Factors Affecting Student Academic Success in Gateway Courses at Northern Arizona University

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Abstract

Students in gateway business, math, and science courses at Northern Arizona University receive non-passing grades (grades of D, F, and W) at high rates. To identify possible trends in demographic groups that receive DFWs and to investigate why students receive DFWs in these courses, a student survey was administered to 719 students in 7 gateway courses, and institutional data were collected on 23255 students enrolled in 15 gateway courses. Student achievement and socioeconomic data on high schools from which gateway students originated were also collected. Student and high school data were analyzed to elucidate differences between ABC and DFW students, and to determine if differences in DFW rates existed between genders and among ethnicities. To determine if instructional style of gateway courses affected DFW rates or patterns in the demographics of DFW distribution, an instrument was used to characterize instructional styles used in the 15 gateway courses. Resulting data were analyzed for trends in DFW rates, gender, and ethnicity. Data suggest that possible causes of DFWs are inadequate student recruitment standards, student academic underpreparedness, lack of student and faculty ethnic and cultural diversity and interaction, and ineffective and inequitable instructional techniques. Possible interventions are discussed.

Factors Affecting Student Academic Success in Gateway Courses at Northern Arizona University

Introduction

The level of success students achieve in their first semesters of college has far-reaching implications for students' personal and professional lives. Student success has an immediate influence on a student's academic self-esteem, persistence in elected majors, and perseverance in higher education. Success in early semesters at college also ultimately impacts students' post-college experiences, such as career choice, personal income and level of success, and degree and nature of participation in community life. Thus, the experience a student has in the introductory college classes she or he attends can have a significant influence on the course of that student's adult life.

It is therefore alarming that introductory college classes are among the least enjoyed and least understood classes in a student's postsecondary academic career. Disaffection with and low performance in introductory college classes is a serious problem at colleges and universities nationwide (Horn *et al.* 2002, Horn and Premo 1995). The problem is especially evident in introductory business, mathematics, and science courses. Such courses are often required and integral components of an undergraduate education, yet many students who enroll in these courses achieve moderate or low levels of success in them. Low levels of success in introductory business, mathematics, and science courses result in significant attrition of talented students in these areas of study (Gainen 1995, Congress of the United States, Office of Technology Assessment 1988).

Attrition in business, mathematics, and science courses does not occur in all demographic groups at an equal rate. Of the major ethnic groups in the United States, African Americans, Hispanics, and Native Americans are less likely to enroll in and more likely to resign from business, mathematics, and science-related majors. Additionally, females are less likely to enroll in and more likely to resign from these courses than are males (Brower and Ketterhagen 2004, National Center for Educational Statistics 2002, Herndon and Moore 2002, Brush 1991, Hilton and Lee 1988). The greatest period of attrition for female students in science-related educational tracks is between the end of high school and the beginning of college (Oakes 1990). When the current employment demographics of science and science-related occupations in the United States are considered (Figures 1 and 2), the notion of undergraduate attrition in the groups that are least well-represented in these areas of employment is disturbing.

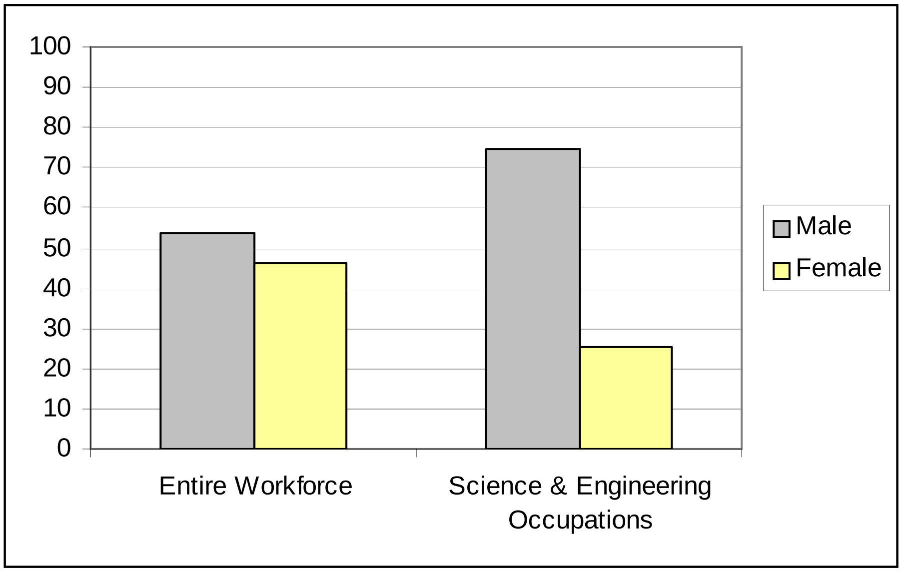


Figure 1: Gender trends in employment (bachelor's or higher degree recipients) in the United States (National Science Foundation 2004)

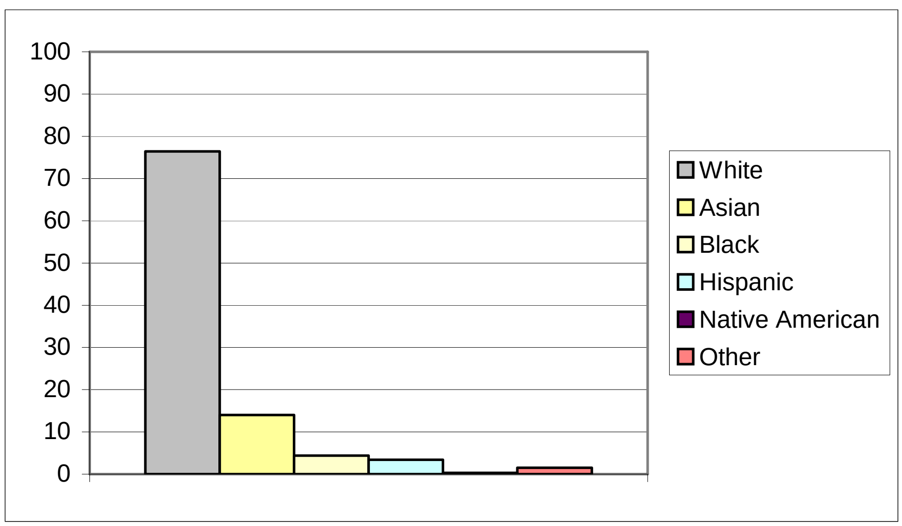


Figure 2: Ethnic trends in science and engineering occupations (bachelor's or higher degree recipients) in the United States (National Science Foundation 2004)

As these data indicate, student disaffection with and attrition in introductory business, mathematics, and science courses is a national problem. The problem is also, unfortunately, a local one. Levels of student dissatisfaction with and rates of attrition in introductory business, mathematics, and science courses at Northern Arizona University are consistent with national trends (Office of Planning and Research 2003, Horn *et al.* 2002). Because student satisfaction and perseverance are vital to student success in college, understanding factors that diminish student satisfaction and perseverance is necessary if these problems are to be addressed and overcome. Understanding these factors and implementing administrative changes to address them is especially important in entry-level courses, where student attitudes and habits are fundamentally shaped.

Large enrollment, entry-level college courses that are prerequisites for majors or graduation are commonly called “gateway” courses. Students enrolled in gateway courses in business, math, and science at Northern Arizona University (NAU) receive grades of D, F, or W at an alarmingly high rate (mean = 27.1%, SD ± 8.3%*). Such a high DFW rate in gateway courses is of particular concern, because these courses are populated primarily with freshmen and sophomores, and the experiences of these lower division students are likely to affect these students’ personal choices at and after college.

It is therefore important to characterize the individuals and groups who have recently received final grades of D, F, or W in these courses, and, if trends in these demographics are apparent, to understand why such individuals and groups have received these grades. Once this is done, a method for identifying individuals who are at increased risk of receiving these grades in the future could be developed, and strategies to help students succeed in these courses could be employed.

The percentage of students who receive a final grade of D, F, or W in a course – the DFW rate – is a metric that can be used to gauge a course's academic success. Assuming grades in the course are awarded for individual merit (opposed to relative standing in the class), a low DFW rate suggests that many students are achieving an acceptable level of competency with the subject matter of the course. Thus, the course is a successful educational endeavor.

The interpretation of a course's DFW rate becomes more complicated, however, when the many factors that can affect the DFW rate are considered. Student factors such as aptitude, motivation, and study habits obviously affect student success. But non-student factors such as the academic environment, course curricula, and pedagogical techniques used by the course instructor can also dramatically affect student success. It is therefore appropriate to also consider student, teacher, curricular, and environmental influences in concert when interpreting DFW data to evaluate the academic success of a course.

Understanding challenges that students face in gateway business, math, and science courses at Northern Arizona University is requisite to helping students achieve a higher level of success in these courses. Greater success is important, because most students enroll in gateway courses at the beginning of their academic careers, and conceptions they form during this period about college life and their own academic skills are lasting. Such conceptions are likely to affect personal, academic, and career choices that students make. Negative conceptions could steer students who perform poorly in gateway courses away from their careers of choice. This change in direction could perpetuate the under-representation of certain groups in business, math, and science professions experienced in the United States today.

Thus, the objectives of this study are: 1) to determine who receives DFWs in gateway business, math, and science courses at NAU, 2) to determine why these students receive DFWs in these courses, to 3) to develop a model for identifying students who might be at risk of receiving a D, F, or W in these courses, and 4) to identify and recommend intervention strategies that could improve the rates of academic success in these courses.

* Based on data from ACC256, BA201, BIO100, BIO181, BIO182, CHM151, CHM152, CIS120, ENV101, GLG100, MAT110, MAT125, MAT137, MAT155, PHY111, Fall 2000 through Spring 2002 semesters.

Predictors of Student Achievement in Introductory Business, Mathematics, and Science Courses

An abundance of research has been performed in the most recent four decades attempting to identify predictors of student performance in introductory business, mathematics, and science courses. Both cognitive and noncognitive factors have been considered, because numerous studies have shown both types of variables to be useful predictors. Some studies have shown that noncognitive variables are more useful than cognitive variables in predicting the academic success of nontraditional students (e.g. Sedlacek 2002). In addition to considering numerous types of variables, various methods of data collection and analysis have been used. Varied methods seem appropriate in research on predictors in business, math, and science because quantitative measures have the potential to overlook the presence and/or magnitude of non-cognitive and qualitative variables (Glesne 1999), and qualitative measures such as free-response questionnaires and interviewing are likely to contain biases. For example, in a meta-analysis of research on variables that contribute to classroom success, McAllister (1996) reports that both teachers and students make "self-serving attributions taking credit for success, but not for failure." Such biases could result in poorly informed analyses. While some discrepancies among conclusions from disparate studies exist, overall trends are apparent within each discipline. Furthermore, trends that transcend disciplines are evident, and will be discussed at the end of this review.

Predictors of Student Achievement in Business, Marketing, and Economics

Cognitive and academic variables have been shown to be only adequate predictors of success in introductory business, marketing, and economics courses. Sachdeva and Sterk (1982), Eskew and Faley (1988), Liesz and Reyes (1989), and Doran, Boullion, and Smith (1991) report that locally written and administered placement exams that measure student content knowledge and reasoning skills predict student performance in introductory finance courses. Eckel and Johnson (1983) report that the ACT score in math predicts success in introductory accounting courses. However, some studies contradict this conclusion and suggest that standardized entrance exam scores are not effective predictors in introductory accounting courses (Brown 1966, Ingram and Peterson 1987).

High school and college performance seems to be a more reliable predictor of student success than are entrance exam scores in introductory courses in the business field. Brown (1966) reports that high school GPA adequately predicts success in accounting courses, and other investigators (Bellico 1972, Cohn 1972, Ingram and Peterson 1987, Borde 1998) report that college GPA is a valid predictor of success in economics courses.

Pre-university exposure to business-related courses is reported to have no effect or a negative effect on student performance in introductory business-related courses at the university level. Baldwin and Howe (1982) report that students who studied accounting in high school performed as well in an introductory accounting course at the university level as students who had no prior exposure. Bellico (1972) found that prior enrollment in community college economics courses negatively affected student performance in economics courses at the university level. Simpson and Sumrall (1979) and Borde, Byrd, and Modani (1996) report similar findings in finance courses.

Surpassing the effectiveness of cognitive and academic variables in their apparent ability to predict student success in introductory business-related courses are the demographic and affective variables of gender and motivation. The effect of gender on success in business-related courses is significant (Siegfried 1979, Heath 1989), and seems to become more pronounced in courses in which analytic exercises become more advanced (Anderson *et al.* 1994). Gender also seems related to attrition. Male students seem more likely than female students to persist in economics courses (Hovrath *et al.* 1992).

Predictors of Student Achievement in Mathematics

The cognitive factors that have been most widely considered as potential predictors of college mathematics achievement are Scholastic Aptitude Test (SAT) and American College Testing Program (ACT) scores. Troutman (1978) and Bridgeman (1982) both found significant relationships between SAT Math scores and student achievement in college algebra and finite mathematics, respectively. Gussett (1974) found strong correlations between SAT Total (Math and Verbal combined) scores and grades in a suite of freshman-level mathematics courses.

Likewise, Kohler (1973) found that ACT Math and Composite (Math and English combined) scores were significant predictors of grades in college algebra. Edge and Friedberg (1984) found that ACT Math, English, and Composite scores were significant predictors of grades in calculus. And House (1995) found that the ACT Composite score was a significant predictor of grade in a variety of introductory college mathematics courses. Other researchers found that combining admissions test scores with high school performance data successfully predicted grades in a variety of college math courses. Richards *et al.* (1966) found that high school grades were good predictors of college math grades, especially when combined with ACT scores. Noble and Sawyer (1989) showed similar results in six college math courses using a combination of ACT Composite scores and high school GPAs. Keeley *et al.* (1994) found that combining admissions test scores with high school rank predicted grades in numerous lower- and upper-division math courses. Troutman (1978) also reports that high school rank and grades in mathematics are good predictors of success in college mathematics.

While many researchers report that standardized test scores and high school grades are effective predictors of success in college mathematics, some researchers report contrary findings. For example, Haase and Caffrey (1983a, 1983b) found that high school grades were almost useless as predictors of grades in introductory mathematics courses, and that SAT and ACT scores did not predict overall scholastic achievement in community college. Yellott (1981) reported that neither the ACT nor results from the Mathematical Association of America Placement testing Program tests predicted success in university level developmental mathematics courses. Despite these contrary findings, the majority of researchers seem to agree that standardized test scores and high school grades are effective predictors of success in university-level mathematics courses.

Many studies examined the utility of nationally administered aptitude tests, but some studies investigated the utility of locally administered subject- or course-specific exams. Crooks (1980), Bone (1981), Helmick (1983), and Shultz and Austin (1987) all found that subject-specific placement exams written and administered by the same institutions that taught the math courses in their respective studies were the best predictors of student performance in those courses. Crooks (1980) also showed that high school rank and GPA, as well as scores from standardized achievement tests were strong and comparable predictors of college math grades.

In addition to cognitive and quantitative factors, noncognitive factors have been used successfully to predict grades in college mathematics. Meece *et al.* (1982) found a relationship between student motivation, academic self-concept (a student's personal opinion toward her or his academic skills), and achievement in introductory math courses, and an associated relationship between initial achievement and downstream persistence in more advanced math courses. Academic self-concept was shown to be a strong predictor of persistence in undergraduate math programs (House 1992) and final grades in math courses (Wilhite 1990, Gerardi 1990, Astin 1993, and House 1995). Interestingly, House (1995) found that academic self-concept specific to mathematical ability was a stronger predictor of final grade than any cognitive factors (including ACT scores) measured, and that this academic self-concept was a stronger predictor of final grade for females than for males.

Factors that were considered but not found to be significant predictors of achievement in introductory math courses include the number of years of high school mathematics taken and student self-confidence in overall intellectual ability (House 1995).

Predictors of Student Achievement in Computer Science

Most studies investigating predictors of performance in college-level introductory computer science and/or computer programming courses report that aptitude in mathematics, measured by grades in high school mathematics courses or performance on institution or course entrance examinations, is the most salient predictor of success (Alspaugh 1972, Peterson and Howe 1979, Kurtz 1980, Fowler and Glorfeld 1981, Hostetler 1983, Konvalina *et al..* 1983, Scymczuk and Ferichs 1985, Oman 1986, Cantwell Wilson 2002, Fan *et al..* 1998). Fan *et al..* 1998 report that math proficiency is a more accurate predictor of success in college computer science courses than standardized college entrance exam scores.

Some studies report that factors related to student interaction with the curricular materials are relevant to student success. Violet (1997) reports that student effort predicts achievement. McGill *et al.* (1997) report a significant relationship between success and the number of hours per week students engage in practical work (i.e. programming, homework assignments), but no relationship between success and the time invested in studying theory.

Other studies report that prior experience with computers is an important predictor of success in collegiate computer science courses. McGill *et al.* (1997) report that students with previous programming experience are less likely to droup out of computer science courses than students with no previous programming experience. Taylor and Moundfield (1991) found that having a structured computer-programming course in high school is a significant predictor of success in undergraduate computer science courses. Taylor and Moundfield (1994) report that any type of pre-college exposure to computers improves the likelihood of success for females. However, predicting success for males seems more complicated. General experience with computers did not differentiae successful from unsuccessful males; the only factor that differentiated males was participation in a pre-college computer course that involved computer programming. Cantwell Wilson (2002) reports that formal classroom exposure to computer programming is a positive predictor of success, while computer game playing is a negative predictor of success. Clarke and Chambers (1989) report that experience with computers, including computer gaming, is the best predictor of both grades and persistence in tertiary computer science courses.

Numerous affective predictors of student performance are also documented in the literature. McGill *et al.* (1997) report that students' level of confidence in their ability to pass the course, and perception of the importance of the need to seek tutorial assistance, predict student success. Cantwell Wilson (2002) reports that student comfort level, even more than math background, is the best predictor of success in introductory level computer science classes. Numerous studies report that students who attribute their successes in computer science to skill and their failures to bad luck are generally successful, while students who attribute their successes in computer science to good luck and their failures to lack of experience or ability are generally unsuccessful (Clark and

Chambers 1989, Bernstein 1991, Howell 1993, Moses 1993, Pearl *et al.* 1990, Cantwell Wilson 2002).

Predictors of Student Achievement in Physics

Several studies report simple correlations between good high school grades, academic preparation, and success in introductory physics courses in college. Gifford and Harpole (1986), Hart and Cottle (1993), and Alters (1995) all report that students who had good grades in high school mathematics and had taken physics in high school performed well in introductory physics courses in college. However, Champagne and Klopfer (1982) and Halloun and Hestenes (1985), found that these correlations did little to explain the actual cause of strong performance and deep conceptual understanding in college physics. Both Champagne and Klopfer (1982) and Halloun and Hestenes (1985) found that student preconceptions of physics concepts affected student success in college physics significantly, and that performance on specialized conceptual tests to identify these preconceptions was a better predictor of college physics grades than either high school grades or academic preparation was.

Sadler and Tai (2001) report that rigorous preparation, including calculus and two years of physics, in high school predicts high grades in college physics. Additionally, Sadler and Tai (2001) and Tai and Sadler (2001) report that variables not related to student preparation, but are instead related to curricular design and pedagogy were salient predictors of student success. Curricula that moved slower and addressed fewer concepts in more depth, and classroom cultures that deemphasized reliance on the text and quantitative problem solving were more successful at helping students achieve higher grades and deeper understandings of course materials.

Sadler and Tai (2001) report additional interesting trends that are relevant to student success in college physics. For example, they report that college physics students perform better in classes that are taught by an instructor that is the same gender as the student. Sadler and Tai (2001) and Tai and Sadler (2001) report that, when other factors are controlled for, females perform better in algebra-based college physics, but males perform better in calculus-based classes.

Sadler and Tai (2001) also report that Asian and white students, students from affluent communities, and students whose parents had advanced educations, tend to perform better in college physics than their peers who are black and Hispanic, who are raised in socioeconomically disadvantaged communities, and whose parents are less well educated. Similarly, Neushatz and McFarling (1999) report that students from socioeconomically disadvantaged communities are less likely to take physics in high school. Gender, race, socioeconomic status, parental education, and educational achievement are factors that are commonly correlated, suggesting a common underlying cause. These factors and their potential underlying causes have received little attention in formal research investigations on student success in college business, mathematics, and science courses.

Predictors of Student Achievement in Chemistry

Various measures of student cognitive ability have been used as predictors of achievement in undergraduate college chemistry. Numerous studies have shown college admissions test scores to be significant predictors of achievement (Craney and Armstrong 1985, Ozsogomonyan and Loftus 1979, Andrews and Andrews 1979, Pederson 1975, and Reiner 1971; although see House 1995). Other studies have found that advanced logico-mathematical reasoning skills are important for success in freshman chemistry (BouJaoude and Giuliano1994, Niaz and Robinson 1992, Chandran *et al.* 1987, Demko *et al.* 1985, Good 1983, Howe and Durr 1982), although such skills may only account for between 21% (Albanese *et al.* 1976) to 15% of the variance in student grades, leaving 85% of the variance to other variables (Good 1983).

In addition to standardized reasoning tests, locally developed placement tests have been found to be effective predictors of student success in freshman chemistry. Wagner *et al.* (2002) report that performance on their “Student Pre-Semester Assessment” test predicted the pass/fail status of 41% of their general chemistry students, while the College Board’s Scholastic Aptitude Test only predicted pass/fail status at 17%. Tests of prior content knowledge and/or academic experience in chemistry have also been shown to be strong predictors of success in freshman chemistry (Yu 1999, BouJaoude and Giuliano1994, Chandran *et al.* 1987, Coley 1973).

Measures of noncognitive student variables such as initial attitudes toward chemistry, academic self-esteem (particularly self-rating of mathematical ability) and achievement expectancy have been reported to be better predictors of student success in college chemistry at a large public university than are cognitive variables (House 1995). However, Ferarri and Parker (1992) report that high school achievement (measured by grade point average) is a better predictor of achievement in college chemistry than initial student attitudes such as global (both academic and non-academic) self-efficacy.

Additionally, Okebukola (1987) reports that student attitude, as well as a classroom climate that emphasizes student participation in laboratory activities, were the best predictors of student success in chemistry in 37 secondary schools.

Predictors of Student Achievement in Biology

Numerous studies have shown that logico-mathematical skills are strong predictors of advanced performance in secondary and tertiary biology. Numerical and analytical skills measured by the quantitative section of the College Board's Scholastic Aptitude Test are reported to be predictors of student achievement (Helseth *et al.* 1981, Yeany *et al.* 1981). Arithmetical skills (Detloff

1982) and general mathematical skills (Marsh and Anderson 1985, Biermann and Sarinsky 1989) are also valid predictors of success in freshman biology. More general reasoning skills, such as those measured by Piagetian or neo-Piagetian logic questions (Piaget 1966), have also been demonstrated to be strong predictors of student success in college biology (Bullock *et al.* 1976, Dettloff 1982, Helseth *et al.* 1981). Davidson and Haffey (1979) suggest that a student's intelligence quotient (IQ) is the best predictor of her or his success in high school biology.

In addition to logic and reasoning skills, background knowledge in biological concepts also seems important to success in college life science courses. Pretests that measure students' biological background knowledge have been shown to be useful predictors of understanding advanced biological concepts such as evolutionary theory (Lawson 1983), student success in college biology courses (Hooper 1968), and success in programs designed to prepare students for advanced study in various health professions (Carmichael 1986).

Interestingly, a variety of studies have demonstrated that verbal skills related to reading and comprehension are the most salient predictors of success in college biology. Several studies (Emmeluth 1979, Detloff 1982) report the usefulness of the Nelson-Denny Reading Test (NDRT) as a predictor. The NDRT is a timed test that measures vocabulary development, comprehension, and reading rate. It is widely used as a reading placement test in American colleges and universities. Emmeluth (1979) reports that the NDRT comprehension score is a more valid predictor for women, and that the NDRT vocabulary score is a more valid predictor for men. However, the value of the NDRT as a predictor is not without controversy. Gudan (1983) reports that the NDRT did not predict grades in two different introductory biology courses.

Like the NDRT, the verbal section of the College Board's Scholastic Aptitude Test (SAT-V) has demonstrated value as a predictor of grade in biology. Nist *et al.* (1995), Marsh and Anderson (1985), Yeany *et al.* (1981), and Szabo (1969) all report that students' SAT-V scores are valid predictors of success in freshman biology.

Prior academic performance has also been shown to be a significant predictor of success in introductory biology. Szabo (1969) reports that performance in high school science predicts achievement in college life science courses. Other studies suggest that high school grade point average and/or rank are strong predictors of success (Hooper 1968, Emmeluth 1979, Yeany *et al.* 1981, Marsh and Anderson 1985, Carmichael 1986).

Finally, student perceptions seem to be important components of success in college biology. Pridmore and Halyard (1980) report that student outcomes on portions of the Academic Motivations Inventory, when coupled with other quantifications of student aptitude such as grade point average or scores on the Scholastic Aptitude Test, can be used to predict student academic success in biology. Nist *et al.* 1995 found that student self-perception of examination performance was also a valid predictor of final grade. The authors suggest that accurate self-evaluation is a metacognitive talent that is well-developed in successful students.

Summary of Factors That Predict Student Success in Introductory Business, Mathematics, and Science Courses

Three variables seem to be general predictors of success in freshman business, mathematics, and science courses. One variable is cognitive: students' quantitative and analytical skills. Standardized tests such as the mathematics sections of the ACT or the SAT, and local tests that contain neo-Piagetian questions and questions focused on course-specific logical skills, provide data relevant to this variable. Data from such tests are easily generated or acquired and readily interpretable.

A second general variable that predicts success is affective, and relates mostly to students' academic self-esteem. Measures of academic self-esteem are less not as widely available as measures of mathematical skills, but numerous instruments are available for measuring this variable. The results these instruments yield, however, might not be as easily interpretable as results from a mathematics test. Mathematics tests typically contain questions that have correct or incorrect answers, whereas instruments that measure student affection typically generate graded responses. Furthermore, student affection can vary from course to course, teacher to teacher, even day to day. Still, reliable and valid methods of measuring student affection, including academic self-esteem, exist.

The third nearly universal variable that predicts student success in freshman business, mathematics, and science courses is high school grade point average. Grade point average is neither a cognitive nor affective variable; it is neither a measure of aptitude nor state of mind. Instead, it is a holistic measure of performance. Both cognitive and affective states influence it. Similar to data on mathematical skills, data on students' grade point averages are widely available. But the interpretation of students' GPAs is potentially more challenging, since GPAs are a composite measure of a student's overall high school experience.

In addition to these nearly universal predictors, several subject-specific predictors are documented by multiple researchers. The value of attribution to success in computer science is well demonstrated, and might be an affective characteristic related to academic self-esteem. Hands-on experience with computers, both before college and in class also seems to enhance a student's chances of success in this field.

Experience also seems to be valuable for success in other fields of science. In physics, prior experience with complex physical concepts and theories seems at least as valuable as hands-on experience with physical phenomena. The same has been shown to be true in biology. This could be true because most university-level science courses require students to grasp concepts associated with post-formal operational reasoning, and time, intellectual maturity, and experience are all required for post-formal concept construction (Lawson *et al.* 2000a, Lawson *et al.* 2000b). If this were true, then one would expect that experience also play an important role for success in chemistry. However, the effect of experience on success in chemistry has not yet been thoroughly investigated.

The finding that academic experience can have a negative effect on student success in economics and finance courses is interesting and not well explained. It is possible that the concepts that are introduced in community college economics and finance courses are different than – or even in conflict with – concepts introduced in economics and finance courses at the university level. It is also possible that university level economics and finance courses are more tailored for students who intend to continue their educations in these fields, whereas courses at the community college level are tailored for people who do not plan to continue. Educational content of courses and pedagogy could therefore be different at the two kinds of institutions, and students with experience at the community college level might have a different perception of requirements for success in these courses than students at the university level.

Equally as interesting is the finding that verbal skills are valid predictors of success in biology courses. This phenomenon is also poorly addressed in the research literature, but worthy of pursuit. It is possible that verbal skills help students understand and articulate the critical qualitative arguments that accompany quantitative concepts that constitute deep understanding of biological theories. Such qualitative arguments could be less common and/or important in other natural sciences, including chemistry and physics.

Interpreting Results of Predictive Studies in Business, Mathematics, and Science Education

Although most studies to date have described what seem to be legitimate predictors of success in introductory college business, mathematics, and science courses, these results must be interpreted with caution. All published studies reviewed for this manuscript aspired to find predictors of success in business, mathematics, and science courses, and all studies successfully found them. But few of the studies were actually experimental; most protocols involved *post hoc* comparisons of student grades with other variables. Thus, the results of most studies are correlative, not causal. Factors that ostensibly cause student success in business, mathematics, and science courses – i.e. factors that cause the reported correlations to exist – could be different than those reported in the predictive studies.

For example, numerous authors report that scores on exams that measure quantitative and analytical skills correlate strongly with final grades in business, mathematics, and science courses. But what causes a student to receive a high (or, alternatively, low) grade on an exam that putatively measures quantitative and analytical skills? One obvious possibility is student aptitude. But other possibilities might include the career choices or education level of the student's parents, who could be mentoring the student in this area of achievement. Or perhaps high scores on exams that measure quantitative and analytical skills were driven buy access to educational resources and opportunities, such as attendance at a summer “math camp,” or participation in an extracurricular test preparation course. Access to such resources might ultimately be determined by the students’ socioeconomic circumstances. These circumstances could be a causal factor driving the student’s exam score.

Standardized test scores also seem to have different predictive value for women and men. Brush (1991) reports if a woman and man have the same SAT scores entering college, the woman is likely to achieve higher grades in college. Said differently, women who have lower SAT scores will perform comparably to men who have higher scores. Behnke (1989) reports that, at the Massachusetts Institute of Technology, women who scored 20-25 points lower on the math section of the SAT achieved grade point averages comparable to their male peers in science, math, and engineering courses.

Related to academic self-esteem, student attitude also influences performance in science classrooms. Students with more positive attitudes toward science tend to do better in science courses (Weinburgh 2000, Weinburgh 1994, Oliver and Simpson 1988, Kaballa and Crowley 1986, Willson 1983, Gardner 1975, Ormerod and Duckworth 1975). Females typically have more negative attitudes toward science than do their male peers (American Association of University Women 1992).

Another example of a result that might be challenging to interpret is the finding that a student’s academic self-esteem correlates strongly with her or his final grade. Students with high academic self-esteem tend to do well in business, mathematics, and science courses. But what causes a student to have high academic self-esteem? Intrinsic confidence in one's own intellectual abilities is an obvious possibility. But intrinsic self-confidence in college science is not equivalent among females and males. Females tend to perceive their cognitive styles as imaginative and intuitive, and inconsistent with the rote, serious, and competitive culture of most college science classrooms. Women also raise their hands and manipulate laboratory equipment less frequently, and prefer to work in groups more frequently, than do men (Tobin and Garnett 1987). Forms of engagement that are preferred by females might be discouraged in college science classrooms and labs and contribute to the discomfort of women students. Using engagement techniques that are discouraged in the classroom, or having the perception of being out of place in the classroom could affect a female student's level of comfort (Cantwell Wilson 2002) or belief in her ability to succeed (Brush 1991, Bar-Haïm and Wilkes 1989, Blenkly *et al.* 1986).

In addition to intrinsic factors, extrinsic factors might also affect a student's academic self-esteem. Again using gender as an exemplar, women and men often respond to pedagogical styles and classroom cultures differently. Many women prefer and are more comfortable in classrooms where deliberation and collaboration are more common than memorization and competitiveness (Tobias 1990). Most introductory business, mathematics, and science courses have classroom cultures that alienate instead of encourage female students (Constantanople *et al.* 1988, Hall and Sandler 1982). In science classrooms, men are engaged more by teachers (Tobin and Garnett 1987), and male role models – including the professor and teaching assistants – are more common than female role models (Brush 1991, Hall and Sandler 1982). Such pedagogical and cultural inequities can have significant negative effects on the academic self-esteem of female business, mathematics, and science students.

Methods

To determine who receives DFWs in gateway business, math, and science courses at NAU and to investigate why these students receive DFWs in these courses, three types of data were collected and analyzed. General student background data such as demographic, standardized test score, and grade information were obtained from NAU's Office of Planning and Institutional Research. Publicly available demographic and performance statistics about high schools from which in-state students originated were collected from the U.S. Department of Education, the Arizona Department of Education, and a nonprofit K-12 education advocacy organization named GreatSchools, Inc. Data about student motivations and social habits were collected by surveying a large group of students enrolled in gateway courses of interest. Each method of data collection is described in detail below.

All information that could be used to personally identify study participants was removed before data were analyzed. The study was performed in compliance with policies and regulations regarding the use of human subjects in research, and under the supervision of NAU's Institutional Review Board.

Unless otherwise noted, all statistics were calculated using JMP® IN Version 4 Release 4.0.4 (SAS Institute Copyright © 2001).

Institutional Records and Public Data

NAU's Office of Planning and Institutional Research (OPIR) collects data on an ongoing basis on a variety of student demographic and academic attributes. These data are warehoused and made available on request for institutional research.

Student data (n = 23255) from the 15 gateway courses listed in Table 1 and taught in regular semesters from Fall 1997 through Fall 2001 were requisitioned from this source. Data that were obtained include age, gender, ethnicity, high school name, high school grade point average, high school class rank, college hours completed, cumulative college grade point average, current semester hours enrolled, current semester grade point average, American College Testing (ACT) score, Scholastic Aptitude Test (SAT) score (a composite of critical reading, math, and writing scores), and major. Data on student final grade in each course were also obtained.

Prefix	Course Name	*n*
ACC 255	Accounting Principals Financial	2198
ACC 256	Accounting Principals Managerial	1154
BA 201	Quantitative Methods (Business)	1151
BIO 100	Principals of Biology	1881
BIO 181	Unity of Life I	1771
BIO 182	Unity of Life II	558
CHM 151	General Chemistry I	2373
CHM 152	General Chemistry II	1129
CIS 120	Introduction to Computer Information Systems	4114
ENV 101	Environmental Science	888
GLG 100	Introductory Geology	1714
MAT 125	Pre Calculus	2009
MAT 137	Calculus II	726
PHY 111	General Physics I	713
PHY 112	General Physics II	394

Table 1: Courses from which institutional data were collected

The name of the high school each in-state student attended was also obtained from the OPIR. A list of the high schools that were included in the study (n = 244) is shown in Appendix A. Public records for each school were searched, and demographic information was collected. Information collected includes the average Arizona's Instrument to Measure Standards (AIMS) reading and math scores, average Stanford 9 (SAT-9) reading and math scores, the average ACT and combined SAT scores, and the percent of the student body that qualifies for the federal free or reduced price lunch program. This statistic is commonly used as a measure of socioeconomic status of high schools and the communities and families they serve.

ABC and DFW Rates in Gateway Courses

Student data were placed in either the ABC or the DFW group based on the final grade students received in each course. Since NAU sometimes awards grades that are more descriptive than traditional letter grades, students who received nontraditional grades were also assigned to one of the two categories. The categories to which each nontraditional grade was assigned are listed in Table 2. Nontraditional grades that could not logically be assigned to either the ABC or the DFW category were categorized as “Not counted.” Grades categorized as “Not counted” included audits, incompletes, and grades of “P” in pass/fail courses. Data categorized as “Not counted” were excluded from the analysis.

Grade	Description	Category
A	Earned A	ABC
A#	Earned A, Repeat	ABC
AU	Audit	Not counted
B	Earned B	ABC
B#	Earned B, Repeat	ABC
C	Earned C	ABC
C#	Earned C, Repeat	ABC
D	Earned D	DFW
D*	Repeat Replaced	DFW
F	Earned F	DFW
F*	Repeat Replaced	DFW
I	Incomplete	Not counted
P	Pass Only	Not counted
W	Withdrawal	DFW

Table 2: Grades reported in gateway courses of interest with their designation in grades by course analysis

ABC and DFW rates in 13 gateway business, math, and science courses at NAU were calculated. Data from BIO 181 and BIO 182 were incomplete and therefore excluded from the analysis. Rates for fall and spring semesters were calculated separately and then averaged. To determine if there was a difference in ABC and DFW rates between fall and spring semesters, Student's t-tests were performed.

Characterizing ABC and DFW Students

Two sources of data were used to characterize ABC and DFW students. The primary source of data was a student survey administered in seven gateway courses in 2002. This 26-item multiple response survey queried gateway students on their demographics, academic habits, motivations, and attitudes related to college and gateway courses. Student survey data were supplemented by student demographic and academic qualification data supplied by NAU's OPIR. These institutional data were used to elucidate or confirm missing, ambiguous, or sensitive results derived from the student survey.

Because most variables in this study are categorical, contingency analyses were usually performed to determine if nonrandom relationships among variables exist. Contingency analyses traditionally yield either a Pearson chi-square (X^2) or a likelihood ratio (G^2) test statistic. Under normal circumstances, both these statistics are equivalent and can be interpreted as such. Under some circumstances, such as when sample sizes (n) are unusually high or when some μ_i (means of cells) are less than 0.5, the X^2 and G^2 statistics diverge. In these circumstances, G^2 is a usually more conservative measure of the effect size than is X^2 (Agresti 2002). For this reason, G^2 is the statistic reported for each categorical analysis.

In some cases, the sample size in each cell of the contingency table (c) is less than 5. In these circumstances, contingency analyses produce results that are suspect (Agresti 2002). When results in this study were suspect for this reason, sparse categories were collapsed into categories that were less descriptive but that provided larger sample sizes per cell. When categories were collapsed, analyses were re-run. Results that were consistent with the results of the original (suspect) analysis were reported with a cautionary note. Results that were not consistent with the results of the original (suspect) analysis were not reported, and the original (suspect) analysis was not reported as significant.

Student Survey

A 26-item survey (Appendix B) designed to assess student attitude toward the University, gateway classes at the University, and personal academic habits was written and administered to 719 students in seven gateway classes (ACC256, BA201, CIS120, ENV101, MAT125, PHY111, and PHY112) during the Spring 02 and Fall 02 semesters. Student participation was voluntary.

The survey was developed in October 2001 by representatives from NAU's Science and Math Learning Center, the College of Social and Behavioral Science, and Office of Student Life. Questions were mostly derived from administrative officials, course instructors, and education researchers at NAU.

The survey contained questions regarding student demographics, academic performance, preparation, study habits, learning styles, goals, obstacles, motivations, and perceptions toward the class and the University.

Response options on the survey were multiple choice. Multiple-choice answer options were derived mostly from a free-response pilot version of the survey administered to 124 BIO100 students in November 2001. The most common responses from that version were incorporated in the response options of the multiple choice survey that was administered and that provided data for this report.

Each participant provided her or his student identification number on the survey response sheet. Student identifiers were used to obtain students' final grades in surveyed courses, and to determine if any student completed the survey in more than one course. Final grades were obtained from NAU's OPIR. If a student completed the survey in more than one course, data from only one of the courses were used in the analysis to prevent pseudoreplication. If a student completed the survey more than once because she or he was enrolled concurrently in two or more courses, data from only one of the courses were used. The course from which data were obtained was randomly chosen. If a student completed the survey in consecutive semesters, data from only the first (i.e. the Spring) semester were used. When final grades were obtained and pseudoreplicates were eliminated, student identifiers were removed. Thus, survey results were ultimately made anonymous.

After survey data were collected, demographic data were used to characterize the student body in gateway courses, and descriptive statistics were performed. Data were then divided into ABC and DFW groups, and analyzed to determine what, if any, differences exist between the two groups. Student's t-tests were used to compare continuous quantitative data such as age, standardized test score, and grade point average. Log-likelihood tests were used to compare nominal and ordinal categorical qualitative data such as gender, ethnicity, and level of academic achievement.

Results in numerous areas of analysis were produced. Demographic data were used to describe student perception of course, student academic habits, effect of course on student, and student perception of college life and NAU. ABC and DFW data were used to investigate hypotheses regarding student success in courses of interest.

These hypotheses were derived from two sources. One source was the primary literature, which proposes a variety of causes of student success in gateway courses. The other source was NAU instructors who teach gateway business, math, and science courses. These instructors provided numerous ideas about determinants of student success in their courses. There was a surprising consistency of opinion among gateway course instructors about why students do or do not succeed. Hypotheses that were offered and investigated included ethnicity, gender, student opinion of course, student perception of academic status in the course, student academic qualifications, impact of course on student goals and interests, attendance, and study habits.

Characterizing Students' Educational and Socioeconomic Contexts

To determine what, if any, effects the educational and socioeconomic contexts from which students originated effected student success in gateway courses, students were grouped together by high school of origin, and the final grades each student received in the first gateway business, math, or science course in which they enrolled at NAU were compiled. If students were enrolled in two courses concurrently, data from only one of these courses were used in the analysis to prevent pseudoreplication. In these instances, the course from which data were used was randomly chosen; data from other courses were excluded from the analysis. The rate at which students from each high school received a D, F, or W in these courses was then calculated, yielding a single DFW rate for the group of students who attended each high school.

To determine if demographic characteristics of high schools and/or neighborhoods of student origin correlated with student achievement in gateway courses, Pearson product-moment correlations were performed on the DFW rates, average standardized test scores, and rates of reduced cost lunches from each high school.

Characterizing Gateway Classrooms and Courses

To investigate the hypothesis that characteristics of the course affect student success and failure rates, observations were made in one randomly chosen section of each of the gateway courses of interest. Courses were characterized with the Reformed Teaching Observation Protocol (RTOP) (Piburn *et al.* 2000, Sawada *et al.* 2002). The RTOP (Appendix D) consists of 25 statements about components of instructional practice such as lesson design and implementation, course content (both propositional and procedural knowledge), and classroom culture (both communicative interactions and student-instructor relationships). Each of the 25 statements is scored on a 0–4 ‘‘Never Occurred’’ to ‘‘Very Descriptive’’ scale. Thus, the RTOP allows observers to rate instruction on a 0–100 scale. This RTOP score describes the extent to which reformed instructional practices (Alexander and Murphy 1999; National Council for the Teaching of Mathematics 1989, 1991, 1995, 2000; National Academy of Sciences, National Research Council 1996, 2000; American Association for the Advancement of Science 1989) are used.

Each course in the study was visited once during two semesters during the span of the study (i.e. in the Fall 1997 through Fall 2001 semesters).

RTOP scores were calculated for courses of interest not to describe the instructional practices employed in each course, but to describe the range and variability of instructional practices employed in all gateway courses. To this end, descriptive statistics on course RTOP scores and of the scores of the subcategories within the RTOP were generated.

Prior research has explored the relationship between the degree of instructional reform and student achievement. These studies have found that instructional reforms, as reflected by RTOP score, have had a positive effect on student achievement in college science and mathematics courses (Falconer *et al.* 2001, Lawson *et al.* 2002). Because these results were obtained in gateway mathematics and science courses at other universities, it is reasonable to predict that similar effects might be seen in courses of interest at NAU. To determine if there was a relationship between instructional strategies used in gateway courses at NAU and student success, Pearson product-moment correlations were performed on course RTOP scores and course ABC rates.

Development of Predictive Model

To develop predictive models for identifying students who might be at risk of receiving a D, F, or W in a course of interest, a stepwise multiple logistic regression was used. Stepwise regression is a statistical technique used to identify a “best” set of predictors from among a variety of variables. “Best” describes a set of variables that is maximally parsimonious and satisfactorily predictive for the requirements of the research (Sokal and Rohlf 1995). In this study, coefficients of determination (R^2) were calculated for all variables that were hypothetically related to student success and for which data were available.

The model was then generated by starting with the variable with the highest R^2 and adding and eliminating other variables to the model until the best model was obtained.

Multiple logistic regression is a statistical technique that employs numerous X variables to predict a single, binomial Y outcome (in this case, Y = membership in either the ABC or DFW group). To fit a single regression line to the logit-transformed data, the maximum likelihood method was used. Because one or more of the assumptions generally associated with Model I regressions (no sampling error, Y is a linear function of X, independence, normality, and homoscedasticity [i.e. equal variance around the regression line]) were likely violated, a Model II regression for predicting ABC or DFW status was performed (Sokal and Rohlf 1995).

Two types of data – "intrinsic" data describing the academic habits and achievements of individual students, and "extrinsic" data describing the demographics and average academic performance of students' high schools or students from those high schools taking gateway courses at NAU at the time the study was conducted – were collected, two separate models were used in the regression analyses. The X variables that were considered in both models are listed in Tables 3 and 4.

Age
Cumulative college credits earned
Cumulative college grade point average
Current semester credits enrolled
Current semester grade point average
Ethnicity
Gender
High school grade point average
High school rank

Table 3: X variables considered in regression model for "intrinsic" student data. Variables are listed alphabetically.

ACT score
Age
Average high school AIMS math score
Average high school AIMS reading score
Average high school grade point average
Average high school rank
Average high school Stanford 9 math score
Average high school Stanford 9 reading score
Cumulative college credits earned
Cumulative college grade point average
Current semester credits enrolled
Current semester grade point average
Ethnic proportions
Percent of females
SAT (combined) score
Socioeconomic status

Table 4: X variables considered in regression model for "extrinsic" student data. Variables are listed alphabetically.

The criteria used for developing predictive models were parsimony and utility. Models with fewer predictor variables and predictor variables that were universally available (e.g. high school grade point average, which is available for all gateway students, rather than ACT score, which is only available for a subset of gateway students) were preferred to models with many or sparsely distributed variables. Furthermore, models that had high predictive values and could be used for all (not just a subset of) gateway students were preferred.

Results

Data on student success rates in gateway business, math, and science courses at NAU are presented below. Statistics on course-oriented variables are presented first. Next, data on student-oriented variables are presented. Finally, several models designed to predict students' ABC or DFW status are described.

Data are presented this way to separate external/contextual factors from internal/personal factors. It is hoped that organizing the data in this fashion will illustrate interesting trends and allow consumers of this information better design appropriate and effective interventions to address specific concerns.

Statistical significance was determined when $p \leq 0.05$. Confidence was described as "approaching significance" when $0.05 \leq p \leq 0.10$. In instances when this occurred, statistical results were reported. When $p \geq 0.10$, results were considered to be non-significant, and they were not reported.

Graphs are provided to help illustrate interesting trends and significant findings. When significant differences between genders or among ethnic groups are present, graphs to illustrate these between and among group differences are provided.

Course-Oriented ABC and DFW Statistics

Because a significant percentage of grades were not reported at the time of data collection for BIO 181 in the Fall 1997 through Spring 2001 semesters (average number of grades not reported = 46%) and BIO 182 in the Fall 2000 through Spring 2001 semesters (average number of grades not reported = 49%), valid ABC and DFW statistics for these courses could not be accurately calculated. Thus, BIO 181 and BIO 182 data were excluded for most analyses in this portion of the study, although data from these courses were included in other portions of the study because these other types of data do not rely on a majority of final grades being reported to ensure their validity.

A significant number of grades were similarly not reported for CIS 120 from Fall 1997 through the Spring 1999 semesters (average number of grades not reported = 49%). However, grade data were complete for the Fall 1999 through Spring 2001 semesters. These data were used to calculate this class' ABC and DFW statistics.

ABC and DFW Rates in Gateway Courses

Average ABC and DFW rates for 13 gateway business, math, and science courses taught in the 1997 through Fall 2001 semesters at NAU are reported in Table 5. The average ABC rate was 75%, and the average DFW rate was 25%. There was no significant difference between ABC and DFW rates in the Fall ($n = 13$, $t = -0.716$, $p = 0.242$) and Spring semesters ($n = 13$, $t = 0.181$, $p = 0.571$).

While most courses' ABC and DFW rates fall within one standard deviation of the mean, two courses fall outside of that distribution. PHY 112 has a comparatively high ABC rate (and thus low DFW rate), and MAT 125 has a comparatively low ABC rate (and thus high DFW rate).

	Spring ABC Rate	Fall ABC Rate	Spring DFW Rate	Fall DFW Rate	Average ABC Rate	Average DFW Rate
ACC255	66%	69%	34%	31%	67%	33%
ACC256	70%	69%	31%	32%	69%	31%
BA201	69%	73%	32%	27%	71%	30%
BIO100	79%	81%	22%	19%	80%	20%
CHM151	68%	73%	33%	27%	70%	30%
CHM152	78%	74%	21%	25%	76%	23%
CIS120	82%	85%	19%	16%	83%	17%
ENV101	81%	78%	21%	22%	79%	21%
GLG100	84%	82%	16%	18%	83%	17%
MAT125	60%	60%	40%	40%	60%	40%
MAT137	67%	72%	33%	28%	69%	30%
PHY111	83%	82%	17%	17%	83%	17%
PHY112	84%	83%	16%	23%	84%	16%
Mean	75%	75%	26%	25%	75%	25%
SD	8%	7%	8%	7%	8%	8%

Table 5: Grades reported in gateway courses of interest. Some totals may not equal 100% because of excluded data, missing data, reporting errors, and/or rounding errors).

Teaching Styles Used in Gateway Courses

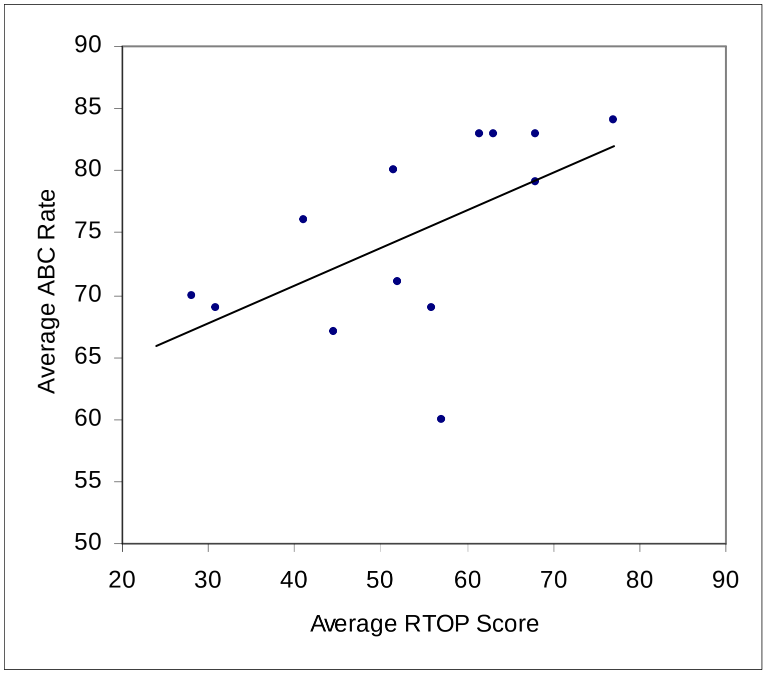
A description of the teaching technique used in each course of interest, measured by the average RTOP score, is shown in Table 6. The range of scores was 24.0 – 77.0, and the mean score was 51.6 (SD ± 15.7), suggesting that most gateway business, math, and science courses at NAU are taught with relatively traditional, didactic methods.

Prefix	Course Name	Average RTOP Score
ACC 255	Accounting Principals Financial	44.5
ACC 256	Accounting Principals Managerial	31.0
BA 201	Quantitative Methods (Business)	52.0
BIO 100	Principals of Biology	51.5
BIO 181	Unity of Life I	24.0
BIO 182	Unity of Life II	52.0
CHM 151	General Chemistry I	28.0
CHM 152	General Chemistry II	41.0
CIS 120	Introduction to Computer Information Systems	61.5
ENV 101	Environmental Science	68.0
GLG 100	Introductory Geology	63.0
MAT 125	Pre Calculus	57.0
MAT 137	Calculus II	56.0
PHY 111	General Physics I	68.0
PHY 112	General Physics II	77.0

Table 6: Description of teaching styles, measured by the RTOP, used in each course. Low scores suggest didactic techniques; high scores suggest reformed techniques.

While most courses had average RTOP scores that were within one standard deviation of the mean, the RTOP scores of several courses were outside of this range. The average scores of three courses (BIO 181, CHM 151, and ACC 256) were lower than one standard deviation, and the scores of three courses (ENV 111, PHY 111, and PHY 112) were above one standard deviation.

A moderate correlation existed between each course's RTOP score and its ABC rate ($n = 13$, $r = 0.575$, $p = 0.040$). This correlation is illustrated in Graph 1. Because the ABC rates for BIO 181 and BIO 182 were not available, these courses were excluded from this analysis.



Graph 1: Correlation between each course's average RTOP score and average ABC rate (n = 13, r = 0.575, p = 0.040).

Student-Oriented ABC and DFW Statistics

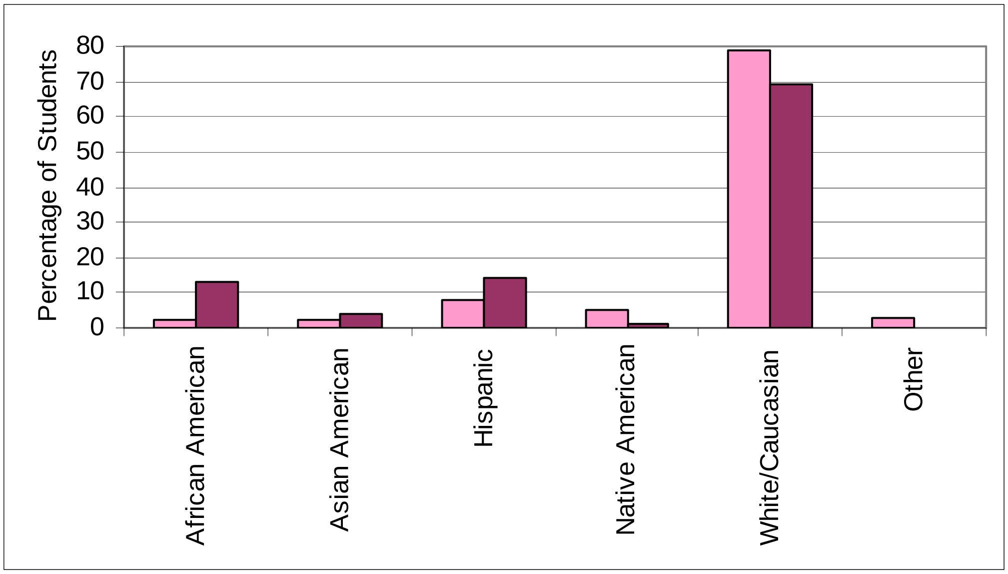
General student survey results, as well as results analyzed by ethnicity and gender, are listed below. Results are grouped in seven major categories: student demographics, student perception of course, student academic habits, effect of class on student, student perception of college life and NAU, student opinion of course, and student awareness of academic status.

The number and percent of students responding to each answer option are provided. The sum of counts for each option might not equal the total sample size because not all students responded to each question. The sum of percents for each question might not total 100% because of rounding or invalid student responses that could not be included in the total.

Twenty-three percent of students asked to participate in the survey did so. Although students in all groups of interest provided valid data, students who received an A in the course in which they took the survey were better represented, and students who received an F or W in the course in which they took the survey were more poorly represented, in the data set. Only three students who received a W were included in the data set. This is primarily because the survey was administered past the drop/add deadline each semester, and most students who received a W were not present when the survey was administered. Thus, the DFW statistics that rely exclusively on this survey data might be preferentially biased toward students who receive grades of D and F, but not W.

Students of both genders were equally represented in the sample. Students of all ethnic groups are not equally represented, nor are the distribution of ethnicities in this data set representative of the distribution of ethnicities in the general U.S. population (U.S. Census Bureau 2000). A comparison of the distribution of ethnicities in each population is below (reporting and rounding errors cause both columns to not total 100%) and in Graph 2.

	% (in sample)	% (in U.S. population)
1) African American	2	13
2) Asian American	2	4
3) Hispanic	8	14
4) Native American	5	1
5) White/Caucasian	79	69
6) Other	3	<1



Graph 2: Comparison of ethnicities in this sample (light bars) and in the U.S. population (dark bars).

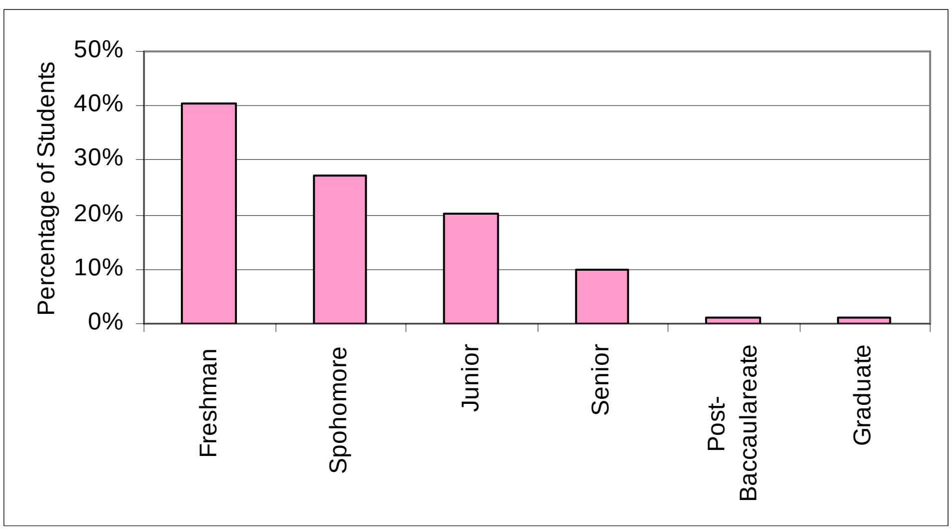
The proportion of White/Caucasian and Native American people in this sample is greater than the proportion of these ethnicities in the general United States population. The proportion of other ethnicities, particularly African Americans and Hispanics, in this sample is lesser than the proportion of these ethnicities in the general United States population. The proportion of ethnicities in this sample is representative of the proportion of ethnicities enrolled as freshmen at NAU (see below).

Student Demographics

A majority of students (68%) in gateway business, math, and science classes are underclassmen (freshmen and sophomores). Thirty percent of students in gateway are upperclassmen (juniors and seniors). Two percent are degree holders (Graph 3). No statistically significant differences exist in the distribution of ABC or DFW grades within any level of academic rank (n = 482, G^2 = 9.547, p = 0.089), although the distribution of grades by academic rank approached significance. Sophomores and seniors seemed slightly more likely to receive ABCs, while freshmen and juniors seemed slightly more likely to receive DFWs.

What is your class status?

	Count	Percent
1) Freshman	291	41
2) Sophomore	194	27
3) Junior	145	20
4) Senior	70	10
5) Post-Baccalaureate	8	1
6) Graduate	9	1

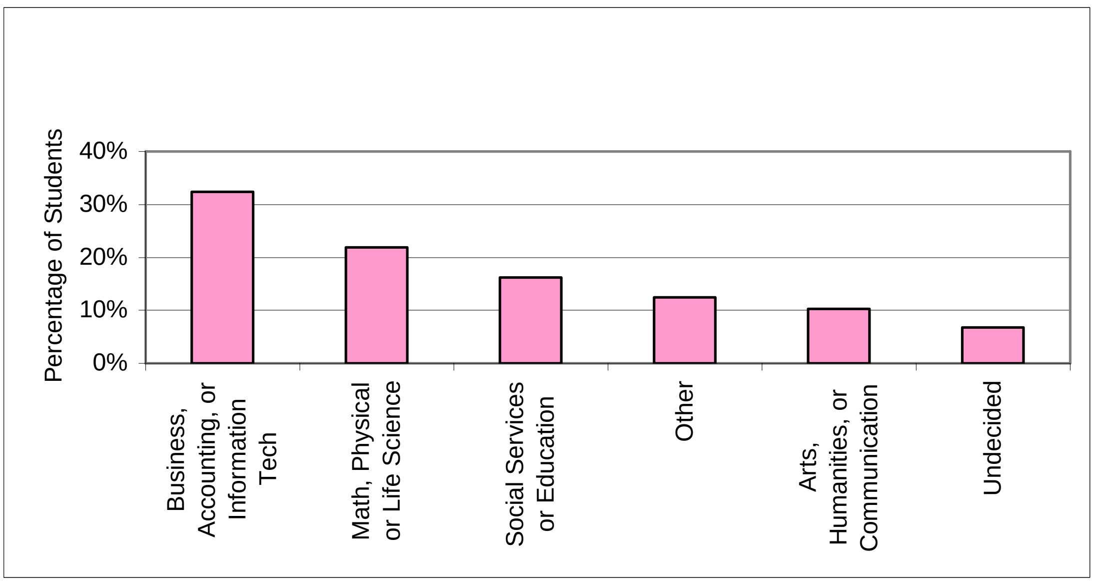


Graph 3: Representation of academic ranks in gateway business, math, and science courses.

Most students (54%) enrolled in gateway business, math, and science courses identify themselves as business, math, and science majors. No statistically significant differences exist in the distribution of ABC or DFW grades among majors. Graph 4 describes the representation of majors in gateway business, math, and science courses.

Which category best describes your major?

	Count	Percent
1) Arts, humanities, or communication	73	10
2) Business, accounting, or information technology	231	32
3) Social services (social science, social work, health care), or education	115	16
4) Math, physical science, life science	156	22
5) Undecided	48	7
6) Other	89	13



Graph 4: Representation of majors in gateway business, math, and science courses.

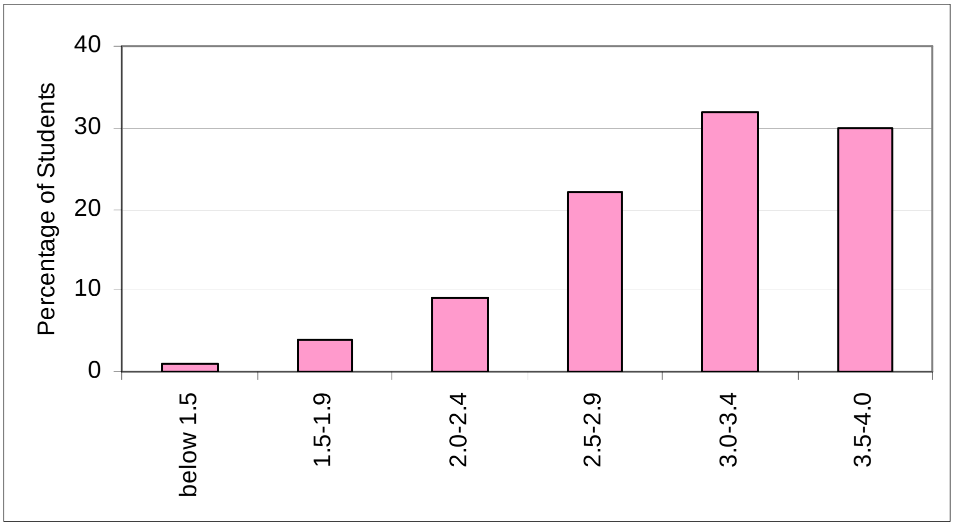
Most students (84%) in gateway courses have a self-reported overall college GPA of 2.5 or better; more than half (54%) have a self-reported overall college GPA of 3.0 or better (Graph 5). It should be noted that overall college

GPA is presumably a metric derived from classes students took *before* enrolling in the gateway course of question, although the possibility that some students included their present semester's grades in their responses does exist. Among all demographic variables measured with the student survey, overall college GPA was the strongest predictor of DFW status.

Significant differences exist in success rates among students who have different overall college GPAs (n = 475, G^2 = 104.652, p = 0.000). Student success in gateway courses was largely split between students with overall college GPAs below and above 3.0. Students who reported that their GPA was between 2.0 and 2.4 were most likely (G^2 = 14.605) to receive a DFW, although all students who had a GPA that was less than 3.0 were comparably likely to receive a DFW in a gateway course. Students who reported that their GPA was 3.5 or above were least likely (G^2 = 24.261) to be in the DFW group, although students with a GPA between 3.0 and 3.4 were comparably likely (G^2 = 4.217) to receive a DFW.

What is your overall college GPA?

	Count	Percent
1) below 1.5	9	1
2) 1.5-1.9	31	4
3) 2.0-2.4	67	9
4) 2.5-2.9	157	22
5) 3.0-3.4	229	32
6) 3.5-4.0	213	30



Graph 5: Distribution of self-reported overall college GPAs in gateway business, math, and science courses.

Significant differences in self-reported college GPA existed among ethnic groups (n = 699, G^2 = 80.865, p = 0.000), although the results of this analysis are suspect because of the poor representation of some ethnic groups in some grade categories. However, a similar analysis performed with institutional data representing GPA as a continuous rather than a categorical value yields similar results (n = 22772, F = 148.323, p = 0.000), although in this case a large sample size might contribute to a confidence level that is educationally unrealistic.

Still, the data suggest that major ethnic groups on campus have significantly different GPAs. The mean cumulative college GPA and standard error for each group is listed in Table 7. A post-hoc Tukey-Kramer HSD test suggests that Native American and African American students have the lowest (there are no statistically significant differences between the GPAs of the two groups), and that International students have the highest, GPAs among all students enrolled at NAU (q^* = 2.95, α = 0.05). Table 7 illustrates statistically significant differences among GPAs of different ethnic groups. Significant differences are represented by letters in the "Group" column; the GPAs of groups labeled with different letters are significantly different from each other.

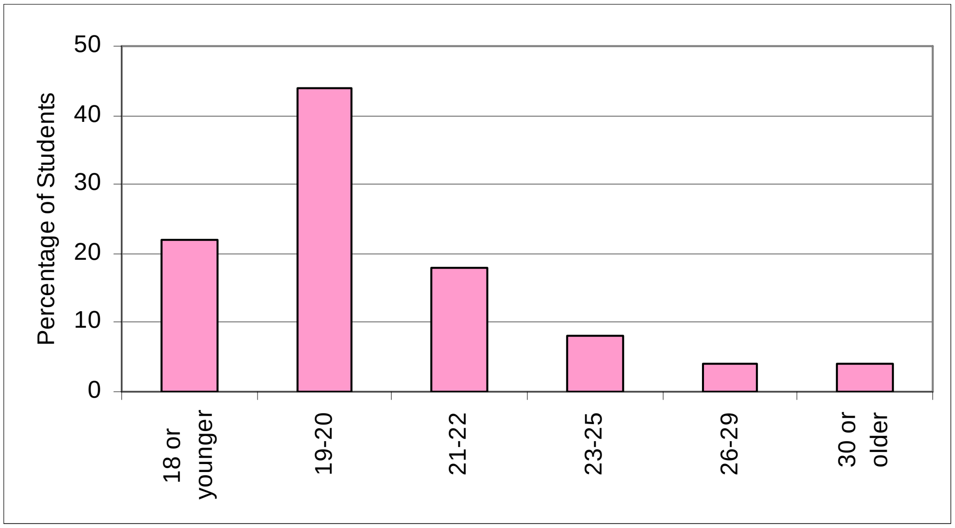
	Mean GPA	Std. Err.	Group
International	3.11	0.046	A
White/Caucasian	2.86	0.006	B
Asian American	2.73	0.037	C
Hispanic	2.66	0.020	C
African American	2.34	0.041	D
Native American	2.30	0.021	D

Table 7: Mean cumulative college GPAs of major ethnic groups at NAU. Groups labeled with different letters have statistically significant differences among GPAs.

Most students (84%) are 22 years of age or younger, with 19 and 20 year olds predominating (Graph 6). There are no statistically significant differences in the distribution of ABC and DFW grades among age.

What is your age?

	Count	Percent
1) 18 or younger	161	22
2) 19-20	316	44
3) 21-22	127	18
4) 23-25	57	8
5) 26-29	27	4
6) 30 or older	31	4



Graph 6: Distribution of ages in gateway business, math, and science courses.

There are roughly equal proportions of females and males enrolled in gateway courses. Survey data suggest that females and males are equally likely to receive ABCs and DFWs.

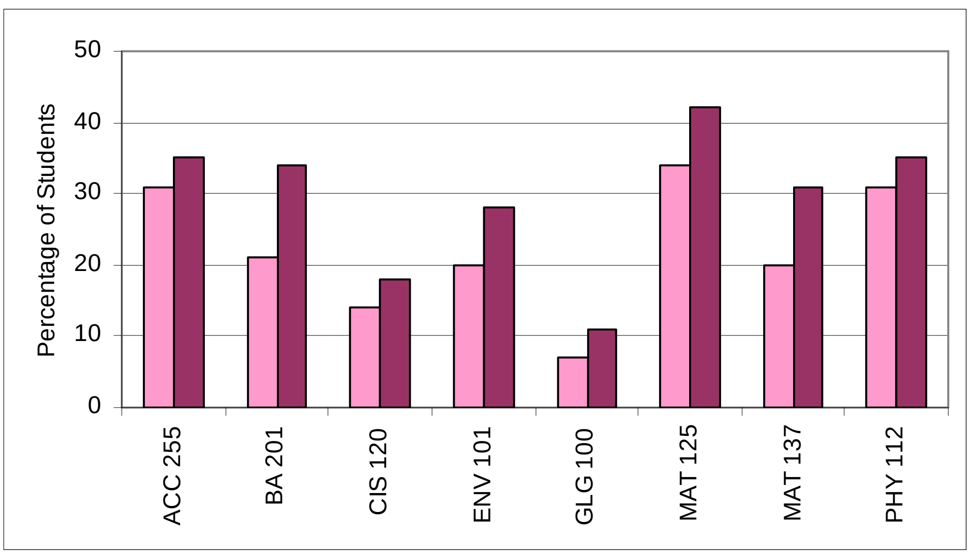
What is your gender?

	Count	Percent
1) Female	351	49
2) Male	362	51

Despite the lack of difference between success rates of females and males evidenced by the survey data, institutional data, analyzed by individual course, suggest that gender differences do exist in a subset of gateway courses. These data suggest that, in eight of fifteen courses in the study, females are slightly more likely than males to be in the ABC group (n = 22773, $G^2 = 59.869$, $p = 0.000$). In the seven other courses, females and males were equally represented in ABC and DFW groups. Males were not better represented in the

ABC group in any of the courses. The DFW rates of females and males in the eight courses where a significant difference was detected follow. These trends are illustrated in Graph 7.

	% Females in DFW Group	% Males in DFW Group
ACC 255	31	35
BA 201	21	34
CIS 120	14	18
ENV 101	20	28
GLG 100	7	11
MAT 125	34	42
MAT 137	20	31
PHY 112	31	35

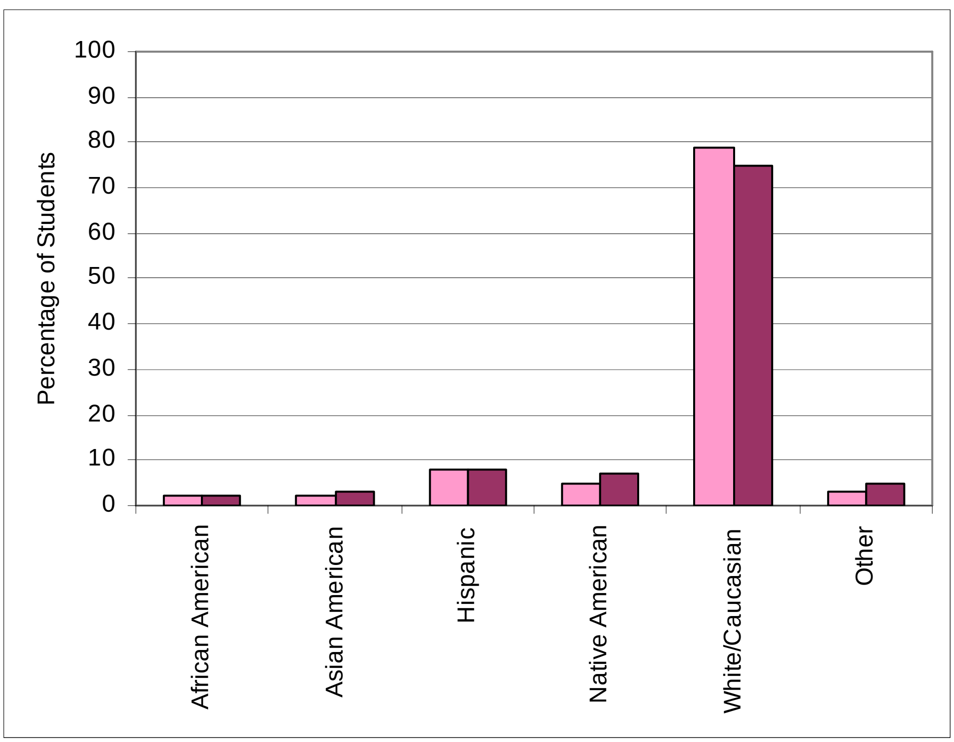


Graph 7: Illustration of differences in DFW rates between females (light bars) and males (dark bars) in courses where the difference was significant (n = 22773, G^2 = 59.869, p = 0.000). In all cases where a difference existed, females were worse represented in the DFW group than were males.

A large majority of students (79%) enrolled in gateway courses describe themselves as White/Caucasian. The representation of ethnic minorities in gateway business, math, and science courses is very low, but this representation is consistent with the distribution of ethnicities among incoming freshmen at the University during the study period. Graph 8 illustrates the distribution of ethnicities within gateway business, math, and science gateway courses (light bars) and of incoming freshmen (dark bars) in the Fall 2002 semester.

Which category best describes your ethnicity?

	Count	Percent (gateway)	Percent (freshmen)
1) African American	16	2	2
2) Asian American	15	2	3
3) Hispanic	59	8	8
4) Native American	36	5	7
5) White/Caucasian	563	79	75
6) Other	22	3	5

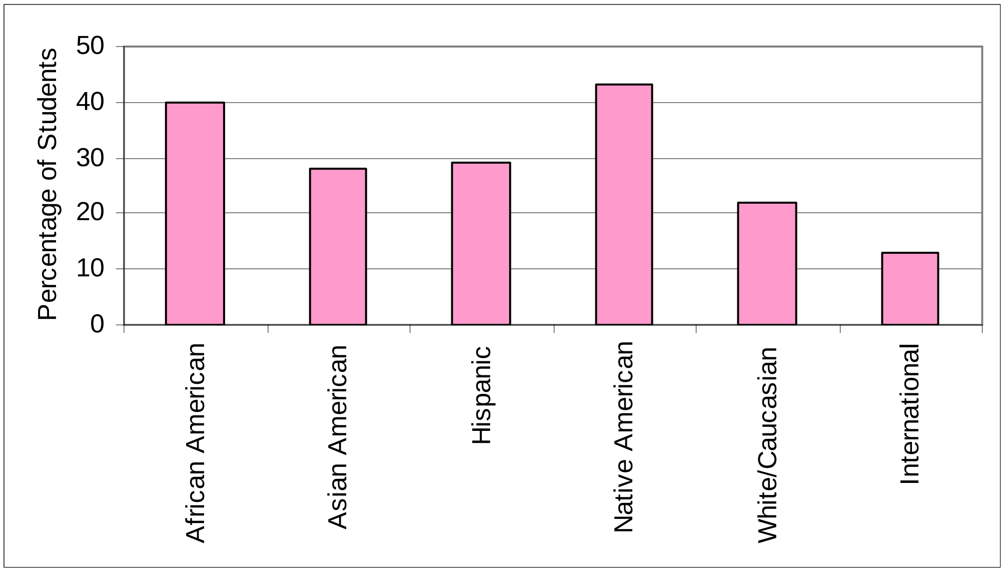


Graph 8: Distribution of ethnicities in gateway business, math, and science courses (light bars) and among incoming freshmen (dark bars) in the Fall 2002 semester.

Significant differences in DFW rates exist among ethnic groups (n = 482, $G^2 = 18.470$, p = 0.005). Students who identified themselves as Native American and Hispanic were most likely ($G^2 = 6.700$ and $G^2 = 5.653$, respectively) to receive a DFW, and students who identified themselves as White/Caucasian were least likely ($G^2 = 1.949$) to receive a DFW.

Institutional data (n = 22773) reveal the percentages of each ethnic group receiving ABCs and DFWs among all gateway business, math, and science courses. The rates at which students in each group receive DFWs are illustrated in Graph 9.

	ABC %	DFW %
Native American	57	43
African American	60	40
Hispanic	71	29
Asian American	72	28
White/Caucasian	78	22
International	87	13



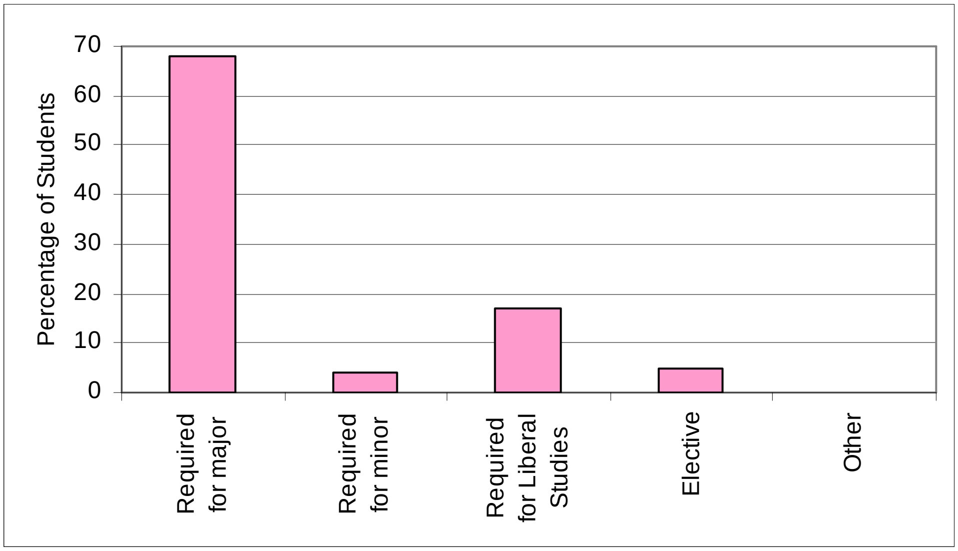
Graph 9: Rates at which students in each major ethnic group at NAU receive DFWs in gateway business, math, and science courses.

Student Perception of Course

Most (89%) students enroll in gateway business, math, and science courses because the courses are a required component of their degree program. Few students (5%) enroll in these courses as electives (Graph 10). No differences in success rates exist among students who are taking the class as a requirement or as an elective.

This class is:

	Count	Percent
1) Required for my major	449	68
2) Required for my minor	29	4
3) Required for Liberal Studies	115	17
4) An elective	32	5
5) Other	1	0

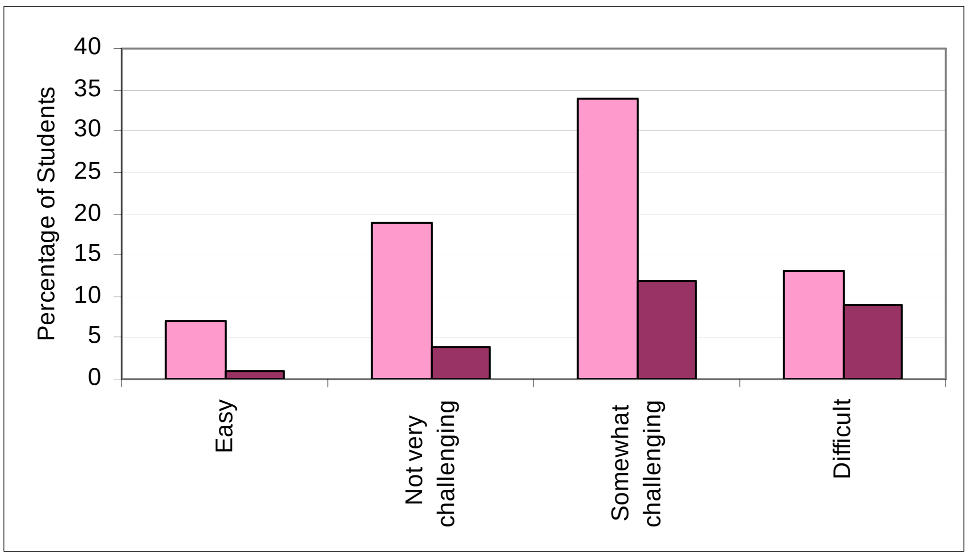


Graph 10: Student motivations for taking gateway business, math, and science courses.

Most students (71%) describe the gateway course in which they were surveyed as either "somewhat challenging" or "difficult" (Graph 11). There is a relationship between how students perceive the difficulty of their gateway courses their level of success in these courses (n = 482, G^2 = 20.391, p = 0.001). Students who describe their gateway course as "difficult" are more likely to receive a DFW (G^2 = 6.191), and students who describe the course as "easy" are least likely to get a DFW (G^2 = 1.142). Interestingly, students who describe the course as "somewhat challenging" are not at an elevated risk of getting a DFW (G^2 = 0.125). Despite their academic status, 68% percent of DFW students describe the class as "not very challenging."

Significant gender differences in student perception of the difficulty of gateway courses exist (n = 714, χ^2 = 19.226, p = 0.038). Females are more likely to describe challenge of gateway courses in moderate terms such as "not very challenging" (G^2 = 2.193) and "somewhat challenging" (G^2 = 1.169); males are more likely to describe challenge of the courses using severe terms such as "easy" ($G^2 = 5.345$) and "difficult" ($G^2 = 0.043$).

How challenging is this class for you?	Count	Percent
1) Easy	43	9
2) Not very challenging	96	20
3) Somewhat challenging	232	48
4) Difficult	109	23

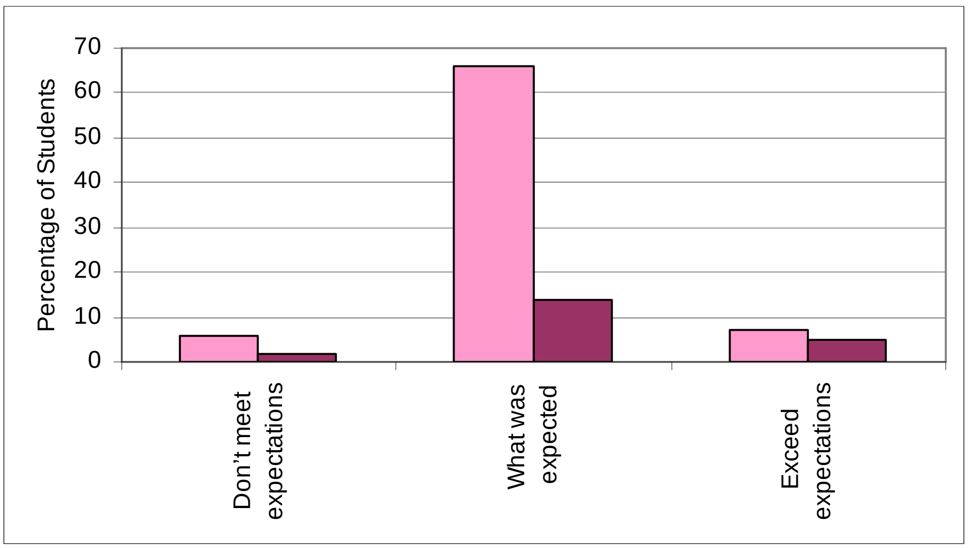


Graph 11: Student opinion of difficulty of class. Light bars represent ABC students; dark bars represent DFW students. Significant differences exist between ABC and DFW students' opinions of the difficulty of gateway courses (n = 482, $G^2 = 20.391$, p = 0.001).

Most students (85%) say that activities in the class are consistent with or exceed their original expectations of the class. No significant differences in DFW rates exist among students whose expectations of the gateway course were not met, were met, or were exceeded, however significance was approached (n = 482, $G^2 = 7.905$, p = 0.095). Notable differences existed only in the group that describes the activities in the course as "what I expected." In this group, ABC students were far better represented than were DFW students. This difference is illustrated in Graph 12.

How consistent are activities in this class with your original expectations of this class?

	Count	Percent
1) The activities don't meet my expectations	96	13
2) The activities are what I expected	505	71
3) The activities exceed my expectations	97	14

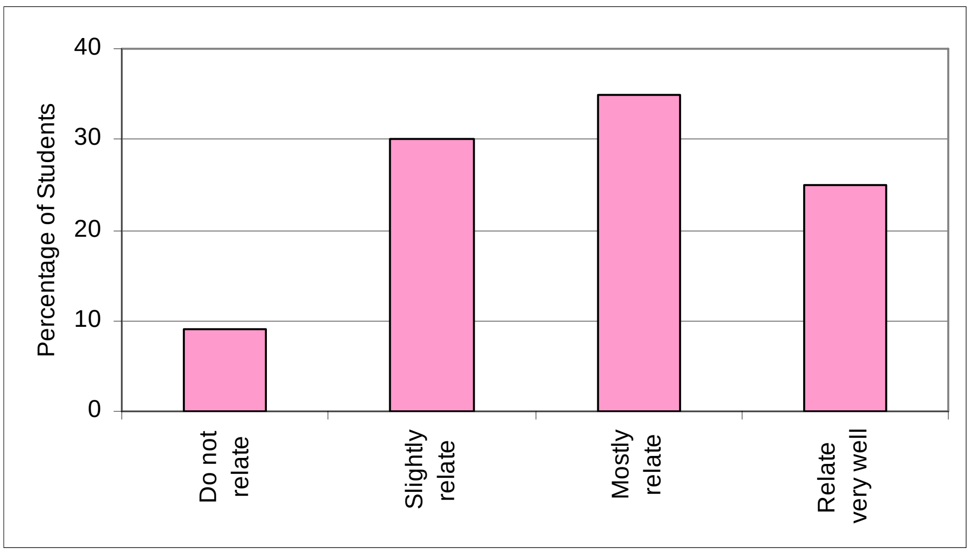


Graph 12: Student perception of the ability of gateway business, math, and science courses to meet their expectations. Light bars represent ABC students; dark bars represent DFW students.

A majority of students (60%) feel as if concepts addressed in their gateway business, math, and science classes relate to real world experiences (Graph 13). No differences in DFW rates exist among students who viewed concepts in the class as relevant or not relevant to real world experiences.

How do things you learn in this class relate to the real world?

	Count	Percent
1) Concepts in this class do not relate to real world experiences	67	9
2) Concepts in this class only slightly relate to real world experiences	217	30
3) Concepts in this class mostly relate to real world experiences	249	35
4) Concepts in this class relate very well to real world experiences	180	25

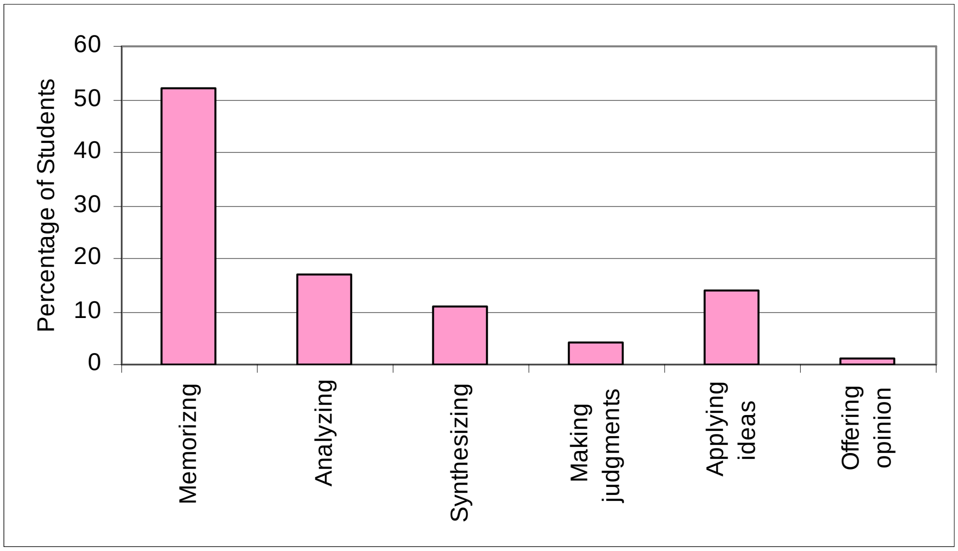


Graph 13: Student perception of the relatedness of concepts addressed in gateway business, math, and science courses to real world experiences.

A majority of students (52%) perceived that success in their gateway class mainly required memorizing facts, methods, and/or equations (Graph 14). No statistically significant differences existed in the way ABC and DFW students describe the strategies necessary for success in gateway courses, but significance was approached (n = 475, G^2 = 9.793, p = 0.081).

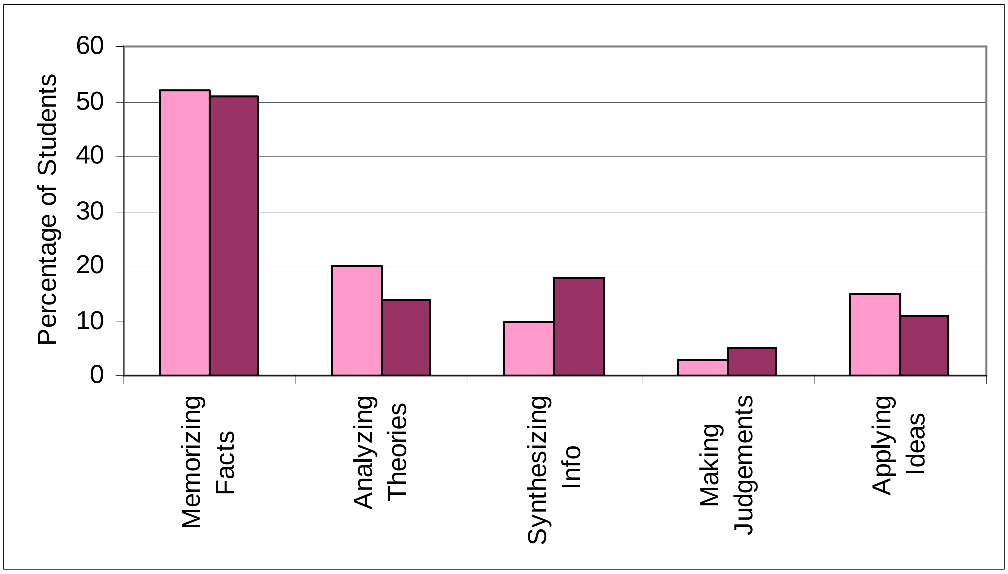
Success in this class mainly requires:

		Count	Percent
1)	Memorizing facts, methods, and/or equations	365	52
2)	Analyzing theories, concepts, or ideas	123	17
3)	Synthesizing new information or ideas	78	11
4)	Making judgments about the value of ideas	31	4
5)	Applying learned ideas in practical situations	102	14
6)	Offering my opinion, expressing my feelings or beliefs	5	1

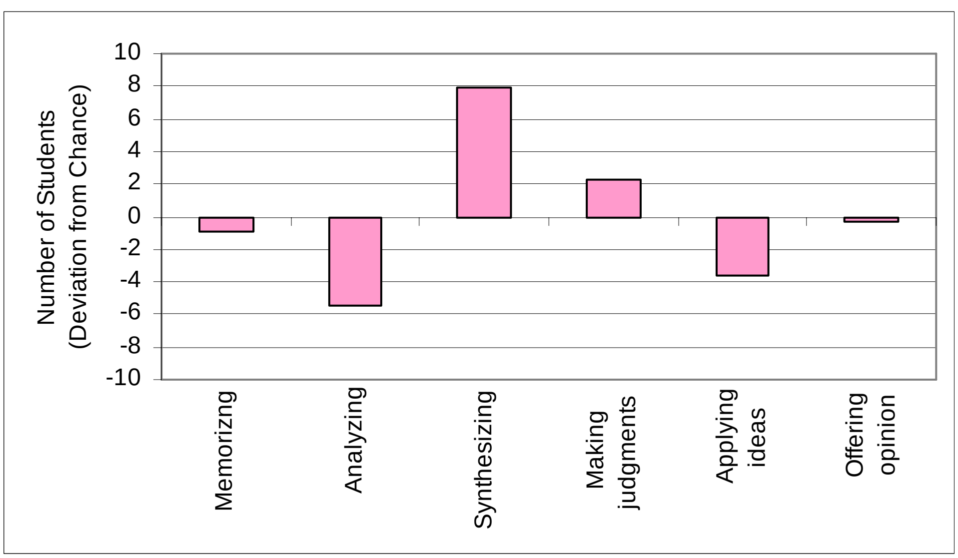


Graph 14: Student perception of the strategies needed for success in gateway business, math, and science courses.

Although the overall results of this analysis were not statistically significant, the data suggest an interesting pattern. Slightly fewer students who perceived that success in their gateway class required memorizing, analyzing, applying ideas, and offering opinions (i.e. responses 1, 2, 5, and 6 on the questionnaire) received DFWs than would be expected by chance. In contrast, slightly more students who perceived that success in their gateway class required synthesizing new ideas and making judgments (i.e. responses 3 and 4 on the question) received DFWs than would be expected by chance. Said differently, students who perceived that success in their gateway class required the synthesis of new ideas and judgments were the students who seemed to be at an elevated risk of receiving a DFW. This possible pattern is illustrated in Graphs 15 and 16.



Graph 15: Study strategies used by ABC (light bars) and DFW (dark bars) students While the differences illustrated in this graph are not statistically significant, they suggest an interesting pattern.



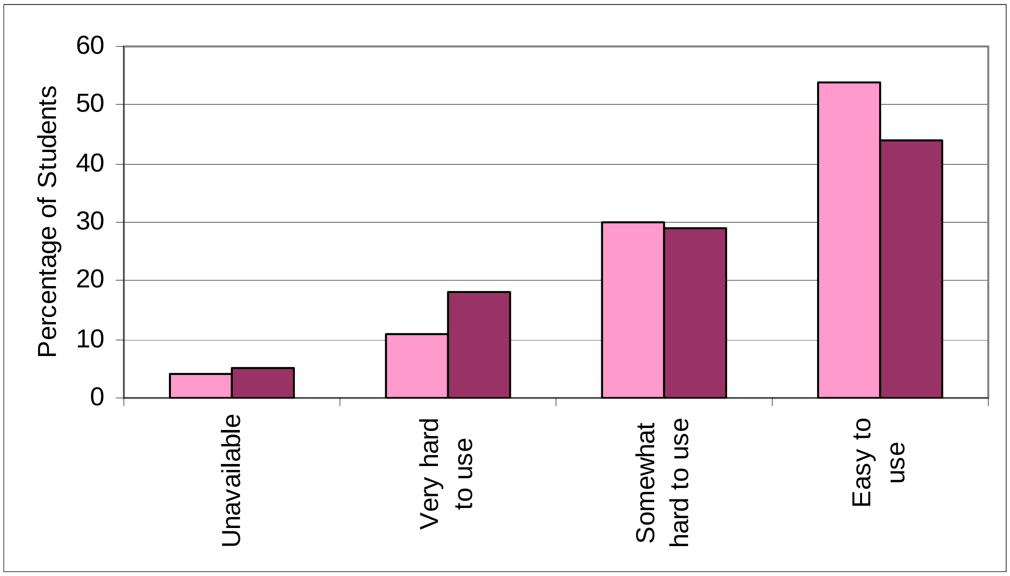
Graph 16: Number of students (out of 472) beyond chance who perceive the primary strategy required for success in gateway business, math, and science courses and who are in the ABC (negative numbers) or DFW groups (positive numbers). While the differences illustrated in this graph are not statistically significant, they do suggest an interesting pattern.

Most students in gateway courses (80%) perceive the resources necessary for success in their gateway course as reasonably available and convenient to use (Graph 17). Significant differences exist among students who differently perceive resource availability (n = 479, G^2 = 12.803, p = 0.025). Students who perceive necessary resources as "available, but very difficult or inconvenient to use" were most likely to be in the DFW group (G^2 = 6.821). Students who perceive necessary resources as "readily available and easy to use" were most likely to be in the ABC group (G^2 = 1.302).

Analyzing the data by gender reveals differences between females and males in their perception of resource availability.

In general, females are more likely to have a favorable view of resource availability (n = 705, G^2 = 22.951, p = 0.011). Females are more likely to describe class resources as "readily available and easy to use" (G^2 = 1.840), whereas males are more likely to describe resources required for this class as "not available" (G^2 = 3.589) or "available, but very difficult to use" (G^2 = 1.270).

The resources necessary for success in this class are:	Count	Percent
1) Not available	37	5
2) Available, but very difficult or inconvenient to use	105	15
3) Available, but a bit difficult or inconvenient to use	210	30
4) Readily available and easy to use	351	5



Graph 17: Difference between ABC (light bars) and DFW (dark bars) student perception of the resources available in gateway business, math, and science courses.

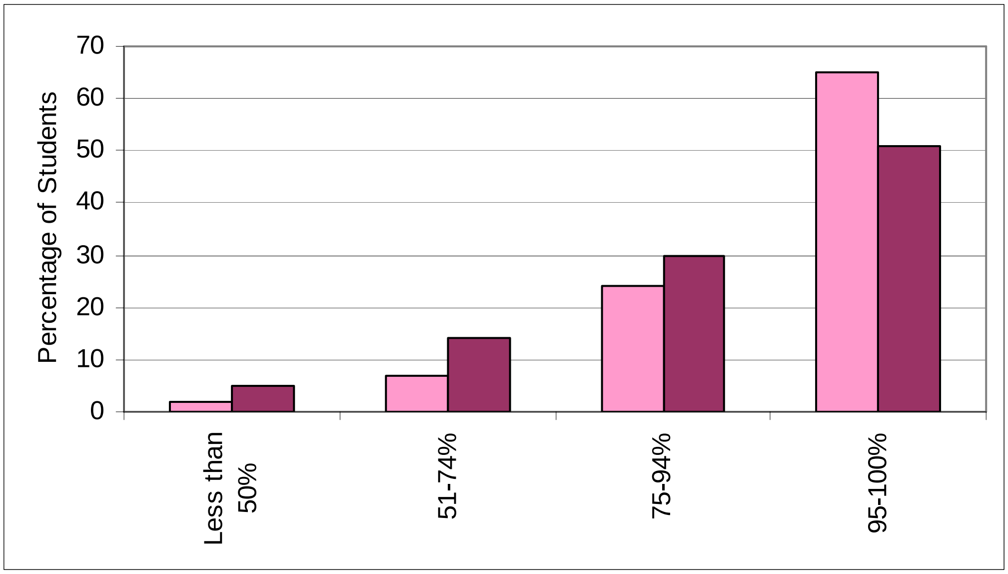
By mid-semester, students are capable of predicting their final grade (n = 482, G^2 = 395.463, p < 0.001) and, thus, their ABC or DFW status in their gateway courses (n = 482, G^2 = 181.683, p < 0.001). There are no differences in the nature of grade predictions among female and male students. However, differences in the nature of grade predictions do exist among ethnic groups (n = 708, G^2 = 38.101, p = 0.045). Students who describe themselves as Native American are most likely (G^2 = 6.700), and students who describe themselves as Hispanic are second most likely (G^2 = 5.653), to predict at mid-semester that they will receive a DFW in the course. Students who describe themselves as White/Caucasian are least likely (G^2 = 1.949) to predict at mid-semester that they will receive a DFW in the course. Caution must be used in the interpretation of these results, however. The analysis is suspect because of poor representation of some ethnic groups in some categories.

Student Academic Habits

A majority (62%) of students say they attend class 95% or more of the time (Graph 18). There is a relationship between class attendance and student success (n = 482, G^2 = 14.609, p = 0.012). Students whose attendance is 95% or greater are more likely to be in the ABC group (G^2 = 0.922). Students whose attendance is between 51% and 74% are most likely to be in the DFW group (G^2 = 3.367). Students whose attendance is less than 50% are similarly at risk (G^2 = 2.482) of receiving a DFW. Females are slightly more likely (G^2 = 0.767) to have a class attendance of 95% or greater. There are no significant differences in attendance rates among ethnic groups.

How often do you come to class?

	Count	Percent
1) Less than 50% of the classes	14	3
2) 51-74% of the classes	45	9
3) 75-94% of the classes	124	26
4) 95-100% of the classes	295	62



Graph 18: Difference between ABC (light bars) and DFW (dark bars) in self-reported student attendance rate in gateway business, math, and science courses.

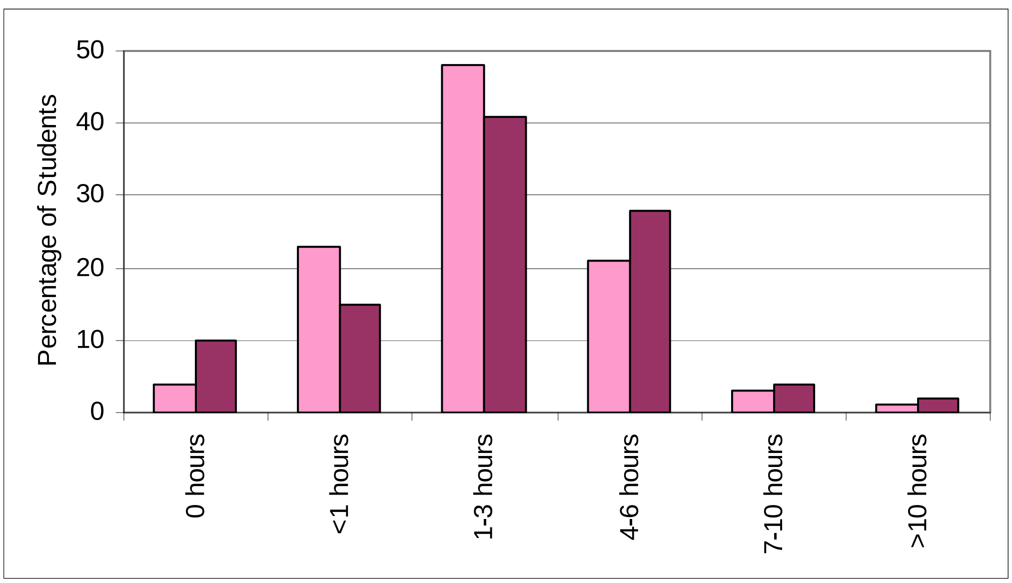
Ninety percent of students spend more than 0 but less than 6 hours per week outside of class on class-related activities such as reading, doing homework, and studying. Many students (46%) spend between 1 and 3 hours per class per week on these activities. Fewer than 5% of students spend 7 or more hours per class per week on these activities (Graph 19).

Significant differences in achievement exist among students who devote different amounts of their time to class (n = 480, G^2 = 13.009, p = 0.023). Not surprisingly, students who devote no time outside of class to coursework are most likely (G^2 = 4.542) to receive a DFW. But there is not a linear relationship between time students spend on schoolwork outside of class and success in class. For example, students who spend between 0 and 1 hours per week on a class are more likely (G^2 = 0.792) to receive an ABC than students who spend more than 1 extracurricular hour per week on class. However, the magnitude of this effect is relatively small and comparable among all groups of students who devote some extracurricular time to class. It is therefore reasonable to say that significant differences in achievement exist simply between students who do and who do not spend time on their coursework outside of class.

No significant differences in time devoted to class exist among gender and ethnic groups.

How many hours per week do you devote to this class *beyond* the time you spend in class (for example, reading, doing homework, and studying)?

	Count	Percent
1) I don't spend any time on this class outside of lecture/lab	26	5
2) Less than one hour	99	21
3) 1-3 hours	222	46
4) 4-6 hours	110	23
5) 7-10 hours	16	3
6) more than 10 hours	7	1



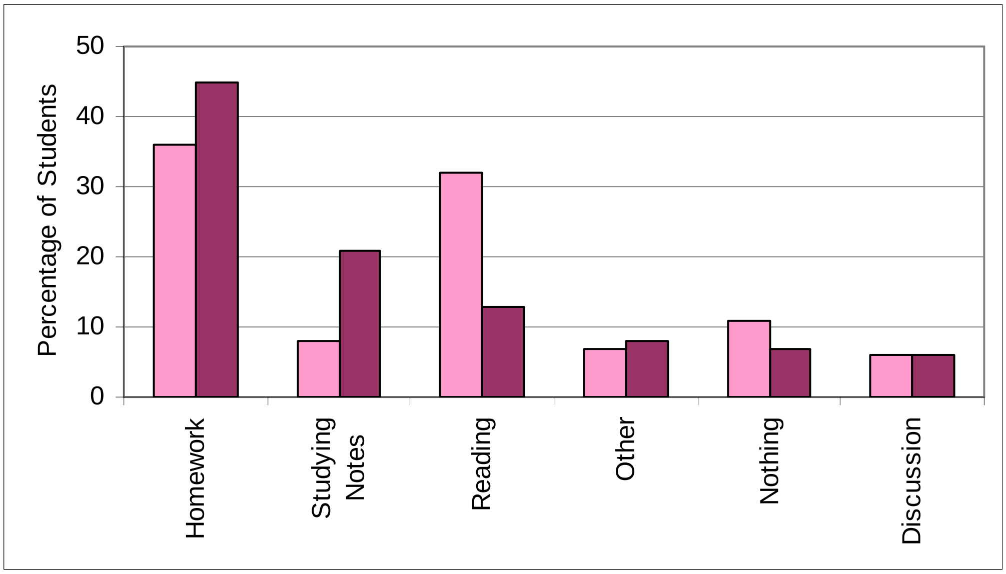
Graph 19: Difference between ABC (light bars) and DFW (dark bars) students in the number of hours per week spent on each gateway course outside of class.

Students regularly prepare for gateway courses by doing homework (40%) and reading the text and assigned readings (25%). Ten percent of students say they do nothing to prepare for class (Graph 20). There are significant differences (n = 470, G^2 = 32.172, p < 0.000) in the success rates of students who use the various preparation strategies listed. Students who prepare for class by reading are more likely (G^2 = 3.496) to be in the ABC group, whereas students who study notes to prepare are more likely (G^2 = 10.388) to be in the DFW group.

There are there no significant differences in use of alternative preparation strategies between genders or among ethnicities.

How do you regularly prepare for this class?

	Count	Percent
1) Reading the text or assigned readings	174	25
2) Studying notes taken in class	79	11
3) Doing homework	279	40
4) Talking with classmates or friends	45	7
5) Other	42	6
6) I don't do anything to prepare	71	10



Graph 20: Differences in preparation strategies between ABC (light bars) and DFW (dark bars) students in gateway courses. ABC students tend to read texts and/or course materials more, whereas DFW students tend to do homework and study notes more.

Seventy-eight percent of students discuss ideas from class with other people outside of class during the semester. Half of these students (40% of total) exchange ideas with their peers 1-3 times per semester, and half (38% of total) exchange ideas 4 or more times. Twenty-two percent of students never discuss class material outside of class (Graph 21).

Significant differences in success exist among students who do and do not discuss class materials with their peers (n = 480, G^2 = 10.579, p = 0.032). Students who discuss ideas from class 1-3 times per semester with their associates outside of class are most likely (G^2 = 1.059) to receive an ABC, while students who never discuss class materials with their peers are most likely (G^2 = 2.790) to receive a DFW.

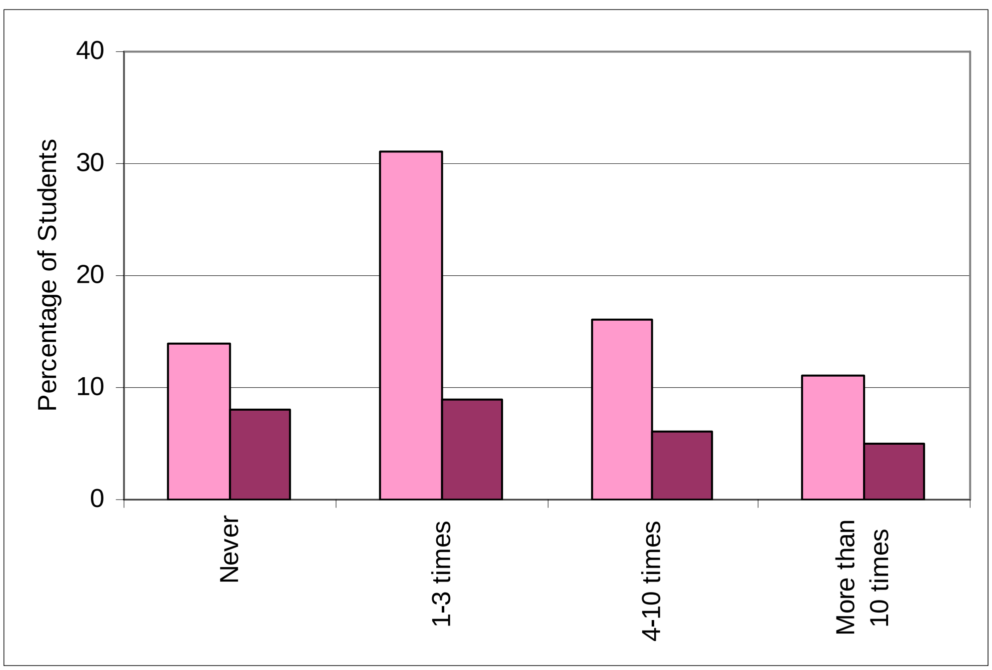
Slight but significant gender differences exist in the frequency with which classroom ideas are discussed outside of class (n = 706, G^2 = 17.639, p = 0.024).

Males seem to exchange classroom ideas outside of class more often than females do. Males are most likely (G^2 = 2.585) to exchange ideas more than 10 times per semester, while females are most likely (G^2 = 1.104) to exchange ideas from 1-3 times per semester.

No differences exist in the frequency of extracurricular idea exchange among ethnic groups.

How often did you discuss ideas from lectures, labs, or readings from this class with people outside of class?

	Count	Percent
1) Never	107	22
2) 1-3 times per semester	190	40
3) 4-10 times per semester	108	23
4) More than 10 times per semester	74	15



Graph 21: Number of times per semester students exchanged class ideas outside of class. Light bars represent students in the ABC group, and dark bars represent students in the DFW group. The greatest difference between groups exists among students who discuss ideas from class outside of class 1-3 times per semester.

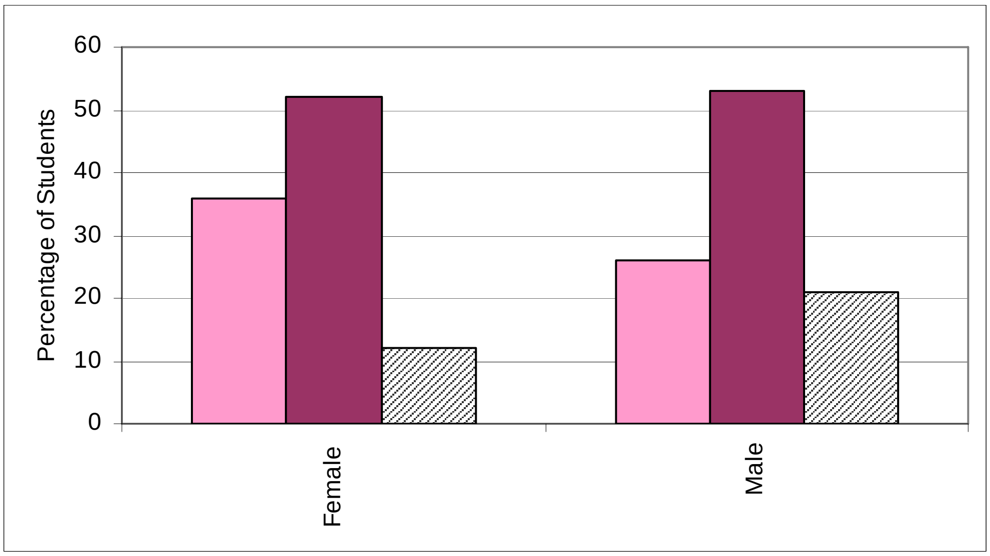
Most students (83%) perceive their level of class participation in class as equal to or less than that of their peers. About half of the students say they participate in class as much as their peers, and about one-third of the students say they participate less than their peers. Only 16% perceive themselves as being among the most active participants in class.

No statistically significant differences exist in levels of achievement among students who say they participate in class more, equally, or less than their peers. However, significant differences in self-described levels of participation exist between gender (n = 706, G^2 = 19.472, p = 0.013) and among ethnic (n = 702, G^2 = 45.232, p = 0.001) groups. Females are more likely (G^2 = 2.975) to say their classmates participate more than they do, and males are more likely (G^2 = 4.013) to say participate more than their classmates do (Graph 22).

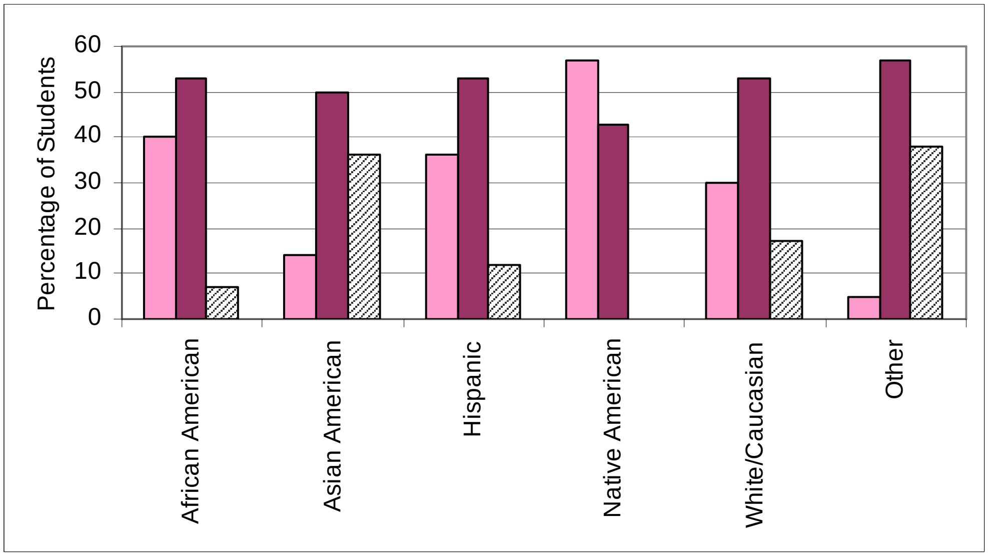
Students who describe their ethnicities as Native American (G^2 = 7.073) or Other (G^2 = 4.646) are most likely to say their classmates participate more than they do. No Native Americans in the sample described their level of participation as greater than that of their classmates. Students who describe themselves as African American and Hispanic seem to show similar trends in their self-described levels of participation, but sample sizes in these groups were too small to make a statistical conclusion about the strength of this possible effect (Graph 23).

Compared to your classmates, what is your level of in-class participation?

	Count	Percent
1) My classmates participate more than I do	219	31
2) I participate about the same as my classmates	370	52
3) I participate more than my classmates	116	16



Graph 22: Percentage of students in each gender who describe their level of class participation relative to their peers. Light bars represent students who say they participate less than their classmates, dark bars represent students who say they participate equally to their classmates, and striped bars represent students who say they participate more than their classmates.



Graph 23: Percentage of students in each ethnic group who describe their level of class participation relative to their peers. Light bars represent students who say they participate less than their classmates, dark bars represent students who say they participate equally to their classmates, and striped bars represent students who say they participate more than their classmates.

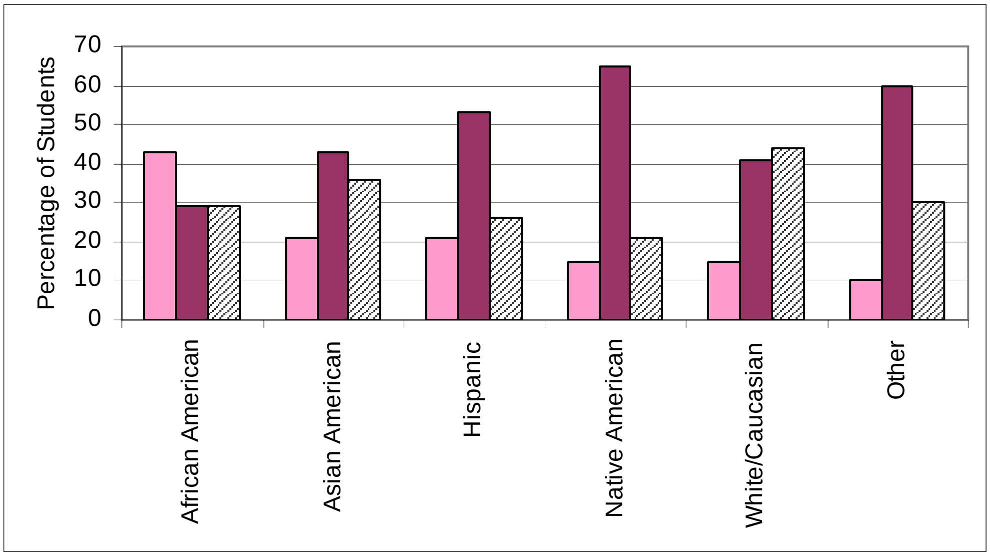
A majority (61%) of students describe themselves as underprepared for the course at the beginning of the semester. Slight but significant differences in achievement exist between students who describe themselves as prepared and not prepared (n = 477, G^2 = 14.867, p = 0.011). Students who describe themselves as somewhat prepared, but lacking some important skills or knowledge for the course are most likely to receive a DFW (G^2 = 0.8733), although students who describe themselves as not prepared are similarly at risk (G^2 = 0.621). Students who describe themselves as prepared are most likely to receive an ABC (G^2 = 1.447).

No significant differences exist in student self-perception of preparedness between genders, but this effect approaches significance (n = 703, G^2 = 16.340, p = 0.090). In this analysis, females seem more likely to describe themselves as not or somewhat prepared, and males seem more likely to describe themselves as prepared.

Significant differences in the perception of preparedness exist among ethnic groups (n = 699, G^2 = 40.389, p = 0.027). Students who describe themselves as Native American (G^2 = 3.584) and Hispanic (G^2 = 2.632) are least likely to describe themselves as prepared, and students who describe themselves as African American are most likely to describe themselves as not prepared (G^2 = 5.148). Students who describe themselves as White/Caucasian are most likely to describe themselves as prepared (G^2 = 1.812), and least likely to describe themselves as not prepared (G^2 = 0.397). These trends are illustrated in Graph 24.

How academically prepared were you for this class at the beginning of the semester?

	Count	Percent
1) Not prepared	70	15
2) Somewhat prepared, but lacking some important skills or knowledge	211	46
3) Prepared	178	39



Graph 24: Percentage of students in each ethnic group who describe their level of preparedness for their gateway class. Light bars represent students who describe themselves as not prepared, dark bars represent students who describe themselves as somewhat prepared, and striped bars represent students who describe themselves as prepared.

Effect of Class on Student

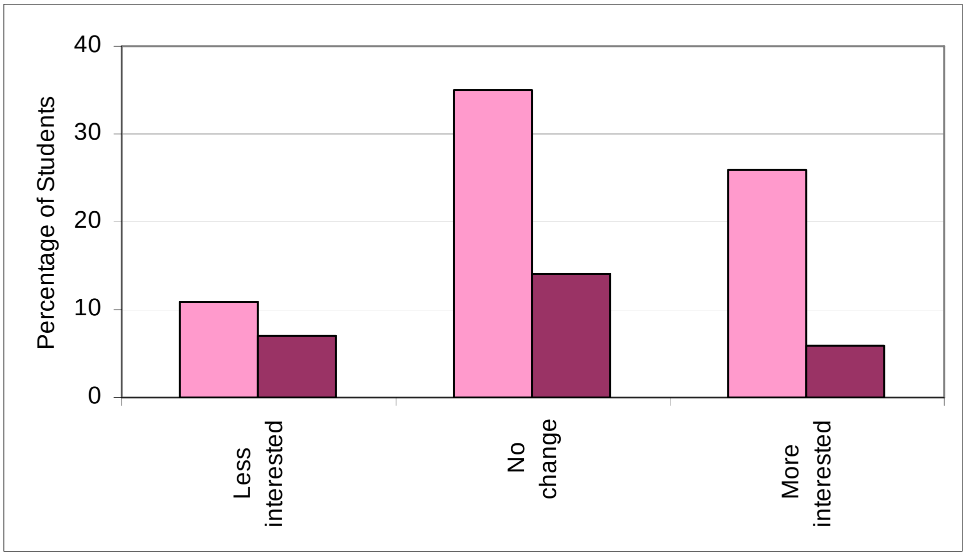
Most (50%) students report that their experience in a gateway course has not affected their interest in the subject. Of the students whose interest was affected, more students became more interested in the subject (32%) than less interested in the subject (18%).

A significant relationship exists between the change in attitude toward the subject students experience as a result of their experience in their gateway class and their likelihood to receive an ABC or DFW in the class (n = 482, $G^2 = 17.328$, p = 0.004). Students who become more interested in the subject as a result of the class are most likely to be in the ABC group ($G^2 = 1.852$), whereas students who become less interested in the subject as a result of the class are most likely to be in the DFW group ($G^2 = 3.202$). It is unclear which variable, change in student interest in the subject or student performance, is the causal variable in the observed relationship (i.e. a change in attitude toward the subject could be affecting a student's grade, or the grade a student receives in the subject could be causing changes in her or his attitude toward the subject). These trends are illustrated in Graph 25.

There is no difference between genders or among ethnicities in the affect of the class on student interest in the subject. However, the relationship between student ethnicity and change in attitude toward the subject approaches significance (n = 710, $G^2 = 41.298$, p = 0.082). African Americans seem most likely to experience a negative change ($G^2 = 8.490$) or not experience a change ($G^2 = 4.310$) in attitude toward the subject as a result of their experience in the course, whereas Asian Americans seem most likely to be positively affected seem most likely to experience a positive change ($G^2 = 1.389$) in attitude toward the subject as a result of their experience in the course.

How has taking this class affected your interest in the subject?

	Count	Percent
1) As a result of this class, I am now less interested in the subject	84	18
2) Taking this class has not affected my interest in the subject	232	50
3) As a result of this class, I am now more interested in the subject	152	32



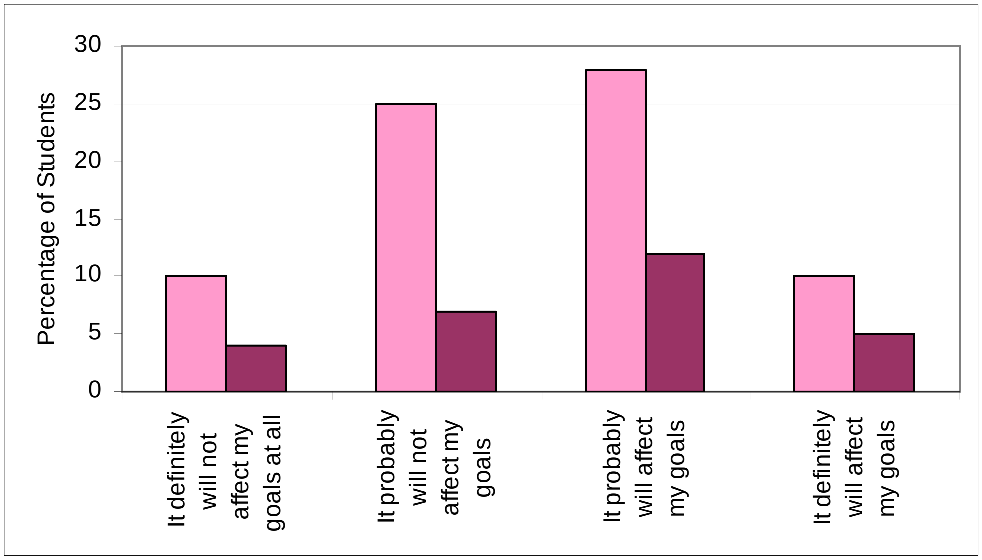
Graph 25: Change in student interest in the subject as a result of experience in the gateway class. Light bars represent students in the ABC group; dark bars represent students in the DFW group.

Fifty-five percent of students say that their level of success in the class will affect their academic, career, or personal goals (Graph 26). The influence of student success in gateway courses on students' academic, career, or personal goals is significant (n = 483, $G^2 = 23.279$, $p < 0.000$). The data suggest that the effect is more negative than positive. Students who say their level of success will definitely affect their goals are most likely ($G^2 = 0.746$) to receive a DFW. Students who say their level of success will probably not affect their goals are most likely ($G^2 = 1.056$) to receive an ABC. Said differently, ABCs in gateway courses probably do not affect student academic, career, or personal goals, but DFWs probably do affect student goals.

The influence of the class on student academic, career, or personal goals is not different between gender or among ethnic groups.

How will your level of success in this class affect your academic, career, or personal goals?

	Count	Percent
1) It definitely will not affect my goals at all	66	14
2) It probably will not affect my goals	149	31
3) It probably will affect my goals	189	40
4) It definitely will affect my goals	72	15



Graph 26: Student description of how their experience in a gateway course will affect their academic, career, or personal goals. Light bars represent students in the ABC group; dark bars represent students in the DFW group. DFW students are proportionately more likely to say their experience in a gateway course will affect their goals.

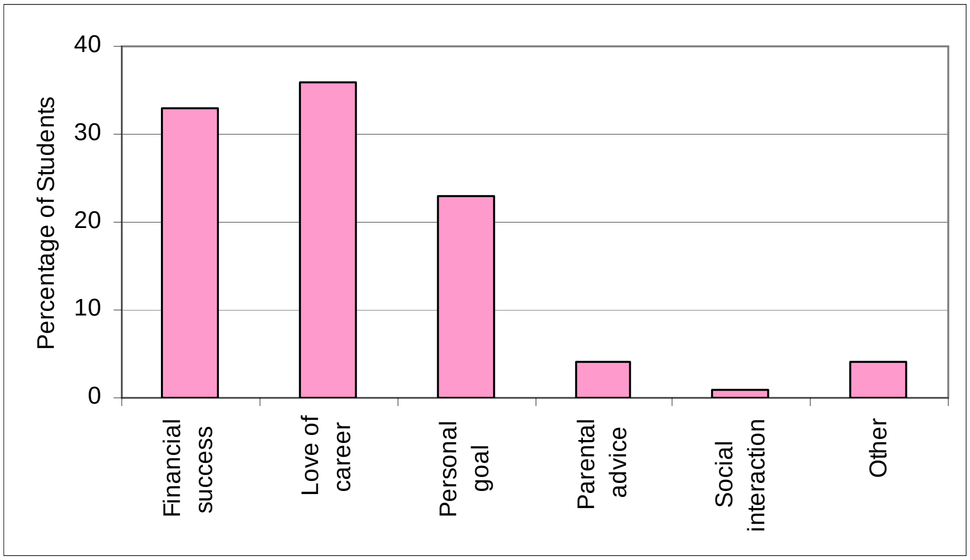
Student Perception of College Life and NAU

Most students (92%) are pursuing a college degree for personal or economic reasons. Thirty-six percent of students are seeking a college degree to pursue a career they love, 32% to be financially successful, and 23% to satisfy a personal interest or goal (Graph 27).

There are no differences in student success rates in gateway courses among students with different self-described motivations for pursuing a college degree. However, there are significant differences among gender groups in motivations for pursuing a college degree (n = 700, G^2 = 25.711, p = 0.004). Females are more likely than males to attain a college degree to pursue a career they love (G^2 = 2.794). Males are more likely than females to pursue a college degree for "other reasons (G^2 = 3.565), or because they are following the advice of a parent or guardian (G^2 = 2.524). There are no significant differences among ethnicities in motivations for pursuing a college degree.

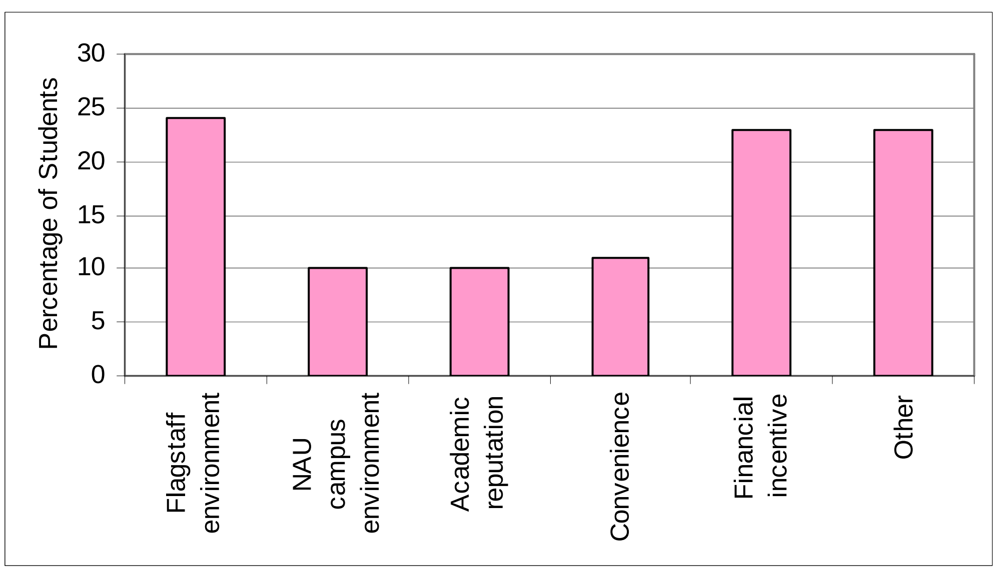
The primary motivation you are pursuing a college degree is to:

	Count	Percent
1) Be financially successful	230	33
2) Pursue a career I love	250	36
3) Satisfy a personal interest or goal	159	23
4) Follow the advice of a parent or guardian	27	4
5) Interact socially with other college students	8	1
6) Other	30	4



Graph 27: Student self-description of motivation for pursuing a college degree.

A majority of students are attending NAU because of the social or physical environment on campus or in Flagstaff. Many others are attending NAU because of financial incentives such as low tuition or a scholarship, and for "other" [undescribed] reasons. Only 10% are attending because of NAU's academic reputation or campus environment (Graph 28).



Graph 28: Student motivations for attending NAU.

Although there are no significant differences in success rates among students with various motivations for attending NAU (n = 480, G^2 = 9.901, p = 0.129), the differences approach significance and are worth discussion and further investigation. Students whose primary motivation for attending NAU is a financial incentive seemed slightly more likely to receive an ABC in their gateway courses (G^2 = 0.614). Students whose primary motivation for attending NAU is convenience seemed slightly more likely to receive an DFW in their gateway courses (G^2 = 1.923).

No significant differences exist in the motivations of females and males for attending NAU. However, significant differences in motivations do exist among various ethnic groups (n = 705, G^2 = 80.234, $p < 0.000$). This analysis is suspect, however, because of the poor representation of non-White/Caucasian students in some categories. Still, the data seem to illustrate following trends within the motivations of students of different ethnicities:

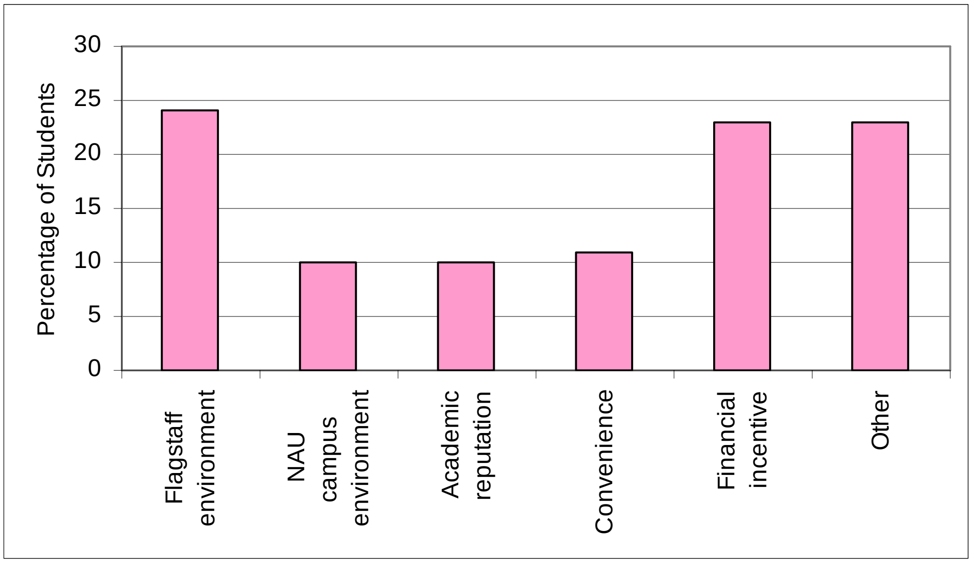
- African Americans are more likely to be attending NAU because of the social or physical environment on campus (G^2 = 0.614), and less likely to be attending NAU because of the social or physical environment in Flagstaff (G^2 = 1.874), compared to other motivations for attending.
- Asian Americans are more likely to be attending NAU because of because of the social or physical environment on campus (G^2 = 8.497), but less likely to

be attending NAU because of the reputation of NAU's academic programs (G^2 = 1.447).

- Hispanics are most likely to be attending NAU because of financial incentives (relative low cost of tuition, scholarships, etc.) offered to them (G^2 = 5.680), and least likely to be attending NAU because of the social or physical environment on campus (G^2 = 2.467).
- Native Americans are most likely to be attending NAU because of convenience (G^2 = 36.257), and least likely to be attending NAU because of the social or physical environment in Flagstaff (G^2 = 3.673).
- Whites/Caucasians are most likely to be attending NAU because of the social or physical environment in Flagstaff (G^2 = 0.614), and least likely to be attending NAU because of convenience (G^2 = 1.536).
- Students who describe their ethnicity as "other" (i.e. not African American, Asian American, Hispanic, Native American, or White/Caucasian) are most likely to be attending NAU because of the reputation of NAU's academic programs (G^2 = 1.662), and least likely to be attending NAU because of convenience (G^2 = 2.434).

Why did you come to NAU?

	Count	Percent
1) Social or physical environment of Flagstaff	169	24
2) Social or physical environment on campus	69	10
3) Reputation of academic programs	68	10
4) Convenience	78	11
5) Financial incentive (relative low cost of tuition, scholarship, etc.)	159	23
6) Other	160	23



Graph 28: Student self-description of motivation for attending NAU.

Most students (80%) are satisfied with their overall experience at NAU. The level of student satisfaction with NAU does not significantly relate to the level of student success in gateway courses (Graph 29). However, student satisfaction does differ significantly between genders (n = 712, G^2 = 21.146, p = 0.007). Among students who are dissatisfied with their experience at NAU, females are most likely to be very dissatisfied (G^2 = 1.939), whereas males are more likely to be only slightly dissatisfied (G^2 = 4.150).

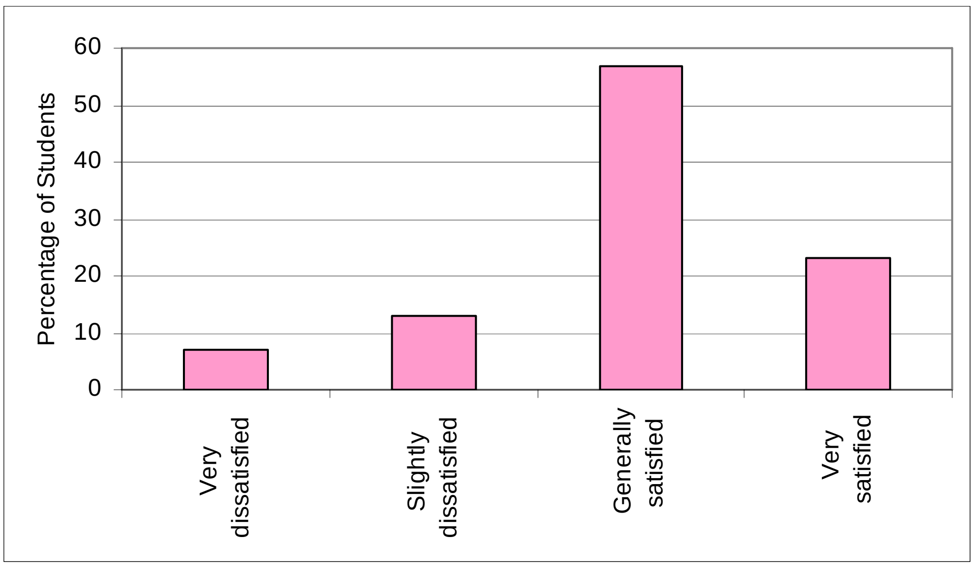
Student ethnicity does not significantly relate to level of satisfaction with NAU, but because this relationship approaches significance (n = 707, G^2 = 30.536, p = 0.062) and might illustrate an interesting trend, it will be discussed. In addition to not being statistically significant, this analysis is suspect because of the poor representation of some ethnicities in some categories. Those cautions aside, the data seem to illustrate following trends within the levels of satisfaction of students of different ethnicities:

- African Americans are most likely to be very dissatisfied with their overall experience at NAU (G^2 = 3.225), and least likely to be very satisfied (G^2 = 1.897), compared to other levels of satisfaction.
- Asian Americans are most likely to be slightly dissatisfied (G^2 = 2.387), and least likely to be very satisfied (G^2 = 1.484).
- Hispanics are most likely to be slightly dissatisfied (G^2 = 1.191), and least likely to be very dissatisfied (G^2 = 2.334).
- Native Americans are most likely to be slightly dissatisfied (G^2 = 0.279), and least likely to be very satisfied (G^2 = 1.216).
- Whites/Caucasians are most likely to be very satisfied (G^2 = 0.310), and least likely to be slightly dissatisfied (G^2 = 2.956).
- Students who describe their ethnicity as "other" (i.e. not African American, Asian American, Hispanic, Native American, or White/Caucasian) are most likely to be very satisfied (G^2 = 0.210), and least likely to be slightly dissatisfied (G^2 = 2.956).

In summary, students in non-White/Caucasian groups (excluding the "other" group) seem more likely to be dissatisfied and less likely to be satisfied with their overall experience at NAU, while students in the White/Caucasian and "other" ethnic groups seem more likely to be satisfied and less likely to be dissatisfied with their overall experience at NAU. While this possible trend is not statistically significant, it could warrant further investigation.

How satisfied are you with your overall experience at NAU?

	Count	Percent
1) Very dissatisfied	48	7
2) Slightly dissatisfied	94	13
3) Generally satisfied	402	57
4) Very satisfied	161	23



Graph 29: Levels of satisfaction with students' overall experience at NAU.

A large majority (89%) of students say that obligations outside of school at least occasionally affect their success at school (Graph 30). There are no differences among ABC and DFW students in the self-described frequency that outside responsibilities affect students' scholastic success.

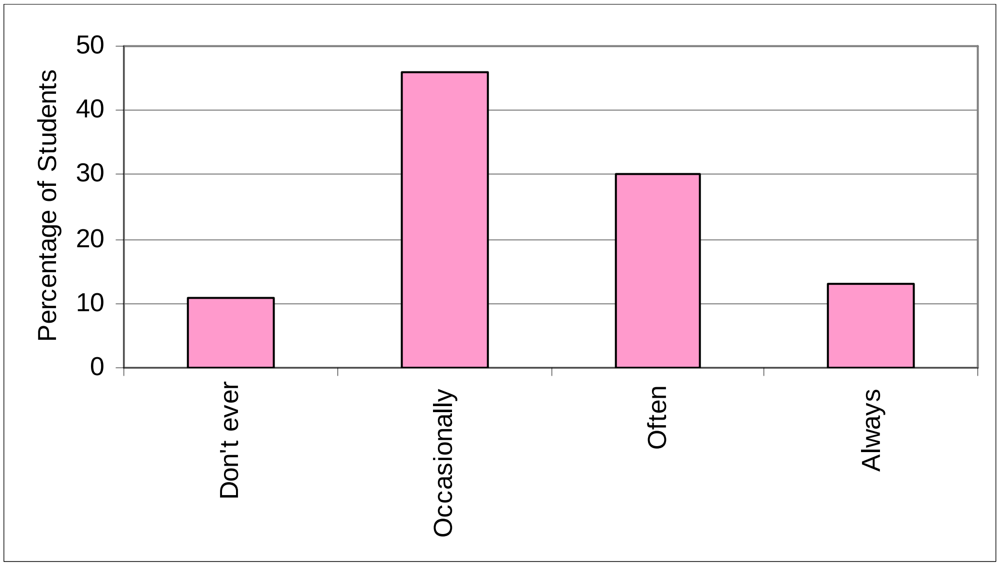
There are no significant differences in the self-described frequency that outside responsibilities affect females' and males' scholastic success (n = 711,

G^2 = 16.685, p = 0.082). However, a possible trend approaches significance and is worthy of discussion. From all answer options, females are most likely to say that outside responsibilities never affect their scholastic success (G^2 = 0.182), and least likely to say that outside responsibilities often affect their scholastics (G^2 = 0.679). Males demonstrate the opposite pattern. Males are least likely to say that outside responsibilities never affect their scholastic success (G^2 = 0.303), and more likely to say that outside responsibilities often affect their scholastics (G^2 = 0.599). These effects are small, but could warrant further investigation.

There are no significant differences in the self-described frequency that outside responsibilities affect students of various ethnicities' scholastic success.

How do responsibilities outside of school affect your success at school?

	Count	Percent
1) They don't ever affect my success at school	73	11
2) They occasionally affect my success at school	320	46
3) They often affect my success at school	209	30
4) They always affect my success at school	92	13



Graph 30: Self-described frequency in which outside responsibilities affect students' scholastic success.

Work and/or finances, and interest and/or motivation are the two non-academic factors that seem to influence student success the most. Twenty-eight percent of students say that work or their financial situation is the primary concern that affects their success in this class. An equal percentage of students say their interest in the class or school is the primary concern that affects their success (Graph 31). There are no significant differences in ABC or DFW rates among students who describe these different non-academic influences. The distribution of non-academic influences is not different between genders.

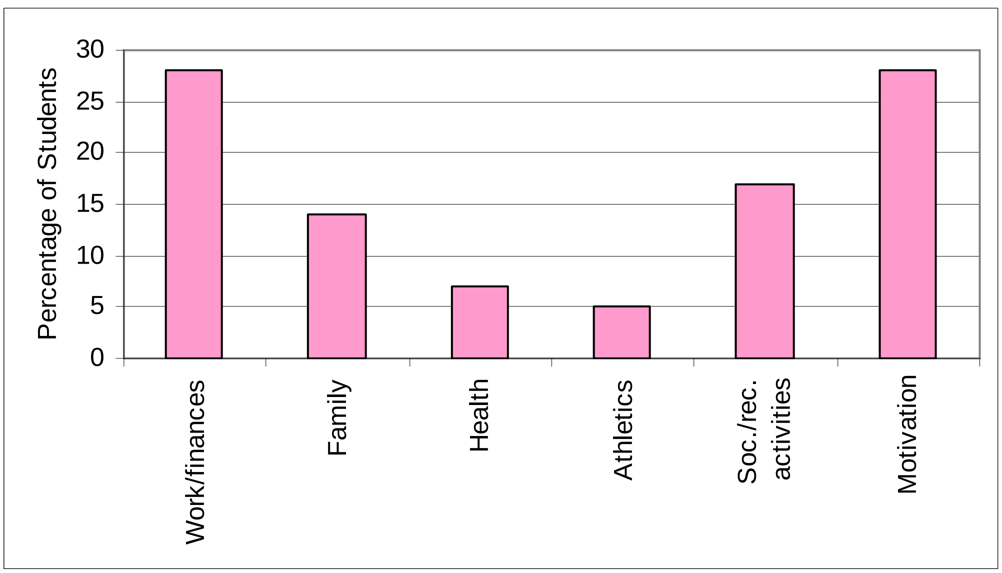
There are significant differences in self-described non-academic influences on success among ethnic groups (n = 690, $G^2 = 76.820$, $p < 0.000$) (Graph 32). As with other analyses involving ethnicity, results are suspect because of the poor representation of non-White/Caucasian ethnicities in some categories. The following trends seem to be present:

- African Americans are most likely to say that athletics are the non-academic factor that most influences their scholastic success (G^2 = 1.959), and least likely to say that physical and/or emotional health is the non-academic factor that most influences their success (G^2 = 0.994), compared to other levels of satisfaction.
- Asian Americans are most likely to say that work and/or their financial situation influences their scholastics (G^2 = 1.798), and least likely to say that social and/or recreational activities influence their scholastics (G^2 = 2.565).
- Hispanics are most likely to say that work and/or their financial situation influences their scholastics (G^2 = 1.485), and least likely to say that interest and/or motivation in this class or school influences their scholastics (G^2 = 1.533).
- Native Americans are most likely to say that family obligations influence their scholastics (G^2 = 19.931), and least likely to say that social and/or recreational activities influence their scholastics (G^2 = 6.157).
- Whites/Caucasians are most likely to say that social and/or recreational activities influence their scholastics (G^2 = 0.594), and least likely to say that family obligations influence their scholastics (G^2 = 1.620).
- Students who describe their ethnicity as “other” (i.e. not African American, Asian American, Hispanic, Native American, or White/Caucasian) are most likely to say that their physical and/or emotional health influences their

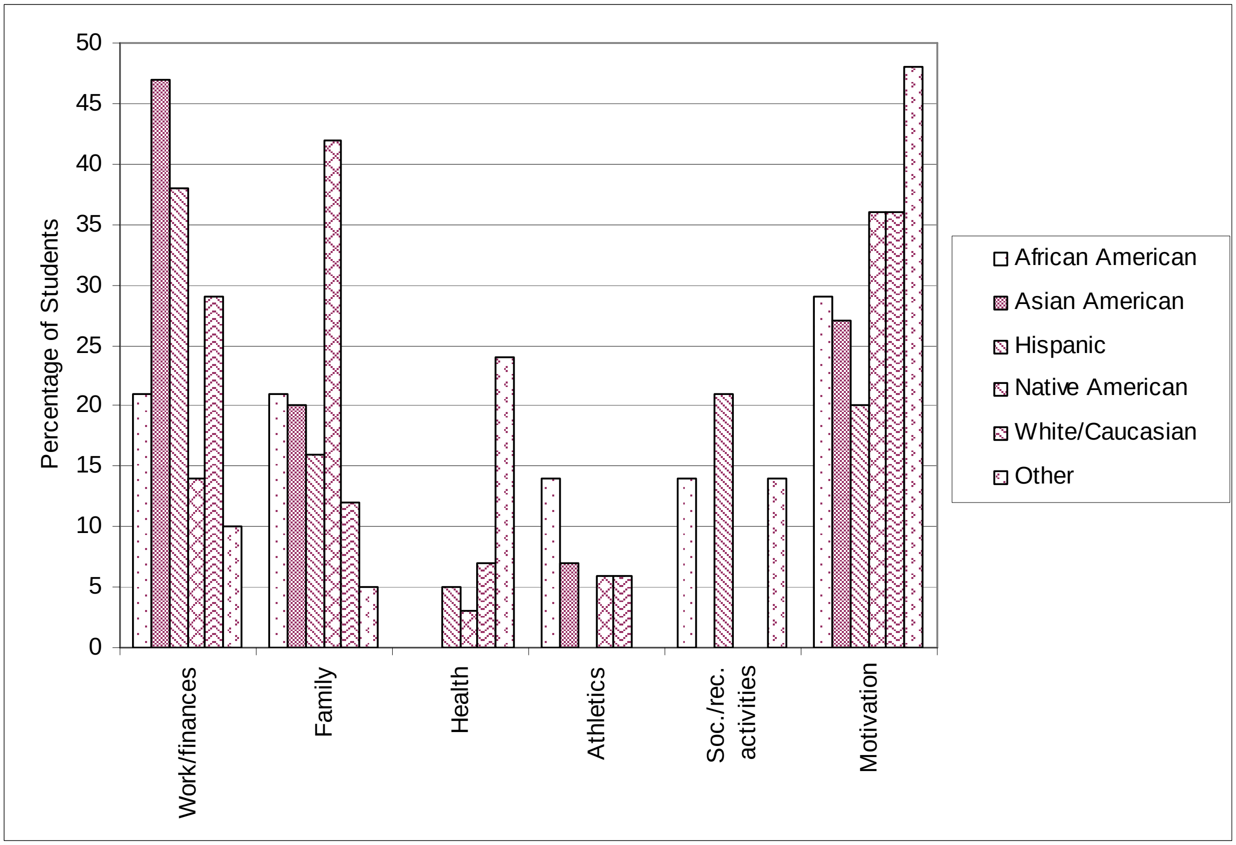
scholastics (G^2 = 8.255), and least likely to say that work and/or financial situation influence their scholastics (G^2 = 2.609).

What non-academic factor most influences your success in this class?

	Count	Percent
1) Work and/or financial situation	196	28
2) Family obligations	97	14
3) Physical and/or emotional health	50	7
4) Athletics	38	5
5) Social and/or recreational activities	120	17
6) Interest and/or motivation in this class or in school	195	28



Graph 31: Overall self-described frequency with which outside responsibilities affect students' scholastic success.



Graph 32: Differences among ethnic groups in the self-described frequency with which outside responsibilities affect students' scholastic success. Each bar represents the percentage of students in each ethnic category (n = 689).

Predictors of Student Success

Two criteria, parsimony and utility, for model-building were used. Unfortunately, all viable models violate one of these criteria. The three most powerful models violate the utility criterion because they are potentially not applicable to all gateway students. The most powerful model ("Model One") is not applicable to incoming freshmen who do not have a college grade point average on record. The second most powerful model ("Model Two") is not applicable to students who do not have a combined Scholastic Aptitude Test

(SAT) score on record. The third most powerful model ("Model Three") is not applicable to students who do not have an American College Testing Program (ACT) score on record.

The weakest viable model ("Model Four") does not violate the utility criterion because it is applicable to all gateway students. Unfortunately, this model is less parsimonious than the three stronger models because it uses four predictor variables instead of three. A comparison of the strengths and weaknesses of the four models is provided in Table 8. Numerous models are provided so that model users can use their own discretion to decide which model is most appropriate for their application.

Table 8 lists the predictor variables used in each model, as well as abbreviations used for these variables in the description of the model given below. Table 8 also lists the lack of fit statistics for each model. These statistics demonstrate that the variables used in the model are sufficient in number and predictive capacity such that the lack of fit hypothesis can be rejected (note that Model Three fails to reject the lack of fit criterion). Table 8 also includes the sample size of NAU gateway students used to generate the model, as well as the mismatch rate of each model. Mismatch rates were calculated by comparing grade predictions each model made for each student in the database with actual grades these students received. The mismatch rate is equivalent to the error rate of each model.

All models rely on student GPA and the number of credit hours enrolled in the semester of interest to predict student ABC/DFW status. College GPA is a more useful predictor variable than high school GPA, but, as stated, college GPA is not available for all students enrolled in gateway courses. A pairwise analysis reveals a moderate correlation ($n = 20035$, $r = 0.481$, $p = 0.000$) between a student's high school and college GPAs.

Model Number	Predictor Variables	Lack of Fit	Sample Size	Mismatch Rate
One	Student's cumulative college GPA (*CLGPA*) Number of current semester hours in which student is enrolled (*SMHRS*) Student's high school GPA (*HSGPA*)	X^2 = 11844.01 p = 1.000	19894	16.2%
Two	Number of credit hours in which student is currently enrolled (*SMHRS*) Student's high school GPA (*HSGPA*) Student's SAT score (*STSAT*)	X^2 = 8078.09 p = 0.923	11767	19.3%
Three	Number of credit hours in which student is currently enrolled (*SMHRS*) Student's high school GPA (*HSGPA*) Student's ACT score (*STACT*)	X^2 = 6575.36 p = 0.000	10074	20.9%
Four	Number of credit hours in which student is currently enrolled (*SMHRS*) Student's high school GPA (*HSGPA*) Student's ACT score (*STACT*) Student's age (*STAGE*)	X^2 = 7581.42 p = 0.391	10074	20.6%

Table 8: Four mathematical models that predict student ABC and DFW status.

Models that best predict student the grade status of gateway business, mathematics, and science students at NAU are listed below. Each model calculates the log of the likelihood of any student receiving a grade of A, B, or C in a gateway course. The first portion of each regression function (left of the equal sign) represents this likelihood. The symbol π represents the probability of a student receiving an ABC in a gateway course. The second portion of each regression function (right of the equal sign) provides the formula used to calculate this likelihood.

Model One

$$\log n\left(\frac{\pi}{1-\pi}\right) = -6.4166 + 2.0413(CLGPA) + 0.1761(SMHRS) + 0.0389(HSGPA)$$

Model Two

$$\log n\left(\frac{\pi}{1-\pi}\right) = -6.9639 + 0.2668(SMHRS) + 1.0850(HSGPA) + 0.0012(STSAT)$$

Model Three

$$\log n\left(\frac{\pi}{1-\pi}\right) = -6.0343 + 0.2334(SMHRS) + 0.9115(HSGPA) + 0.0588(STACT)$$

Model Four

$$\log n\left(\frac{\pi}{1-\pi}\right) = -8.9708 + 0.2462(SMHRS) + 1.0270(HSGPA) + 0.0592(STACT) + 0.01212(STAGE)$$

Student Educational and Socioeconomic Contexts

While no variables related to the general academic performance or socioeconomic status of a student’s high school were relevant predictors of student ABC/DFW status (percent free lunch was a minor predictor in all models, but it was excluded because of parsimony), one high school variable emerged as a potential prejudice in the recruitment of incoming students. Significant correlations exist between the socioeconomic status (measured by free and reduced lunch percentage) of a student's high school and the average standardized test scores of students graduating from those high schools and enrolling in gateway courses at NAU. Generally speaking, a strong negative correlation exists between the percentage of free and reduced lunches provided in a high school and the average standardized test score achieved in that school – regardless of the test (Table 9). Said differently, students from high schools in affluent neighborhoods achieve high scores on standardized aptitude tests, while students from high schools in poor neighborhoods achieve low scores on standardized aptitude tests. While natural variation exists among students in all high schools, a relationship between affluence and achievement on standardized aptitude tests is evident. This relationship might introduce significant bias to recruitment decisions at NAU, if these scores are used as selection criteria for incoming students and/or incentive packages designed to attract and retain incoming students. Test scores from tests such as the AIMS and Stanford 9, which are traditionally used to evaluate student performance in high school, were most strongly correlated with the socioeconomic status of the high school (mean $r = -0.633$), whereas test scores from tests such as the ACT and SAT, which are traditionally used as college entrance criteria, were least strongly affected by socioeconomic status of the high school (mean $r = -0.335$).

Standardized Test Score	Correlation with High School Free Lunch Percentage*
AIMS Reading	-0.630
AIMS Math	-0.579
Stanford 9 Reading	-0.708
Stanford 9 Math	-0.625
ACT	-0.411
SAT	-0.259

Table 9: Correlation between high school socioeconomic status and average standardized test score of students who graduated from in-state high schools represented at NAU. *All correlations are significant at the p = 0.000 level.

Discussion

Summary and Interpretation of Results

The average ABC rate in gateway business, math, and science courses at NAU is 75%. The average DFW rate is 25%. While these rates would be expected if grades in these courses were normally distributed around a mean of 75%, they are of some concern when one considers the relevance of success levels in gateway courses to the indoctrination and retention of students at the university, and the potential impact of students' gateway experiences on choice of and persistence in college majors and, ultimately, careers.

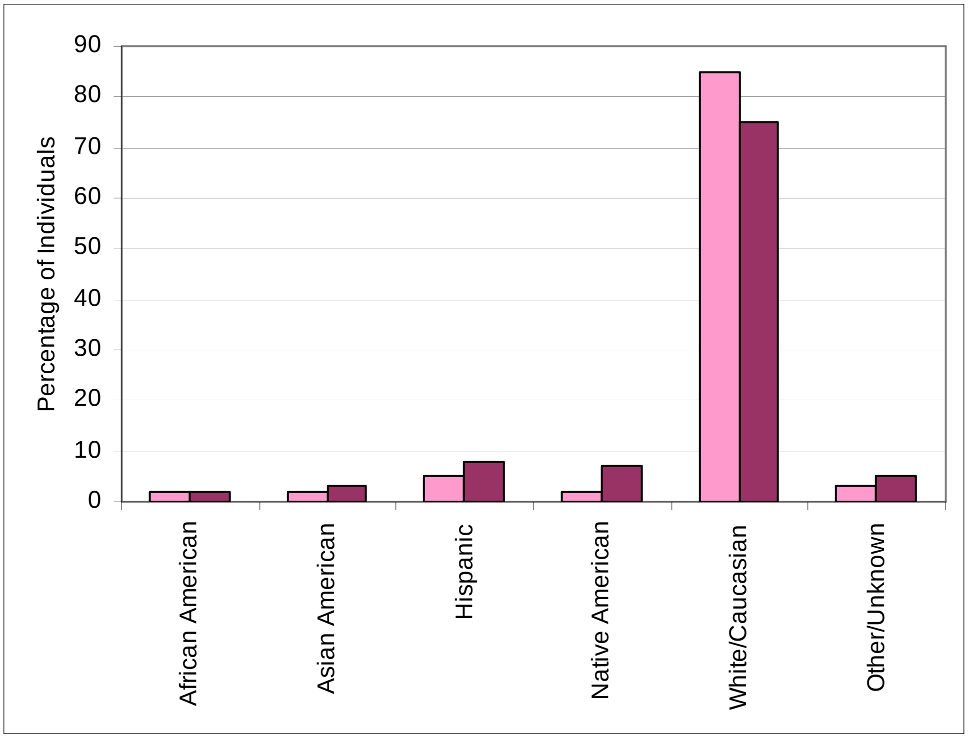
Teaching techniques used in gateway courses are varied, but can be generally described as traditional and didactic. A relationship seems to exist between teaching style and rate of student success in these courses, but it is unclear if teaching style is a causal factor determining student success. Prior studies have found that progressive teaching styles involving student interaction and "hands-on, minds-on" activities have strong positive effects on student achievement (Falconer et al.. 2001, Adamson et al.. 2002, Lawson et al.. 2002), so it is possible that similar effects are contributing to student achievement in courses at NAU. Still, a direct link between student achievement and instructional style has not yet been demonstrated in NAU's gateway courses. The effect of varied teaching styles on student achievement in gateway courses merits further investigation.

The predominant ethnicity at NAU is White/Caucasian. White/Caucasian and Native American individuals are proportionally better represented in NAU's gateway courses than they are in the general population of the United States. All other ethnic groups are more poorly represented in NAU's gateway courses than in the general population. The overall representation of ethnicities at NAU is similar to the representation of ethnicities in NAU's gateway courses.

Some ethnicities are more likely to be in the ABC group than others. White/Caucasian students are more likely to be in the ABC group, while Native American and Hispanic students are more likely to be in the DFW group. Thus, the ethnic groups that seem more prone to not succeed NAU's gateway business, math, and science courses are comparable to those that seem more prone to not succed in similar courses nationwide (Brower and Ketterhagen 2004, National Center for Educational Statistics 2002, Herndon and Moore 2002, Brush 1991, Hilton and Lee 1988).

Does student ethnicity contribute to the DFW rate in gateway courses? Research suggests that students tend to perform better in classrooms led by instructors who share demographic traits with them (e.g. Sadler and Tai 2001). Despite this reality, students who are members of ethnic minority groups have few alternatives to selecting White/Caucasian instructors of NAU courses. The faculty at NAU is predominantly (85%) White/Caucasian. Minority representation is poorer in NAU's faculty than it is among NAU students (Graph 33; Office of Planning and Research 2006) and within the general United States population.

The lack of ethnic and cultural diversity among faculty who teach NAU's gateway courses could be leading to disproportionate success rates among students in various ethnic groups. Increasing the ethnic and cultural diversity of the faculty teaching gateway courses might improve cultural understandings and communicative interactions among gateway instructors and students. Improved understandings might promote the success of students who are members of non-White/Caucasian ethnic groups (Kordalewski 1999, Sheets 1995).



Graph 33: Distribution of ethnicities among NAU faculty (light bars) and NAU freshmen (dark bars). All ethnic minority groups are better represented in the student body than in the faculty.

In contrast to ethnicities, genders are equally represented in gateway courses, and the representation of genders in gateway courses is equivalent to the representation of genders in the general population. Overall, gender differences in achievement in gateway courses do not exist. But such differences do exist in some courses. Females, the gender traditionally underrepresented in business, math, and science-related majors and professions, had significantly higher rates of success than did males in ACC 255, BA 201, CIS 120, ENV 101, GLG 100, MAT 125, MAT 137, and PHY 112. It is not known why this occurred. However, it is possible that these courses have instructors who are more demographically similar to their students, that they are taught with more progressive methods, or other reasons.

To investigate the hypothesis that courses in which females received significantly higher ABC rates than males were taught with more progressive methods, a Student's t-test was performed to compare the RTOP scores of classes in which females were and were not more successful than males. The test revealed that courses in which females performed better had significantly higher average RTOP scores ($n = 13$, $t = 2.525$, $p = 0.015$). These data support the hypothesis that these courses are taught with more progressive methods. The data do not, however, rule out alternative hypotheses that would explain the advanced performance of females in this group of courses.

Most gateway students have a self-reported college GPA of 2.5 or better; those with a GPA of 3.0 or better are more likely to be in the ABC group than their peers who have a GPA that is less than 3.0. International students generally have the best college GPAs, White/Caucasian students have the next best, Asian American and Hispanic the next best, and African American and Native American students generally have the worst.

ABC students are aware of their grade status in gateway courses, but DFW students might have an overly optimistic view of their grade status. ABC students predict with 99% accuracy several weeks before the semester ends their status as an ABC student. However, DFW students only predict their status as DFW students with only 16% accuracy several weeks before the semester ends. Native American and Hispanic students are most likely to predict before the semester ends that they will receive a DFW as a final grade, whereas White/Caucasian students are least likely to make this prediction.

Why are DFW students typically so unsuccessful at assessing their grade status? One possibility is that DFW students are overly optimistic about changing their grade status late in the semester. If this were the case, then allowing poorly performing students more opportunities to realistically assess their grade status – and the likelihood of improving their grade – throughout the semester might empower them to better understand their grade status as the semester progresses.

One way to allow students more opportunities to realistically appraise their grades before the end of the semester is to emphasize the use of formative over summative evaluation techniques. Another way is for up-to-date student grades to be posted and updated regularly over the course of the semester. A third way is to encourage or require all students who are at risk of receiving a DFW when midterm grades are available to seek advice from the instructor on how to improve their grades, and/or to seek extracurricular academic counseling or tutoring.

DFW students are more likely than ABC students to describe having some difficulty with their gateway courses. Despite their greater chances of finding their courses difficult, over two-thirds of DFW students describe their gateway courses as “not very challenging.” It is possible that a majority of DFW students are not aware of the challenges gateway courses offer, and are thus unaware of the requirements for receiving better grades. If this were true, then a clear articulation of requirements for success in course syllabi and verbally from course instructors at the beginning of and throughout the semester might help

DFW students better understand course requirements. Such reminders might not only list assignments and exams and their associated point values, they might also include direct advice on study habits and strategies for success. Extracurricular counseling might help DFW students, as might emphasizing the importance of recognizing the warning signs of failure.

Females are more likely to have moderate views about the level of challenge of gateway courses, while males are more likely to have extreme positive or negative views. DFW students seem to preferentially report that gateway courses exceed their expectations, while ABC students seem to preferentially report that gateway courses do not meet their expectations.

Students who describe the strategies most important for success in their gateway courses as synthesizing information and making judgments seem more likely to be in the DFW group than students who describe less intellectually demanding strategies for success such as memorizing facts and applying ideas. It is possible that DFW students perceive strategies required for success differently than do ABC students. This could be due to the students' varied academic backgrounds. DFW students might not have been required to synthesize ideas and make judgments in prior classes, while ABC students might have had this experience. Thus, these behaviors might be more demanding for DFW students when they are required to engage in them in gateway courses.

If this is true, then either encouraging better preparation of students in their pre-college or early college experience, or eliminating these requirements from gateway courses are possible remedies to this problem. Since both the

National Science Education Standards (National Academy of Sciences 1996, 2000) and the Professional Standards for Teaching Mathematics (National Council for the Teaching of Mathematics 1991) strongly recommend that courses include more, not fewer, of these advanced intellectual activities, the first suggestion seems more advisable. Better preparing students for more challenging intellectual tasks could be encouraged in high schools and college preparatory experiences. Such skills might also be exercised in a lower-stakes environment such as first-year experience classes.

Consistent with this idea, a slight majority of students describe themselves as underprepared for their gateway course at the beginning of the semester. Students who describe themselves as partially or seriously underprepared are more likely to be in the DFW group. Native American and Hispanic students are most likely to describe themselves as underprepared, whereas White/Caucasian students are most likely to describe themselves as prepared.

Most students perceive that the resources necessary for success in gateway courses are available, but DFW students are more likely to describe some difficulties accessing or using these resources. Males are more likely than females to have difficulty using resources.

Students who prepare for class mostly by reading course materials are more likely to be in the ABC group. Students who prepare for class mostly by studying notes are more likely to be in the DFW group. Students who discuss ideas from courses outside of class are more likely to be in the ABC group than are students who do not discuss ideas outside of class. Males exchange ideas outside of class more frequently than do females.

Reading assigned course materials and discussing course concepts with others seem to be more effective preparation strategies. Studying one's notes seems to be less effective. Reading assigned materials is probably effective because these materials are more likely to contain terminologically and conceptually factual materials than are student notes taken in the classroom. Furthermore, assigned readings might contain important supplemental information that course instructors did not introduce in classroom activities, or that better explain and apply complex concepts that were superficially introduced in the classroom. If this is true, instructors might consider discouraging classroom note-taking and encouraging active listening and engagement in classroom activities. Instructors might even consider supplying notes or lecture summaries for their students to ensure the accuracy of the resource and to encourage students to focus on understanding concepts instead of on transcribing information.

Group discussion has been shown in prior research (Bartlett 2002, Asitn 2001) to be an effective study technique. Group discussion requires students to explain potentially confusing concepts in more simple language. It demands that they articulate their ideas clearly, and it helps students identify areas of understanding that are inadequate. Group discussion also allows for the social vetting of ideas. In a social context, peers can enhance each other's understanding by providing additional information and challenging misconceptions. Group study is seldom used by gateway students at NAU; only 7% report that they discuss concepts outside of class to prepare for class. This could be because instructors rarely recommend or encourage group interaction in or out of class. Encouraging the social exchange of ideas might help improve students' understanding of ideas, and in turn their success rate in gateway courses.

Although success rate does not seem to be related to participation in the classroom, self-described levels of classroom participation vary between genders and ethnic groups. Females participate in class less often than males do, and Native Americans and students who describe their ethnicity as "other" participate less than members of other ethnic groups do. Differences in participation rates between genders might be explained by biological/psychological differences in aggressiveness and self-image. Tobin and Garnett (1987) found similar gender differences in participation levels in Australian universities, but did not speculate on a cause. Differences in participation rates among ethnicities might be explained by social and cultural differences among ethnic groups. It is unknown whether differences in the level of participation required in gateway classes affect genders or ethnicities dissimilarly.

Relationships between the amount of time devoted to a gateway class and success in that class exist. Students who attend class regularly are more likely to receive ABCs. Females attend class more regularly than do males. Students who devote some time outside of class to the class are more likely to receive an ABC than students who devote no time to class outside of class. Only a weak relationship exists between the number of extracurricular hours devoted to a class and level of success in that class. Students who devote 1 – 3 extracurricular hours per week to their gateway courses are more likely to be in the ABC group.

The effect gateway experiences have on students is significant. Students in the ABC group are more likely to become more interested in the subject as a result of their experience in the course. Conversely, students in the DFW group are more likely to become less interested in the subject as a result of their experience in the course. African Americans seem most prone to become less interested in a subject as a result of their experience in a gateway course, and Asian Americans seem most prone to become more interested in a subject as a result of their experience.

A majority of students say their level of success in a gateway course will affect their academic, career, or personal goals. DFW students are more likely to say their goals will be affected than are ABC students.

Students are most likely to be pursuing a college degree to work in a career they love. Females are more likely than males to be pursuing a degree for this reason. Students are almost as likely to be pursuing a degree for financial reasons.

Outside responsibilities seem to affect the academics of gateway students. Work/finances and motivation are the two non-academic factors that seem to most affect academic success. This finding is particularly meaningful, because many students work part or full time in addition to pursuing their undergraduate degrees (Horn *et al.* 2002).

Females are more likely than males to be academically affected by non-academic factors. Various ethnicities are affected by different outside influences on their academics. Asian Americans and Hispanics are more likely to be affected by work or their financial situations. African Americans are more likely to be affected by athletics. Native Americans are more likely to be affected by family obligations. And students who describe their ethnicity as “other” are more often affected by concerns with their physical or emotional health.

Most students are satisfied with their overall experience at NAU. However, this effect might be ethnically biased because most NAU students are White/Caucasian, and members of this ethnicity are most likely to be very satisfied with their experience at NAU. Members of all non-White/Caucasian ethnic groups are most likely to be dissatisfied with their NAU experience. Asian American, Hispanic, and Native American students are most likely to be slightly dissatisfied, and African American students are most likely to be very dissatisfied with their NAU experience.

Students are more likely to be attending NAU because of the social or physical environment in Flagstaff. African American, Asian American, and White/Caucasian students are more likely to be attending NAU for this reason. Students are nearly as likely to be attending NAU because of a financial incentive offered to them. Hispanic students are more likely to be attending NAU for this reason. Native American students are most likely to be attending NAU because of it’s convenience, possibly because of the proximity of NAU’s main campus to major Native American population centers such as the Navajo and Hopi Nations.

Conclusions and Recommendations

The objectives of this study were to: 1) to determine who receives DFWs in gateway business, math, and science courses at NAU, 2) to determine why these students receive DFWs in these courses, to 3) to develop a model for identifying students who might be at risk of receiving a D, F, or W in these courses, and 4) to identify and recommend intervention strategies that could improve the rates of academic success in these courses.

In general, students who receive DFWs in gateway courses are likely to have low grade point averages in high school, college, or both. DFW students are also likely to be enrolled for more credit hours than their academic skills warrant and have relatively low scores on their college entrance exams. They are more likely to be Native American and Hispanic than to be of other ethnicities. They are less likely to regularly attend class and more likely to be using less effective study habits. And they are more likely to be negatively affected by their experience in gateway courses than are their peers who receive ABCs.

Although this study was not causal in nature, it did identify several DFW correlates and patterns within the body of students that receives DFWs. These patterns can be grouped into five major categories. These categories, which are listed below, represent the main findings of this research, and warrant further investigation and consideration as administrative changes are made to help identify and provide assistance for potential DFW students.

Student Recruitment

Gateway students are attending NAU not, as one might hope, for its reputation of academic excellence. Instead, gateway students mainly come to NAU to enjoy the physical and/or social environment in Flagstaff. Secondary motivations for student attendance are financial incentives, such as scholarships, offered to students and convenience. It is unclear what is meant by "convenience", but one possibility is that many Native American students attend NAU because of the main campus' physical proximity to major Native American population centers such as the Navajo and Hopi Nations. Native American students are more likely to be attending NAU because of convenience. Hispanic students are more likely to be attending NAU because of financial incentives. White/Caucasian students, who comprise 79% of the gateway student body, are most likely to be attending NAU because of the physical and/or social environment in Flagstaff.

The implications of the fact that students primarily attend NAU for non-academic reasons are unknown, but it is possible that the academic capacities and priorities of some incoming students are somehow related to their motivations for enrollment. The general abilities of NAU students are not suspect, but NAU's recruitment incentives might be attracting some students who might thrive better in different environments. Such students might be prone to receiving DFWs in NAU's gateway courses.

At least two strategies can be used to attract more academically-oriented students to NAU. First, more active recruitment of students with strong academic priorities, as well as more active rejection of students with non-academic priorities, could change the demography of incoming student populations. Identifying students with strong academic priorities could be more challenging than simply screening students with common metrics such as standardized test scores. Standardized test scores can be biased by gender (Behnke 1989, Gross 1988) and ethnicity (e.g. Boutte and McCoy 1994). Furthermore, the disturbing correlation between student achievement on standardized tests and the socioeconomic context of high schools suggests that non-cognitive variables should also be considered when student recruitment decisions are made.

A second strategy to attract more academically-minded students to NAU is to general improvement of NAU's reputation as a serious academic institution could passively attract more academically-oriented students. Such improvement could include activities such as strengthening NAU's financial commitment to research, and expanding its undergraduate and graduate research programs. Strongly reaffirming NAU's commitment to academic excellence could improve the quality and change the priority of NAU's student body and positively affect students' chances for success in gateway courses.

Student Preparation

Not all gateway students are enrolling in gateway courses with the academic skills necessary for success in these classes. This is a national phenomenon (Horn *et al.* 2002), but it does seem to affect student success at NAU. Many of NAU's gateway students are not using effective study strategies. DFW recipients tend to study more by doing homework and reading their class notes, while ABC recipients tend to study more by reading and participating in extracurricular discussions about concepts introduced in class. Differential study habits between ABC and DFW groups could be a result of differential preparation. Insufficient preparation could have introduced and reinforced ineffective study habits among DFW students. Such preparation could have occurred at home, in high school, or in early semesters at college.

Although DFW students seem to use less effective study habits, it is possible that these habits could be reversed with an intervention early in a student's college career. Interventions from counselors and support groups, in first year experience courses, and even in gateway courses could improve the study habits of DFW students and allow the a greater chance of success in all of their classes.

In addition to using ineffective study techniques, DFW students seem more likely to struggle with higher-order intellectual activities such as the synthesis and evaluation of ideas. Such skills, sometimes colloquially referred to as creative and critical thinking skills, usually emerge early in a student's life, but can be shaped well into adulthood (Lawson *et al.* 2000b, Piaget 1966). Encouraging high schools that are sources of students for NAU to work to develop these skills is one possible strategy to improve the preparedness of students. Another possibility is to more strongly emphasize the development and application of these skills in freshman courses at the university. Still another strategy is to offer extracurricular tutoring in these skills to students who request it. Helping DFW students improve their critical thinking skills and study habits early in their college careers would likely have a positive influence on their ability to succeed in all their classes and better capitalize on their entire college experience.

Student & Faculty Diversity

Ethnic and cultural diversity among gateway students is extremely low. White/Caucasian students are by far the most populous group; the proportion of White/Caucasian students at NAU is even greater than it is in the general population of the United States. The lack of diversity among students could potentially affect student success in gateway classes several ways. First, classroom experiences for all gateway students might not be as rich as they could be. Ethnic and cultural diversity in the classroom invites alternative ways of thinking and problem solving into the classroom and encourages all class participants to consider these alternatives and think more broadly about everyday issues. Experiencing diversity, arguably, is an integral part of a liberal arts education. NAU students have fewer opportunities than students at more diverse universities to benefit from cultural experiences.

Gateway students can also suffer from NAU's lack of student diversity because students who are members of ethnic minorities have limited opportunities for peer tutoring, counseling, and support. Group study is not as common among many minority groups as it is among the majority group. This could be caused by differences in cultures (Tinto 1993). Alternatively, is could be caused because of restricted opportunities to engage in group activities among students in minority groups. Peer tutoring can be an effective intervention to improve the success rates of gateway students (Reitz and McCuen 1993).

Social interaction among students not only can have direct academic benefits; it can also have indirect benefits that arise from social support. Such support can have a significant impact on the entire college experience, and particularly on the first year experience, of gateway students (Bartlett 2002, Gardner 2001). Having adequate social and cultural resources available could turn potentially negative academic experiences into manageable ones. Evidence suggests that limited access to social support is a real issue among minority students (Brower and Ketterhagen 2004, Herndon and Moore 2002). Students who describe their ethnicity as "Other" report that concerns with their physical and emotional health is the primary non-academic factor that influences their academic success.

Diversity among gateway students is a serious issue affecting achievement in gateway classes. Diversity among faculty is a similarly serious issue. NAU's faculty is even less diverse that its student body, with members of the White/Caucasian ethnicity predominating. The percentage of White/Caucasian faculty is greater at NAU than the percentage of White/Caucasian students. The percentage of faculty in the next most populous ethnic groups among students, Hispanic and Native American, is less among faculty than among students. This is particularly disturbing, since the representation of Hispanic and Native American ethnicity and culture in Arizona is so prevalent. The regional prevalence of these ethnicities and cultures could be, but apparently is not, drawn upon as a meaningful learning resource for students.

Demographic mismatches between instructors and students can be responsible for stunting the achievement of students that belong to minority groups. Research demonstrates that students who have similar traits to their instructors have greater success rates in class, presumably because students and instructors can better communicate, and because students have immediate positive role models to inspire and motivate them (Seymour 1992, Hewitt and Seymour 1991, Hill and Pettis 1990, National Science Foundation 1989). Gateway students at NAU have restricted access to faculty members who belong to ethnic minority groups. This restricted access could be negatively affecting minority students' prospects for achievement in gateway courses.

This problem could be addressed in two ways. First, more members of ethnic minority groups, particularly Hispanic and Native American, could be added to the faculty through affirmative hiring efforts. Second, existing faculty could be offered professional development opportunities that help them understand how to better relate to minority students and facilitate their achievement in gateway courses.

Curriculum Design & Implementation

Gateway courses at NAU are generally taught in a traditional, didactic manner. This is common among university classrooms in the United States (Antony and Boatsman 2004, Singer 1996, Tobias 1990), but not consistent with recommendations made from education research and advocacy organizations (National Council for the Teaching of Mathematics 2000, National Academy of Sciences 1996, American Association for the Advancement of Science 1989). Didactic teaching, which is commonly used in gateway courses at the university level, has been shown to be a somewhat effective delivery technique for rote material and for students who belong to demographic groups that are traditionally well-represented in business, math, and science-related careers (Anderson 2002, Brush 1991). However, this delivery technique is less effective for helping students understand concepts at higher intellectual levels, and for students who belong to demographic groups that are traditionally poorly represented in business, math, and science (Anderson 2002, Astin 2001, American Association for the Advancement of Science 1989). In many cases, students who belong to these traditionally underrepresented groups are the same students who are receiving DFWs in gateway courses at NAU (note, for instance, the advanced achievement of women at NAU in courses that are taught with more progressive methods). It is therefore reasonable to hypothesize that some students in NAU's gateway courses are receiving DFWs at least partly because of the instructional methods used in these courses.

If this is true, then encouraging the use of progressive teaching techniques in gateway courses should help students better understand the fundamental but complex concepts that are often presented in these courses. Furthermore, using such techniques should help students who are often more likely to be at risk of receiving a DFW perform at a more advanced level. Research has demonstrated that progressive teaching techniques help at-risk students achieve higher levels of success in gateway courses (Burdge and Daubenmire 2001, Gebelt 1996)

Encouraging the use of progressive teaching techniques requires that course instructors be familiar and proficient with these techniques. Many instructors of gateway courses have received no formal instruction in pedagogy and have had little or no opportunity to study progressive techniques. Assigning instructors who have had formal exposure to educational psychology and pedagogical technique could have positive downstream effects for the students of these instructors. Offering professional development opportunities to existing teachers of gateway courses could have similar effects. Prior research suggests that such effects can be significant on not only the educational achievement, but also the attitude of gateway students (Adamson *et al.* 2003).

Identification & Intervention

Students who are at risk of receiving DFWs in gateway business, math, and science courses can reliably be identified. Identification of potential DFW students can happen both in the classroom and at the administrative level. Classroom techniques to identify at-risk students include using clear grading strategies, helping students be aware of their grades early and often throughout the semester, the issuance of formal mid-term grade reports, the use of formative assessment, and the implementation of proactive counseling by peers, instructors, and/or administrators to make students aware of the potential implications of their grade status, and to offer them advice and assistance on improving their grades.

Administrative techniques to identify at-risk students include offering passive but readily-available counseling, and the use of predictive modeling to determine before or in the early portion of a semester which students might benefit from counseling and/or intervention. Predictive models rely mainly on student grade point average and the number of hours a student is enrolled in the semester of concern. Models rely secondarily on standardized test scores and, in one instance, student age. Using the best predictive model available, 84% of students who are at-risk of receiving a DFW can be identified and offered support and assistance at the beginning of the semester before their grades become an issue of serious concern or irreconcilable remedy.

Currently, twenty-five percent of students who enroll in gateway business, math, and science courses at NAU receive grades of D, F, or W in those courses. This not number in itself is not surprising; one would expect a proportion of students who enroll in any class to receive unsatisfactory grades. Patterns in the types of students who receive DFWs at NAU are, however, disturbing. DFW students at NAU are generally academically underprepared and members of ethnic minority groups. Gateway courses are also frequently taught with traditional pedagogical methods. Such methods often favor traditionally well-represented groups in math and science and disfavor traditionally underrepresented groups.

Because of the demographic patterns present among DFW students, it is possible to proactively identify at-risk students with accuracy. Identifying at-risk students might allow NAU's administration and faculty to design and implement proactive intervention strategies that provide assistance to at-risk students if they request it. Such assistance might not reduce the overall DFW rate in gateway courses, but it might remedy the demographic inequities among DFW recipients.

The downstream implications of proactive intervention and improving for at-risk the chances for success in gateway courses could be significant. Helping improve the achievement of challenged students could improve the overall college experience for these students and reduce college attrition rates. Furthermore, it could encourage students in groups traditionally underrepresented in business, math, and science-related careers to persist in these majors and pursue careers in these fields.

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Appendix A

High schools of origin for NAU students enrolled in gateway business, math, and science courses from the Spring 1999 – Fall 2000 semesters.

ABBIE LOVELAND TULLER SCHOOL	MIAMI HIGH SCHOOL
ACADEMY OF TUCSON	MILLENNIUM HIGH SCHOOL
AGUA FRIA UNION HIGH SCHOOL	MINGUS UNION HIGH SCHOOL
AJO HIGH SCHOOL	MOGOLLON HIGH SCHOOL
ALCHESAY HIGH SCHOOL	MOHAVE HIGH SCHOOL
ALHAMBRA HIGH SCHOOL	MONUMENT VALLEY HIGH SCHOOL
AMPHITHEATER HIGH SCHOOL	MOON VALLEY HIGH SCHOOL
ANTELOPE UNION HIGH SCHOOL	MORENCI HIGH SCHOOL
APACHE JUNCTION HIGH SCHOOL	MOUNTAIN POINTE HIGH SCHOOL
APOLLO HIGH SCHOOL	MOUNTAIN RIDGE HIGH SCHOO
ARIZONA LUTHERAN ACADEMY	MOUNTAIN VIEW HS (MESA)
ARIZONA STATE SCH DEAF BLIND	MOUNTAIN VIEW HS (TUCSON)
ASH FORK HIGH SCHOOL	NEW SCHOOL FOR THE ARTS
AZ AGRIBUSINES & EQUINE C	NINETY FIRST PSALM CHRSTN SCH
BABOQUIVARI HIGH SCHOOL	NOGALES JR-SR HIGH SCHOOL
BAGDAD HIGH SCHOOL	NORTH CANYON HIGH SCHOOL
BARRY GOLDWATER HIGH SCHOOL	NORTH HIGH SCHOOL
BENSON UNION HIGH SCHOOL	NORTHLAND PREPARATORY ACA
BISBEE HIGH SCHOOL	NORTHWEST CHRISTIAN ACADEMY
BLUE RIDGE HIGH SCHOOL	NORTHWEST CMTY CHRISTIAN SCH
BOURGADE CATHOLIC HIGH SCHOOL	OAK CREEK RANCH SCHOOL
BRADSHAW MT HIGH SCHOOL	OUR LADY LOURDES HIGH SCHOOL
BROPHY COLLEGE PREPARATORY	PAGE HIGH SCHOOL
BUCKEYE UNION HIGH SCHOOL	PALO VERDE CHRISTIAN HIGH SCH
BUENA HIGH SCHOOL	PALO VERDE HIGH SCHOOL
CACTUS HIGH SCHOOL	PARADISE VALLEY HIGH SCHOOL
CACTUS SHADOWS HIGH SCHOOL	PARKER HIGH SCHOOL
CAMELBACK HIGH SCHOOL	PATAGONIA UNION HIGH SCHOOL
CAMP VERDE HIGH SCHOOL	PAYSON HIGH SCHOOL
CANYON DEL ORO HIGH SCHOOL	PEORIA HIGH SCHOOL
CARL HAYDEN HIGH SCHOOL	PHOENIX CHRISTIAN HIGH SCHOOL
CASA GRANDE UNION HIGH SCHOOL	PHOENIX COUNTRY DAY SCHOOL
CATALINA FOOTHILLS ALT SC	PHOENIX UNION H S
CATALINA FOOTHILLS HIGH SCHOOL	PIMA HIGH SCHOOL
CATALINA HIGH SCHOOL	PINON HIGH SCHOOL
CATHEDRAL CHRISTIAN ACADEMY	POLARIS HIGH SCHOOL
CENTENNIAL HIGH SCHOOL	PPEP TEC CHARTER SCHOOLS
CENTRAL HIGH SCHOOL	PRESCOTT HIGH SCHOOL
CHANDLER HIGH SCHOOL	PROJECT MORE
CHAPARRAL HIGH SCHOOL	PUEBLO HIGH SCHOOL
CHINLE HIGH SCHOOL	QUEEN CREEK HIGH SCHOOL
CHINO VALLEY HIGH SCHOOL	RAY DISTRICT HIGH SCHOOL
CHOLLA HIGH SCHOOL	RED MESA HIGH SCHOOL

CHURCH AT SAFFORD CHRISTIAN SC	RED MOUNTAIN HIGH SCHOOL
CIBOLA HIGH SCHOOL	RINCON HIGH SCHOOL
COCONINO HIGH SCHOOL	RIO RICO HIGH SCHOOL
COLORADO CITY ACADEMY	ROUND VALLEY HIGH SCHOOL
COOLIDGE HIGH SCHOOL	SABINO HIGH SCHOOL
CORONA DEL SOL HIGH SCHOOL	SAFFORD HIGH SCHOOL
CORONADO HIGH SCHOOL	SAHUARITA HIGH SCHOOL
CORTEZ HIGH SCHOOL	SAHUARO HIGH SCHOOL
COVENANT CHRISTIAN HIGH S	SAINT DAVID HIGH SCHOOL
DEER VALLEY HIGH SCHOOL	SAINT GREGORY HIGH SCHOOL
DESERT CHRISTIAN HIGH SCHOOL	SAINT JOHNS HIGH SCHOOL
DESERT MOUNTAIN HIGH SCHOOL	SAINT MARYS HIGH SCHOOL
DESERT VIEW HIGH SCHOOL	SAINT MICHAELS HIGH SCHOOL
DESERT VISTA HIGH SCHOOL	SALOME HIGH SCHOOL
DOBSON HIGH SCHOOL	SALPOINTE CATHOLIC HIGH SCHOOL
DOUGLAS HIGH SCHOOL	SAN CARLOS HIGH SCHOOL
DUNCAN HIGH SCHOOL	SAN MANUEL HIGH SCHOOL
DYSART HIGH SCHOOL	SAN SIMON HIGH SCHOOL
EAST FORK LUTHERAN HIGH SCHOOL	SANTA CRUZ VALLEY UNION HS
EAST HS	SANTA RITA HIGH SCHOOL
EAST VALLEY HIGH SCHOOL	SCHOLARS ACADEMY
EAST VALLEY INSTITUTE OF TECH.	SCHOOL THE
EL MIRAGE CHRISTIAN SCHOOL	SCOTTSDALE ARCADIA HIGH
EXCEL EDUCATION CENTERS I	SCOTTSDALE CHRISTIAN ACADEMY
FAITH CHRISTIAN SCHOOL	SCOTTSDALE HIGH SCH
FENSTER SCHOOL OF SOUTHERN AZ	SCOTTSDALE SAGUARO HIGH SCHOOL
FLAGSTAFF ARTS & LEADERSH	SEDONA RED ROCK HIGH SCHL
FLAGSTAFF HIGH SCHOOL	SELIGMAN HIGH SCHOOL
FLORENCE HIGH SCHOOL	SETON CATHOLIC HIGH SCHOOL
FLOWING WELLS HIGH SCHOOL	SHADOW MOUNTAIN HIGH SCHOOL
FOOTHILLS ACADEMY	SHILOH CHRISTIAN SCHOOL
FORT THOMAS HIGH SCHOOL	SHOW LOW HIGH SCHOOL
FOUNTAIN HILLS HIGH SCHOOL	SINAGUA HIGH SCHOOL
FREDONIA HIGH SCHOOL	SKYLINE HIGH SCHOOL
GANADO HIGH SCHOOL	SNOWFLAKE HIGH SCHOOL
GATEWAY COMMUNITY HIGH SC	SOUTH MOUNTAIN HIGH SCHOOL
GILBERT HIGH SCHOOL	SOUTHWEST INDIAN SCHOOL
GLENDALE HIGH SCHOOL	SOUTHWESTERN ACADEMY
GLOBAL RENAISSANCE ACADEM	ST JOHNS INDIAN H S
GLOBE HIGH SCHOOL	ST PAUL'S ACADEMY
GRACE CHRISTIAN SCHOOL	SUNNYSIDE HIGH SCHOOL
GRAND CANYON HIGH SCHOOL	SUNNYSLOPE HIGH SCHOOL
GREEN FIELDS COUNTRY DAY SCH	SUNRISE BAPTIST ACADEMY
GREENWAY HIGH SCHOOL	SUNRISE MOUNTAIN HIGH SCH
GREY HILLS HIGH SCHOOL	SUPERIOR HIGH SCHOOL
HA:SAN PREP & LEADERSHIP	TEMPE ACCELERATED HIGH SC
HAMILTON HIGH SCHOOL	TEMPE HIGH SCHOOL
HERITAGE ACADEMY	TEMPE PREPARATORY ACADEMY

HERITAGE BAPTIST SCHOOL	THATCHER HIGH SCHOOL
HIGHLAND HIGH SCHOOL	THE ORME SCHOOL
HOLBROOK HIGH SCHOOL	THUNDERBIRD ADVENTIST ACADEMY
HOLBROOK SDA INDIAN SCHOOL	THUNDERBIRD HIGH SCHOOL
HOME SCHOOL	TOHONO ODHAM HIGH SCHOOL
HOPI JR/SR HIGH SCHOOL	TOLLESON UNION HIGH SCHOOL
HORIZON CHARTER SCHOOL	TOMBSTONE HIGH SCHOOL
HORIZON HIGH SCHOOL	TREVOR G BROWNE HIGH SCHOOL
HOWENSTINE HIGH SCHOOL	TRI-CITY PREP HIGH SCHOOL
IMMACULATE HEART HIGH SCHOOL	TUBA CITY HIGH SCHOOL
INDEPENDENCE HIGH SCHOOL	TUCSON ACADEMY OF EXCELLE
INTELLI SCHOOL-CENTRAL	TUCSON MAGNET HIGH SCHOOL
INTELLI SCHOOL-METRO	UNIVERSITY HIGH SCHOOL
INTERNATIONAL STUDIES ACA	VAIL CHARTER HIGH SCHOOL
IRONWOOD HIGH SCHOOL	VALLEY CHRISTIAN HIGH SCHOOL
IRONWOOD HILLS SCHOOL	VALLEY HIGH SCHOOL
JOSEPH CITY HIGH SCHOOL	VALLEY LUTHERAN HIGH SCHOOL
JUDSON SCHOOL	VALLEY UNION HIGH SCHOOL
KINGMAN HIGH SCHOOL	VERDE VALLEY SCHOOL
KOFA HIGH SCHOOL	VILLE DE MARIE ACADEMY
LAKE HAVASU HIGH SCHOOL	WASHINGTON HIGH SCHOOL
MANY FARMS HIGH SCHOOL	WESTVIEW HIGH SCHOOL
MARANA HIGH SCHOOL	WESTWOOD HIGH SCHOOL
MARCOS DE NIZA HIGH SCHOOL	WICKENBURG HIGH SCHOOL
MARICOPA HIGH SCHOOL	WILLCOX HIGH SCHOOL
MARYVALE HIGH SCHOOL	WILLIAMS HIGH SCHOOL
MAYER HIGH SCHOOL	WINDOW ROCK HIGH SCHOOL
MCCLINTOCK HIGH SCHOOL	WINSLOW HIGH SCHOOL
MESA HIGH SCHOOL	XAVIER COLLEGE PREPARATORY
MESQUITE HIGH SCHOOL	YOUNG PUBLIC SCHOOL
METROPOLITAN ARTS INSTITU	YUMA HIGH SCHOOL

Appendix B

Survey on Factors Contributing to Student Success
Faculty Increasing Student Achievement Success (FISAS) Project
Northern Arizona University
October, 2002

The faculty at Northern Arizona University is interested in helping students succeed in classes such as this. Please take a moment to complete the following survey. The information you provide will help curriculum designers identify challenges that you face and factors that contribute to your success in this course, and it will help them improve the academic experience for you and other students who take courses like this.

The responses you provide are meaningful to the success of this study. Although you will be asked to provide the last six digits of your school identification number on your response sheet, your responses will be kept confidential and anonymous, and your responses will not affect your grade in this course. Your participation in this survey is optional.

To take this survey, first fill out the last six digits of your NAU identification number and the course code on the top of your response sheet. Next, answer the 26 survey questions to the best of your ability. Please provide *only one response* per item. If none of the responses provided for an item applies to you, please leave that item blank.

1. What is your age?

   1) 18 or younger
   2) 19-20
   3) 21-22
   4) 23-25
   5) 26-29
   6) 30 or older

2. What is your gender?

   1) Female
   2) Male

3. Which category best describes your ethnicity?

   1) African American
   2) Asian American
   3) Hispanic
   4) Native American
   5) White/Caucasian
   6) Other

4. What is your class status?

   1) Freshman
   2) Sophomore
   3) Junior
   4) Senior
   5) Post-Baccalaureate
   6) Graduate

5. Which category best describes your major?

   1) Arts, humanities, or communication
   2) Business, accounting, or information technology
   3) Social services (social science, social work, health care), or education
   4) Math, physical science, life science
   5) Undecided
   6) Other

6. How challenging is this class for you?

   1) Easy
   2) Not very challenging
   3) Somewhat challenging
   4) Difficult

7. What grade do you expect to get in this class?

   1) A
   2) B
   3) C
   4) D
   5) F
   6) Other

8. What is your overall college GPA?

   1) below 1.5
   2) 1.5-1.9
   3) 2.0-2.4
   4) 2.5-2.9
   5) 3.0-3.4
   6) 3.5-4.0

9. How will your level of success in this class affect your academic, career, or personal goals?

   1) It definitely will not affect my goals at all
   2) It probably will not affect my goals
   3) It probably will affect my goals
   4) It definitely will affect my goals

10. How has taking this class affected your interest in the subject?

   1) As a result of this class, I am now less interested in the subject
   2) Taking this class has not affected my interest in the subject
   3) As a result of this class, I am now more interested in the subject

11. Why did you come to NAU?

1) Social or physical environment of Flagstaff
2) Social or physical environment on campus
3) Reputation of academic programs
4) Convenience
5) Financial incentive (relative low cost of tuition, scholarship, etc.)
6) Other

12. How satisfied are you with your overall experience at NAU?

1) Very dissatisfied
2) Slightly dissatisfied
3) Generally satisfied
4) Very satisfied

13. How do responsibilities outside of school affect your success at school?

1) They don't ever affect my success at school
2) They occasionally affect my success at school
3) They often affect my success at school
4) They always affect my success at school

14. What non-academic factor most influences your success in this class?

1) Work and/or financial situation
2) Family obligations
3) Physical and/or emotional health
4) Athletics
5) Social and/or recreational activities
6) Interest and/or motivation in this class or in school

15. How consistent are activities in this class with your original expectations of this class?

1) The activities don't meet my expectations
2) The activities are what I expected
3) The activities exceed my expectations

16. How do things you learn in this class relate to the real world?

1) Concepts in this class do not relate to real world experiences
2) Concepts in this class only slightly relate to real world experiences
3) Concepts in this class mostly relate to real world experiences
4) Concepts in this class relate very well to real world experiences

17. How often do you come to class?

    1) Less than 50% of the classes
    2) 51-74% of the classes
    3) 75-94% of the classes
    4) 95-100% of the classes

18. How many hours per week do you devote to this class *beyond* the time you spend in class (for example, reading, doing homework, and studying)?

    1) I don't spend any time on this class outside of lecture/lab
    2) Less than one hour
    3) 1-3 hours
    4) 4-6 hours
    5) 7-10 hours
    6) more than 10 hours

19. Compared to your classmates, what is your level of in-class participation?

    1) My classmates participate more than I do
    2) I participate about the same as my classmates
    3) I participate more than my classmates

20. How academically prepared were you for this class at the beginning of the semester?

    1) Not prepared
    2) Somewhat prepared, but lacking some important skills or knowledge
    3) Prepared

21. How do you regularly prepare for this class?

    1) Reading the text or assigned readings
    2) Studying notes taken in class
    3) Doing homework
    4) Talking with classmates or friends
    5) Other
    6) I don't do anything to prepare

22. Success in this class mainly requires:

1) Memorizing facts, methods, and/or equations
2) Analyzing theories, concepts, or ideas
3) Synthesizing new information or ideas
4) Making judgments about the value of ideas
5) Applying learned ideas in practical situations
6) Offering my opinion, expressing my feelings or beliefs

23. How often did you discuss ideas from lectures, labs, or readings from this class with people outside of class?

1) Never
2) 1-3 times per semester
3) 4-10 times per semester
4) More than 10 times per semester

24. The resources necessary for success in this class are:

1) Not available
2) Available, but very difficult or inconvenient to use
3) Available, but a bit difficult or inconvenient to use
4) Readily available and easy to use

25. The primary motivation you are pursuing a college degree is to:

1) Be financially successful
2) Pursue a career I love
3) Satisfy a personal interest or goal
4) Follow the advice of a parent or guardian
5) Interact socially with other college students
6) Other

26. This class is:

1) Required for my major
2) Required for my minor
3) Required for Liberal Studies
4) An elective
5) Other

Appendix C

Reformed Teaching Observation Protocol (RTOP)
Adapted from Piburn *et al.*. 2000

Each item is scored on a 0–4 ‘‘Never Occurred’’ to ‘‘Very Descriptive’’ scale. The sum of these scores yields an overall “RTOP score” ranging from 0 – 100. An RTOP score of 0 suggests that activities associated with reformed teaching (Alexander and Murphy 1999; National Council for the Teaching of Mathematics 1989, 1991, 1995, 2000; National Academy of Sciences, National Research Council 1996, 2000; American Association for the Advancement of Science 1989) never occurred. An RTOP score of 100 suggests that activities associated with reformed teaching always occurred.

Lesson design and implementation

1. The instructional strategies and activities respected students’ prior knowledge and the preconceptions inherent therein.

2. The lesson was designed to engage students as members of a learning community.

3. In this lesson, student exploration preceded formal presentation.

4. The lesson encouraged students to seek and value alternative modes of investigation or problem solving.

5. The focus and direction of the lesson was often determined by ideas originating with students.

Content: Propositional knowledge

6. The lesson involved fundamental concepts of the subject.

7. The lesson promoted strongly coherent conceptual understanding.

8. The instructor had a solid grasp of the subject matter content inherent in the lesson.

9. Elements of abstraction (i.e., symbolic representations, theory building) were encouraged when it was important to do so.

10. Connections with other content disciplines and/or real-world phenomena were explored and valued.

Content: Procedural knowledge

11. Students used a variety of means (models, drawings, graphs, concrete materials, manipulatives, etc.) to represent phenomena.

12. Students made predictions, estimations, and/or hypotheses and devised means for testing them.

13. Students were actively engaged in thought-provoking activity that often involved critical assessment of procedures.

14. Students were reflective about their learning.

15. Intellectual rigor, constructive criticism, and the challenging of ideas were valued.

Classroom culture: Communicative interactions

16. Students were involved in the communication of their ideas to others using a variety of means and media.

17. The instructor’s questions triggered divergent modes of thinking.

18. There was a high proportion of student talk and a significant amount of it occurred between and among students.

19. Student questions and comments often determined the focus and direction of classroom discourse.

20. There was a climate of respect for what others had to say.

Classroom culture: Student–instructor relationships

21. Active participation of students was encouraged and valued.

22. Students were encouraged to generate conjectures, alternative solution strategies, and ways of interpreting evidence.

23. In general, the instructor was patient with students.

24. The instructor acted as a resource person, working to support and enhance student investigations.

25. The metaphor ‘‘instructor as listener’’ was characteristic of this classroom.