

Pathways: A Student-Centered Approach to Educational Success

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Abstract —*This paper examines the details, supporting figures, and student responses for Pathways, an undergraduate support program that takes a student-centered approach to educational success. Pathways, now entering its third year, uses two key courses within the Computer Science Department at New Mexico State University as its basis, and is part of a larger effort towards improving recruitment and retention of minority students. Within Pathways, students are the focal point. Their input was instrumental in its design and their continual feedback controls the direction each component takes. Pathways supports, challenges, and offers opportunities for each student as individuals and as part of a community. By doing so, it is hoped students will not only be successful in these key courses, but be motivated and empowered to succeed throughout their college or job careers.*

1. Introduction

Recruiting and retaining underrepresented minorities has been a major hurdle within the field of Computer Science (CS). The CS department at New Mexico State University recognized this and has made a considerable effort to alter this trend within our department. In the 2002 - 2003 school year, the department received a Minority Institution Infrastructure Grant (No. EIA-0220590) from the National Science Foundation. This support enabled us to build an undergraduate program initially aimed at improving short-term educational success and later extended to include the long-term success of our students.

The program development focused on two key courses: a freshman-level computer science course and a sophomore-level mathematics course. These courses were chosen because they are considered fundamental to the degree and because students not successfully completing them tended to change majors or give up on their education. Student input was sought and used during the development process. This input highlighted an interesting revelation: students have many different concerns (i.e., academic, peers, family, work, cultural, and financial), all of which have an impact on the educational process but some of which are not normally considered by support programs. Initially, in an effort to address these concerns and to increase short-term success within the two key courses, this resulted in a program that used a team-oriented framework, offered academic support and challenges in individual and group formats, created employment opportunities, and took advantage of faculty and peer mentoring.

While this is still the core of the program, it has been expanded to offer tools which are expected to lead to the long-term success of our students. Workshops focusing on general issues such as test preparation/taking and study skills to workshops focusing on discipline specific topics such as how to use certain computer programs are now offered. Social events designed to build bonds and trust among the students and to allow them to network with faculty, teaching assistants, mentors, and supporting staff have also been included. Most importantly, student input and feedback are solicited and used to drive the direction of each component. In most cases, within a few days,

students get to see the effect of their input and feedback.

This paper is broken up into three sections. The first section describes the general problem being addressed by the Pathways program. We then focus on the problem within the discipline of Computer Science and state the goals of our program. The next section examines the short-term and long-term details of the program. The last section describes problems to overcome, the future of the program, and analyzes the extent to which we have succeeded.

2. The Problem

The General Problem

In simple terms, recruiting and retaining underrepresented minorities is a difficult problem in the sciences. Figure 1 depicts enrollment at 4-year institutions by ethnicity [NSF2004] for all majors (Note: there is no data provided for 1999). The total number of minorities enrolled is less than half of that for whites for each year. As indicated in the figure the gap is closing, but very slowly.

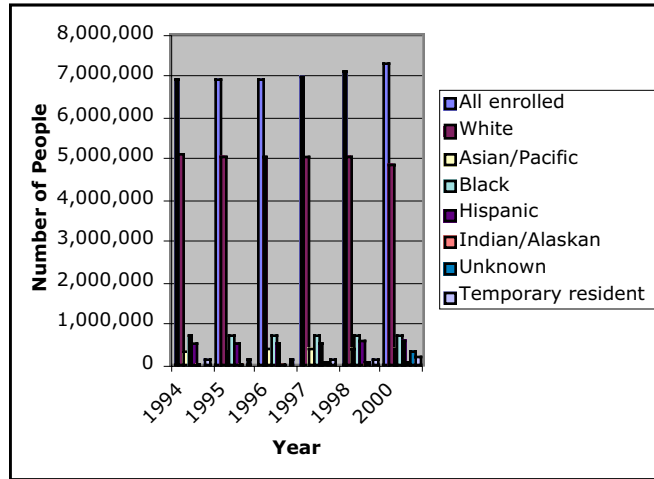


Figure 1 - 1994 - 2000 Undergraduate Enrollment by Ethnicity at 4-Year Institutions.

Figure 2 shows the number of degrees from 4-year institutions over a seven year period. The data is not only broken up by ethnicity, but by Science and Engineering (S&E) fields and by Non-Science and Engineering fields (non-S&E) among each ethnic group.

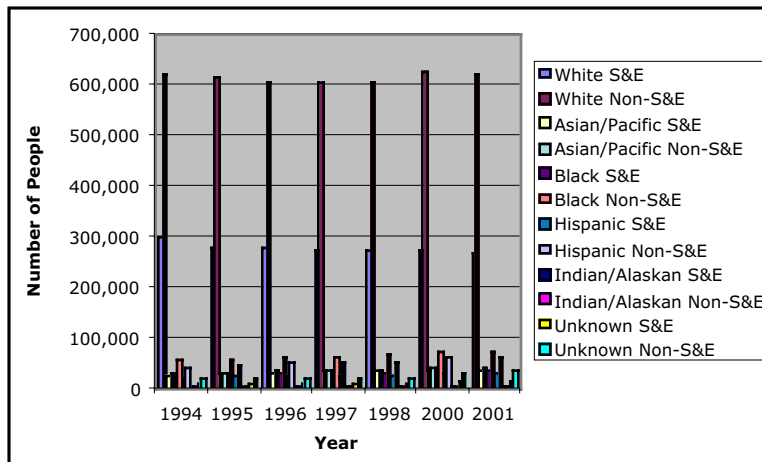


Figure 2 - 1994 - 2000 Undergraduate Degrees by Ethnicity at 4-Year Institutions.

Four or five years later, there is a large drop across the board for all fields compared to the enrollment numbers. For example, in 1996 roughly seven million people enrolled in a degree program at a 4-year institution. Assuming the average number of years to achieve a degree is four or five years, we see only 1.25 million people receiving degrees in 2000 and in 2001.

The numbers for people achieving S&E degrees is roughly 1/2 that of people receiving non-S&E degrees. In the S&E fields the number of whites achieving 4-year degrees starts out at roughly 4 times that of all minorities, but by the 2001 year ends up being only 3 times that of all minorities.

The Computer Science Undergraduate Problem

Historically, and from the perspective of the CS department, students have trouble with two courses:

- **CS171: Algorithmic Computation** - The first course for majors where students learn the basic concepts of CS;
- **Math 279: Introduction to Finite Mathematics** - One of the fundamental mathematics courses for CS majors.

In the case of Math 279 during the four semesters from Spring 2000 through Fall 2001, it was discovered that approximately 49% of students did not pass the class with a satisfactory grade [Steiner2003]. Also, students having difficulties with either course tended to switch majors or drop out of the University completely.

Another problem students face is that they sometimes come into the major with a weak background. This doesn't mean the students are not intelligent. It means that the students failed to prepare themselves or their high schools failed to prepare them for the coursework involved in achieving a CS degree. This, unfortunately, is a simple mistake to make. Many people don't realize the extent to which CS is based on mathematics. As such, a solid background in mathematics is vital.

The NMSU Computer Science Department Goal

Our goal for our students is to have them successfully earn a bachelor's degree in CS and be successful in the work place or in continuing their education. This goal is difficult to achieve if the students are having trouble with basic or fundamental courses.

3. The Hunt for a Solution

Where does one look for a solution? From the perspective of the department, it's clear where students are having difficulties, but what do the students think? Are the difficulties they see the same as the ones the department sees? Or, are there more?

By asking students, it was discovered that students do see some of the difficulties the department believes they have plus a few others. A summary of their responses follows:

- The students have a wide-ranging number of concerns to balance to do well in an educational environment. These concerns include the following: academic, peers, family, work, cultural, time, financial, etc.
- They have different learning styles. Some students liked to work by themselves, others with at most one other individual, and others enjoyed working in groups.
- The students also felt Math 279 wasn't geared strongly enough toward CS. They couldn't see the relationship between the mathematics and the computer science.

- They desired a consistent steady workload with timely feedback.

4. The Pathways Program

The Pathways program is now entering its third year and takes the approach that the concerns of the student must be balanced in order for the student to have educational success (i.e., for students to successfully achieve the degree). Also, the content of the program is driven, although not blindly, by the students.

Roughly at the same time this program was being developed and put into place, the CS department restructured its program to align its curriculum better with the ACM-IEEE-CS Computing Curricula 2001 [ACM2001] and to improve student performance. One of the major changes for the undergraduate degree program, was the replacement of the following two courses:

- **Math 279** - Introduction to finite mathematics;
- **Math 330** - Discrete mathematics.

with the following course:

- **CS/Math 278** - Discrete mathematics for CS.

CS/Math 278 combines the course material from Math 279 and Math 330 and places an emphasis on the mathematics needed by CS majors for future course work in CS.

One way to view the Pathways program is in terms of its short-term and long-term goals. We'll discuss each in the next two following sections.

Short-Term Program

The focus of the short-term program is to support the students along the road to success in each of the two courses (i.e., CS 171 and CS/Math 278). Currently, participation in the Pathways program is voluntary, but in the past extra credit has been offered to gain student attention. Support is offered in the following three ways and is specific to each of the two courses:

Focus Groups—Students meet as an organized group to discuss key concepts, labs, or homework problems in a group setting. Sessions occur weekly and are an hour in length. Each session is lead by the course teaching assistant or someone with good knowledge of course material. Students are solicited for input via two minute papers before the session meets or verbally at the beginning of each session.

Tutoring—Some students prefer to work in a one-on-one setting. Tutoring is a response to that. Meetings occur on a weekly basis and last 30 minutes long. The tutors are not there to answer problems for students, but rather to support or guide them along a path to finding a solution. The students are required to come prepared with questions or problems to each session.

Time Independent Self Support—For students that like to work alone or on their own time table, Pathways offers web-based support. For specific questions, bulletin board style question and answer sessions are available. The web site also offers information on support services, practice questions, and other information not available in class (such as how to install certain types of software or how to use certain software).

Long-Term Program

The focus here is to prepare students for long-term educational success. Support is offered in a

variety of ways, but all of them are aimed at building skills, creating relationships, or giving them access to technology to help them throughout their careers.

Faculty/Peer Mentoring—In the past, students have been paired with either a peer or faculty for mentoring. In either case, the mentor provides the students with someone they can talk about course related or non-course related issues, which may extend beyond the scope of class work, with. Faculty mentors encourage students by offering a positive example of someone that has succeed, while peer mentors share a similar experience.

Talks and Workshops—The talks expose students to new ideas, such as cutting edge technology done by graduate students. Workshops offer students support in two ways: 1) learning general topics like how to prepare for exams and 2) gaining practical experience with technology, such as how to work with different types of software.

Social Events—One aspect of being successful in an educational environment is how well you network. Social events offer students the opportunity to network with faculty, staff, Pathways personnel, and other students. The environment of each social event is typically informal. Food is served and sometimes a game is played to help build bonds amongst the students.

Employment Opportunities—The Pathways program offers employment opportunities to undergraduates from all majors. Currently two peer mentors and one tutor are employed. One peer mentor and the tutor are CS majors. The other peer mentor is a business major. Also, the tutor is a previous student from the Pathways program.

Expanded Program—The Pathways program has shown some success over its existence and hopes to expand to become an integral part of the CS department. For the Spring 2005 semester, two more classes have been added to the program:

- **CS 272: Introduction to Data Structures** - the 2nd required course in the program;
- **CS 372: Data Structures and Algorithms** - the fundamental theoretical CS course in the undergraduate program.

Access to Current Technology—The grant funding the Pathways program has been a major help to the CS department. Using the funds, the department was able to supply the department with wireless networking and a computerized classroom.



Figure 3 - A class using the new computer classroom.

Summer Camp Programs—In an effort to increase recruiting and enrollment of underrepresented minorities, the Pathways program offers summer camp programs to native american high school and 2-year college students.

5. Evaluation

CS 171 Focus Group Results

Here are the actual grade distribution results for the CS 171 focus groups during the Fall 2003 and Fall 2004 semesters:

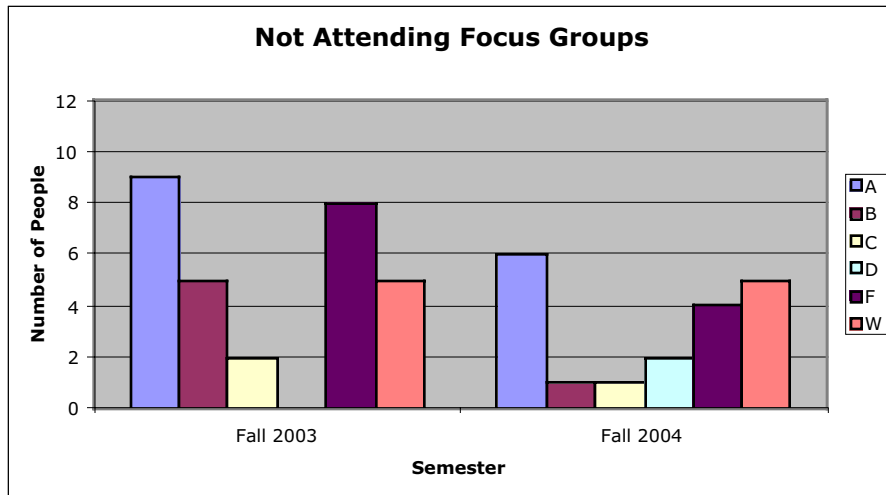


Figure 4 - CS 171 students that did not attend any focus groups.

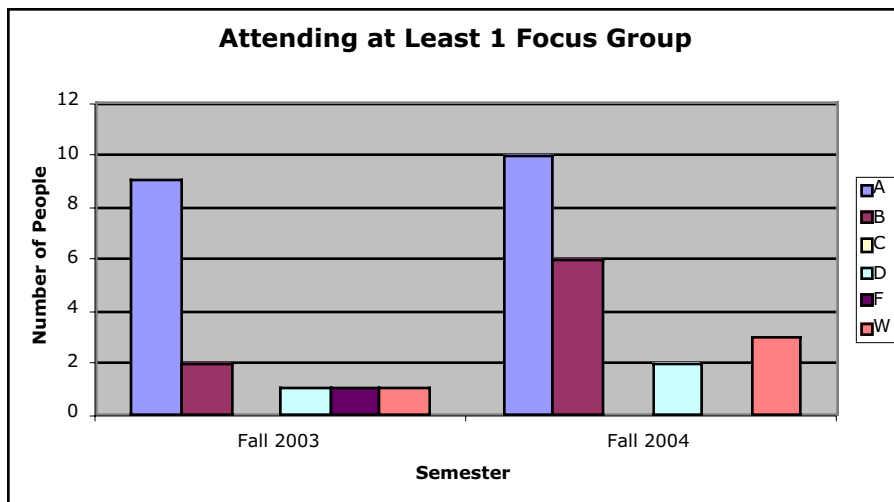


Figure 5 - CS 171 students attending at least one focus group.

As you can see, students attending at least one focus group were more likely to achieve an A or B over a C, D, F, or W.

CS 171 Focus Group Attendance

The following figure shows how many people actually attended focus groups during the Fall 2003 and Fall 2004 semesters. For example, approximately 49 people never attended a focus group. One the other end of the spectrum, one person attended 19 focus groups.

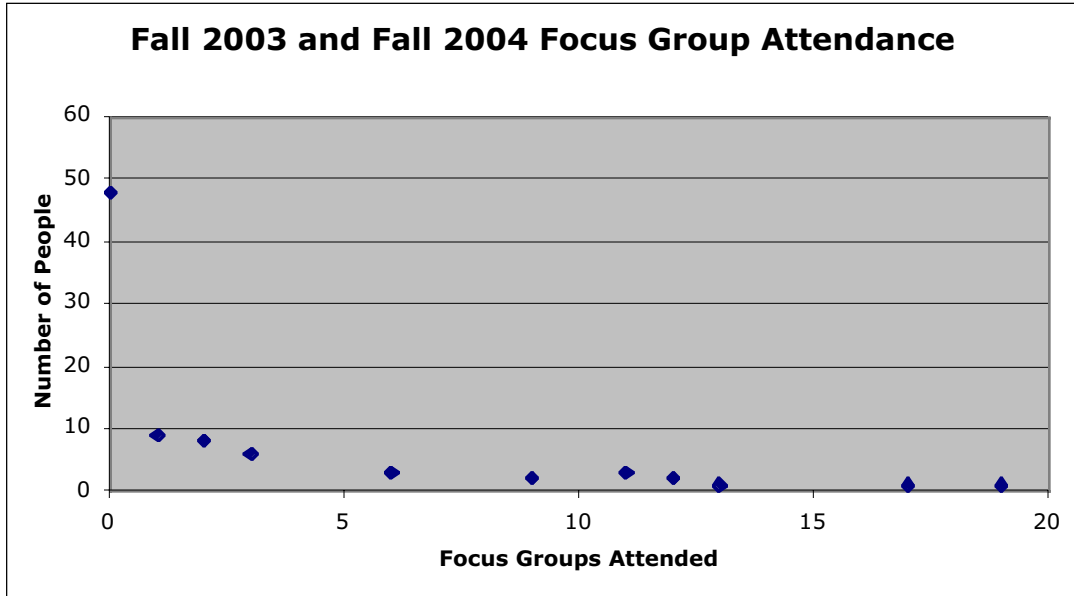


Figure 6 - CS171 focus group attendance.

CS171 Focus Group by Ethnicity

The Pathways program is open to students of all races, religions, and cultures. However, it's main focus is to support underrepresented minorities through the CS degree program. The following 4 figures show that most people attending the focus groups are from underrepresented minorities groups.

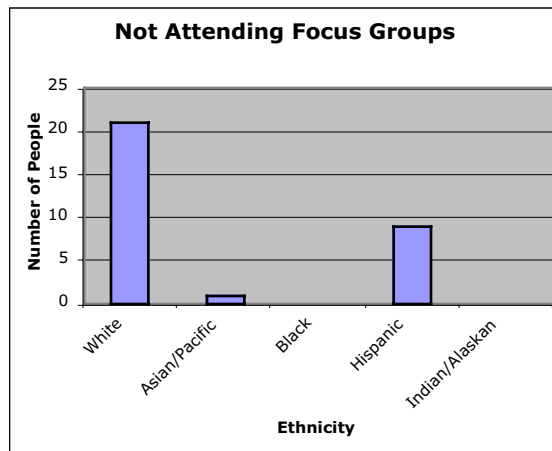


Figure 7 - The ethnicity of Fall 2003 CS171 students that did not attend any focus groups.

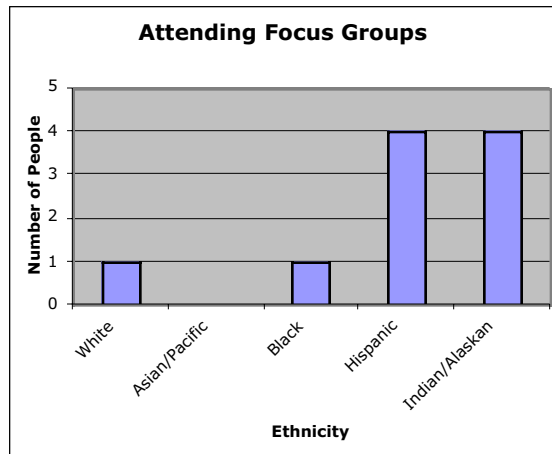


Figure 8 - The ethnicity of Fall 2003 CS171 students that attended at least one focus group.

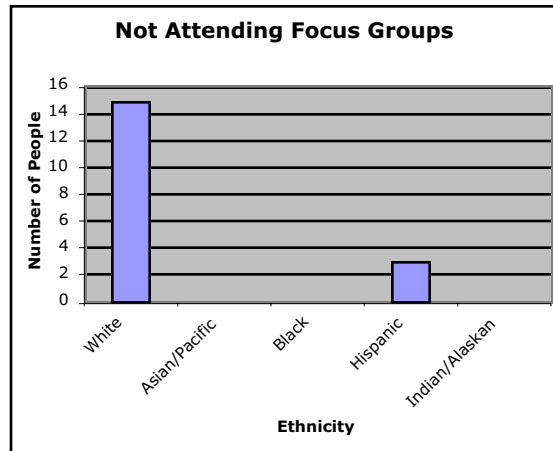


Figure 9 - The ethnicity of Fall 2004 CS171 students that did not attend any focus group.

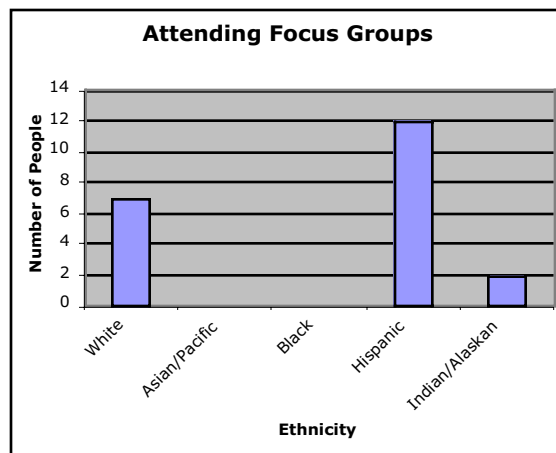


Figure 10 - The ethnicity of Fall 2004 CS171 students that attended at least one focus group.

CS171 Retention Results

The following figure shows the retention results for CS171 during the 2003 and 2004 academic school years. Figure 11 shows the results for all student whether they attended a focus group or not. Figure 12 shows only retention results for those students that attended at least one focus group.

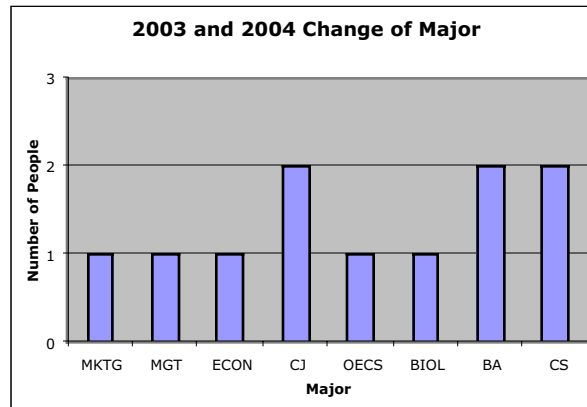


Figure 11 - People who changed majors while taking CS 171.

Here is a brief summary of the result from Figure 11 including the ethnicity of the people involved:

- 11 switched from CS to other degree programs (many of which were non-S&E fields). five were white and six minorities (two of which were female);
- 2 switched their majors to CS. One was white and one a minority;
- 148 stayed in the major.

In the figure below we see the results for those that attended at least one focus group.

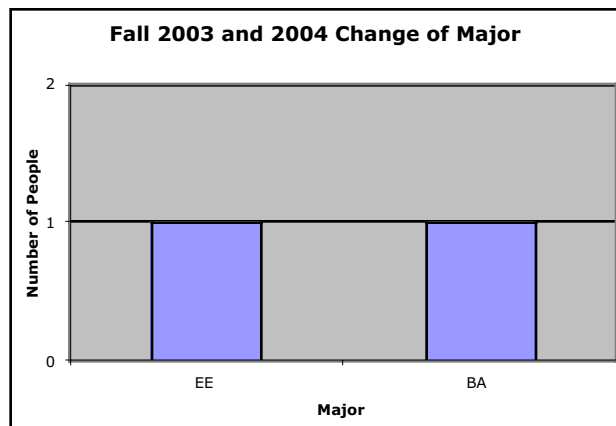


Figure 12 - CS 171 who changed majors and that attended at least one focus group.

Here are the summary results for Figure 12:

- 2 switched majors from CS. One was Asian/Pacific and the other a white female;
- 33 people stayed in the degree program.

CS/Math 278 Focus Group Results

Here are the actual grade distribution results for CS/Math 278 focus groups during the Fall 2003 and Fall 2004 semesters:

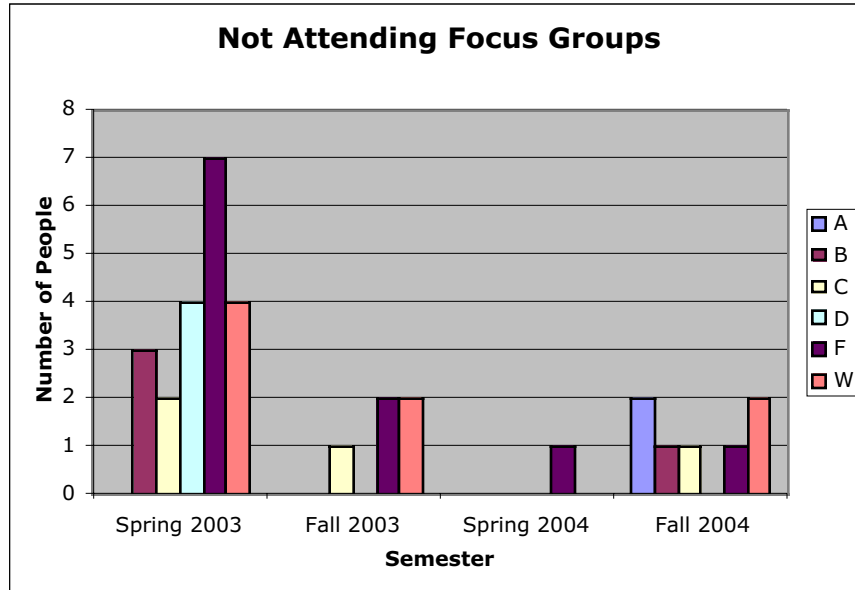


Figure 13 - Grade distribution for students not attending any of the CS/Math 278 focus groups.

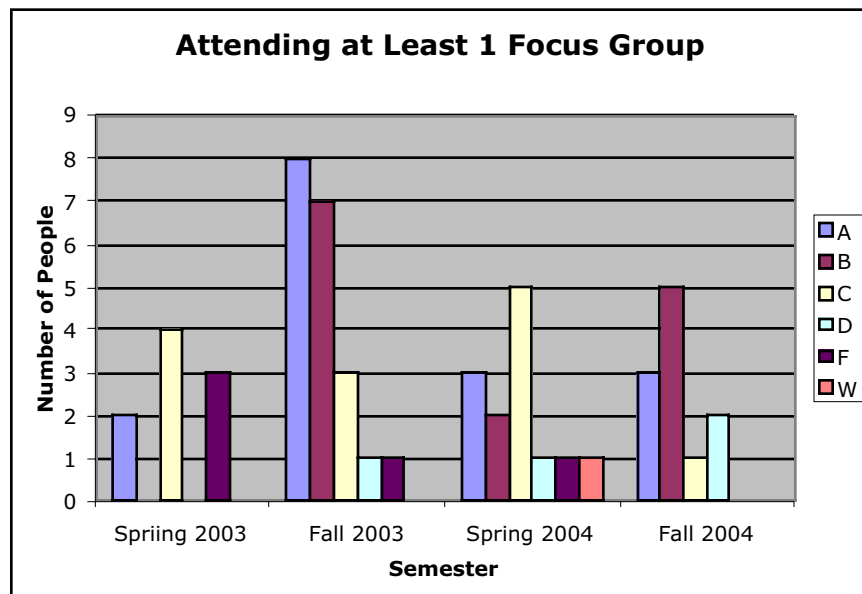


Figure 14 - Grade distribution for students attending at least one CS/Math 278 focus group.

Here the results are more startling than with CS 171. You can clearly see the students attending at least one focus group were more likely to achieve an A or B over a C, D, F, or W. In addition, those students performed significantly better than those that didn't attend any focus groups.

CS/Math 278 Focus Group Attendance

The following figure shows how many people actually attended focus groups during the 2003 and 2004 academic school years. For example, approximately 32 people never attended a focus group. One the other end of the spectrum, one person attended 15 focus groups.

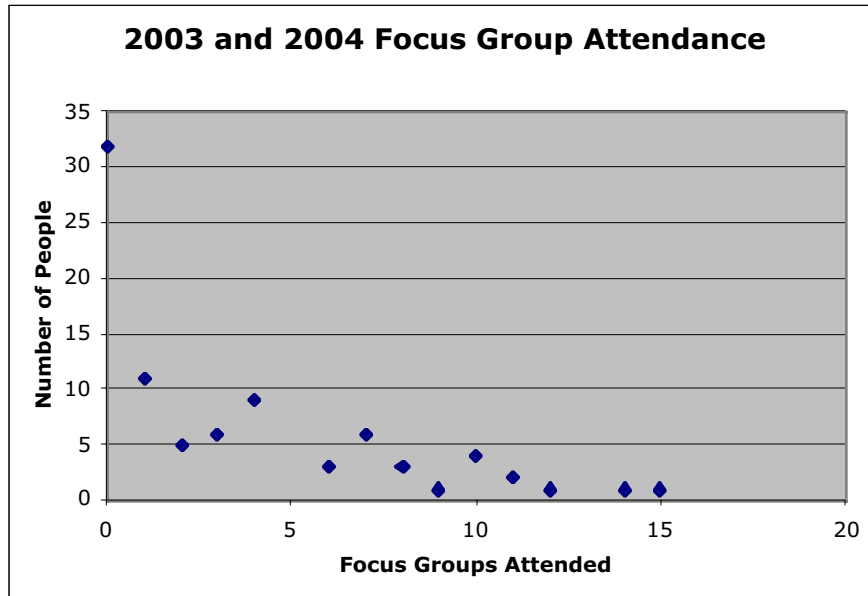


Figure 15 - CS/Math 278 focus group attendance.

6. Conclusion

Overall Evaluation

The Pathways program works. Students attending the focus groups perform better than those that do not. More specifically, students attending at least one focus group are more likely to get a satisfactory grade than those not attending any focus groups. Also, students attending at least one focus group are more likely to stay within the CS degree program.

Problems to Overcome

There are two major problems to overcome to improve the impact of the Pathways program:

- (1) *Student Motivation* - Students show limited motivation to participate in anything, not required of the course. Currently, participation in the Pathways program is voluntary and in the past extra credit has been offered to encourage students to participate. However, keeping track of students for extra credit proved to be significant work and rarely had any impact on student grades. Pathways is considering alternatives, such as requiring students to participate if their grades are below average.
- (2) *Gaining Faculty Member Support* - Pathways not only works with the CS department, but also with the Mathematics department. Because Pathways is centrally located within the CS department, communication with CS faculty members has had greater success than that with Mathematics faculty members. In the coming semesters, Pathways intends to focus on improving communication at all levels, but especially with other department.

The Future

The Pathways program will continue to expand and build upon its past successes. Student input was fundamental in the design of the program and will continue to be a major component as we continue with our long-term plan. Communication and collaborations between our program and other similar programs, our recruitment effort, and our job preparation and continuing education plans will also be emphasized.

7. Acknowledgements

We wish to thank the National Science Foundation for the funding of this program (Minority Institution Infrastructure Grant: No. EIA-0220590). We would also like to thank the Computer Science department secretarial staff, focus group leaders, instructors, peer mentor, previous coordinators, and tutors for their support and hard work in making the Pathways program succeed.

8. References

- [1] Association of Computing Machinery (ACM) and Computer Society of the Institute for Electrical and Electronic Engineers (IEEE-CS) Computing Curricula 2001, <http://www.computer.org/education/cc2001/>
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- [3] Steiner, E.; Summary Sheet: Math 279 Grades at NMSU ; Spring 2000 through Fall 2001; Personal communication November 2003.