educational expectations (Benbow & Arjmand 1990, Copley 1991, Johnson 1993, and Miller 1990); and

- academic factors to include: attendance, class size, course credit hours, course satisfaction, educational support (tutoring, study groups, or supplemental instruction), gender, method of instruction, number of college course withdrawals, number of consecutive semesters attended, student’s intent, major and academic goal, placement exam results, ratio of college credit hours earned to the total number of college credit hours attempted, satisfaction with instruction, teacher’s gender, rate of participation in class, and total number of semesters attended (Benbow & Arjmand 1990, Crane, McKay, & Pozienski 2002, Higbee & Dwinell 1988, Johnson 1993, and Waycaster 2001).

Clearly, there are numerous opportunities for continued research in the area of student academic success particularly at the college-level.
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## Appendices

*Appendix A: Program Overview, Developmental Education Model*

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Appendix B: Looking to the Future, Developmental Education

Description of Components

*Academic Advising* is available for students in the Developmental Studies Program. A counsellor and the teaching faculty in the program meet with students at least twice a semester and more often when needed.

*Academic Labs* are available for use by faculty members and students in a number of different disciplines. There are designated labs for the following disciplines: Music, ESL (English as a Second Language), Language (foreign languages and sign language), Reading/Writing, and Mathematics. Each lab has a faculty member
assigned to provide workshops and tutoring sessions in the specific discipline. A public use Computer/Typing Lab is also available.

*Alternative Courses* are those courses specifically offered through the Developmental Studies/Learning Resources Division. These courses are *not* taught elsewhere in the college. An example is the How to Study Mathematics course, which includes a combination of study skills with problem-solving techniques. The problems used in the course are selected from topics at all levels of mathematics.

*College Testing Area* provides a testing centre for students completing exams outside of the classroom setting.

*College Tutoring Program* provides tutors for a host of courses offered at the college. The Developmental Studies/Learning Resources Division offers a course in tutor training where students successfully completing the course receive tutor certification. The design of this course and program received national attention and an award from the National Center for Developmental Education. As a result, this program became the prototype for other programs instituted at other institutions throughout the nation. Eventually, the movement expanded into establishing a national certification process in tutor training.

*Credit for Prior Learning and External Degrees* addresses the need of those students who enter college with a wealth of life experiences and would like to apply these experiences to their college degree. This program provides the means to apply these experiences through the creation of a portfolio documenting their skills and abilities. This portfolio is then evaluated by faculty in the academic disciplines to determine if and the extent to which college credit may be assigned to the evidence provided.

*Developmental Education (Studies)* classes are the CORE classes taught using an interdisciplinary team teaching approach to the basics of reading, mathematics, writing, and study skills. These courses provide a built-in support system comprised of: peer networking, tutorial assistance, and academic counselling and advising.

*Faculty/Staff Resources* includes a library of professional reading materials and a graphics centre to create instructional materials. Modules include: writing tests, adult learning, and organizing your semester and class.
Independent Study classes are classes taught through a series of one-on-one meetings with the instructor.

Information Referral is an area where staff members assist students and visitors to locating classes, offices and services throughout the campus.

Instructor Reserve is an area in The Learning Center that houses learning materials placed on reserve by faculty members for their students.

Interdisciplinary Courses are taught by integrating several discipline perspectives into a single topic.

Media Materials/Equipment Area is a section of The Learning Center set aside for creating, storing and duplicating media materials. These include video tapes, audio tapes, and slide productions. A media specialist is available to video tape classes and classroom demonstrations. The Instructional Materials Production Center is available to faculty and staff interested in crafting and producing their own innovative learning materials including handouts, slides, video tapes, and books.

Mini or Modular Courses are created by dividing a traditional 3 credit course into 1 credit modules. These courses provide students with the opportunity to complete only a portion of a course and still receive credit for the portion completed.

Multi-disciplinary Courses combine several disciplines together to teach similar concepts from different perspectives, each topic is taught with discipline specific information.

Multi-media Classes use a variety of mediums for teaching including audio visual equipment and computers.

Quiet Study Area is available for students to study and to work quietly on assignments and projects.

Reading Area is a section of The Learning Center with comfortable chairs and a reading library for students.

Self-Paced Classes permit students to progress at their own rate, taking exams as the units of study are completed. These are designed primarily for independent learners.
Staff Development Workshops and Courses are available to faculty and staff members interested in improving their knowledge and expertise in the area of teaching. These sessions provide information on innovative teaching techniques and offer opportunities to exchange of exciting ideas with colleagues.