A Systemic Change Model in Engineering Education and Its Relevance for Women

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Abstract

The paper will present the experience at Texas A&M University (A&M) in institutionalizing its first-year and sophomore curricula using learning communities (LC) as the underlying concept. In 1998-99 academic year, A&M completed the transition from pilot curricula to new first and second year engineering curricula for every student. As the foundation for new curricula, A&M developed LCs. At A&M, a LC is a group of students, faculty and industry that have common interests and work as partners to improve the engineering educational experience. LCs value diversity, are accessible to all interested individuals, and bring real world situations into the engineering classroom. The key components of A&M engineering LCs at are: (1) clustering of students in common courses; (2) teaming; (3) active/cooperative learning; (4) industry involvement; (5) technology-enhanced classrooms; (6) peer teachers; (7) curriculum integration; (8) faculty team teaching; and (9) assessment and evaluation. This presentation will use both quantitative and qualitative assessment methods to try and understand how LCs have affected student retention, performance, and learning experience.

Introduction

In 1993 the National Science Foundation (NSF) funded the fifth engineering education coalition, the Foundation Coalition (FC), with the vision to become a recognized catalyst in changing the culture of engineering education. Since NSF envisioned the engineering education coalitions as a vehicle to create new models of engineering education, the FC, during the first five years of funding, concentrated on creating pilot programs based on seven ideas that are informed by a number of theories of learning and change. The key ideas are: (1) active/cooperative learning; (2) teaming; (3) technology-enabled learning (4) curriculum integration; (5) increasing the participation of women and underrepresented minorities; (6) continuous improvement through assessment, evaluation, and feedback; and (7) managing change. The curricular models and the assessment data that emerged from the pilot programs are well documented in the literature. The second five years of funding, starting in 1998, are focused on how to institutionalize model curriculum programs, how to facilitate systemic change in engineering education, and how to build sustainable models of assessment and evaluation that support systemic change.

In 1998-99 academic year, A&M completed the first phase in the transition from pilot curricula to new first and second year engineering curricula for every student. As the foundation for new curricula, A&M used learning communities. Alexander Meiklejohn originated the concept of learning communities when he created the Experimental College at the University of Wisconsin. Meiklejohn designed the Experimental College to provide a two-year, integrated foundation for liberal arts curricula. The Experimental College operated for two years between 1925-27.[1] The next major experiment in learning communities was initiated by Joseph Tussman at University of California Berkeley in the mid 1960s.[2] Interest and implementation of learning communities have grown during the 1990s as documented by the work by Gabelnick et. al.[3] and the National Learning Communities project.[4] As evidenced by the diversity of implementations of learning communities in engineering curricula across the Foundation Coalition, learning communities provide a concept that can be adopted and adapted by many different engineering programs to offer increased support for the students who are enrolled in very challenging programs.

At A&M, a LC is a group of students, faculty and industry that have common interests and work as partners to improve the engineering educational experience. LCs value diversity, are accessible to all interested individuals, and bring real world situations into the engineering classroom. The key components of LCs at A&M are: (1) clustering of students in common courses (math, engineering, science); (2) teaming; (3) active/cooperative learning; (4) industry involvement in the classroom; (5) technology-enhanced classrooms; (6) undergraduate peer teachers; (7) curriculum integration; (8) faculty team teaching; and (9) assessment and evaluation. Based on the experience with its pilot curricula and the experiences since institutionalization in 1998-99, A&M believes that the LCs offer a superior educational experience for engineering students. Development of learning communities in both the first and second years of the engineering curricula at Texas A&M has been described in a paper by Fournier-Bonilla et. al.[5] Based on the experience with its pilot curricula and the experiences since institutionalization in 1998-99, A&M believes that the LCs offer a superior educational experience for engineering students. The purpose of the present paper is to examine the affect of college-wide implementation of learning communities on the students and faculty at Texas A&M University.

The paper explores four questions. First, what are the components of the LCs at A&M, why would these components be expected to create improved learning environments for all students, and especially women and underrepresented minorities? Second, what quantitative data regarding the efficacy of the learning communities have been obtained since institutionalization in 1998-99 and what conclusions might be drawn from the quantitative data? Third, what qualitative data have been obtained about the experiences of students in the learning communities and what conclusions might be drawn from the qualitative data? Fourth, what types of data are available about the experiences of faculty members in teaching learning communities and how does that experience compare with faculty members teaching students who are not in learning communities.

Components of Learning Communities in Engineering at A&M

The new curricular model developed, in part, from the FC pilot curricula is based on Learning Communities (LC) theory. Broadly defined, LC is a purposefully restructured curriculum and learning environment that link courses together. Linking provides for greater coherence in what students are learning, intentional interaction among students within an academic context, and greater interaction between faculty and students. There are nine components in the LC model in the College of Engineering (COE) at A&M: (1) clustering of students in common courses (math, engineering, science); (2) using student teams inside and outside the classroom; (3) active/cooperative learning in the classroom; (4) industry involvement in the classroom; (5) technology enhanced classrooms; (6) undergraduate peer teachers; (7) curriculum integration between engineering, sciences (physics and chemistry) and mathematics; (8) faculty team teaching; and (9) assessment and evaluation. Below is a brief definition of each component and why it was considered important to under represented groups.

Clustering of students

One aspect of the new curriculum was clustering of students. In the COE, ninety-six (96) students in each cluster enroll in common sections of their first-year courses in science, engineering and mathematics. Faculty members teaching the engineering, science and mathematics have a common set of students about whom they can share insights and assessments. Student teams assigned in the engineering course can be used in the mathematics and science courses. Engineering projects and other learning activities can be developed to reveal relevance and applications of concepts being studied in science and mathematics. Clusters provide an opportunity to integrate concepts across science, engineering and mathematics. In addition, they intentionally construct a social setting in an academic context in which students can talk to and work with each other on a common set of learning activities. This is an important element to the LC model because it creates a classroom where the students get to know each other because they have the same peers in two or three courses. Astin[6] reports that the most important single issue in student persistence is a feeling of belonging.

In the COE at A&M, clusters must be created to accommodate a large, diverse set of entering students. For example, in the Fall Semester of the freshman year, some students enroll in common sections of physics, engineering and calculus. Other students enroll in common sections of engineering and calculus, but not physics, because for a variety of reasons they will not be taking physics. Other students are not prepared to take calculus and clusters are designed to accommodate these students. Finally, clusters must also be constructed to accommodate students with advanced placement. Therefore, a large number of options must be offered to accommodate the diverse backgrounds of the entering students. These combinations are shown in Figure 1.

Figure 1 illustrates the structure of the cluster arrangement for 1800 entering students. Each number in parentheses is the number of students that are being accommodated in each configuration. Each year high school data and test results indicated that approximately 500 entering students are best served by starting in pre-calculus. Of these students about 300 enroll in 3 clusters (of 96 students each) in which students take common sections of pre-calculus, chemistry, and an introduction to engineering seminar designed for students taking pre-calculus. The remaining students take their mathematics, chemistry and engineering courses in non-clustered courses. Another 1000 entering students start their engineering curricula by taking calculus. One cluster of 96 students takes common sections of calculus, physics, and introduction to engineering. Six clusters (96 students each) take common sections of calculus, physics and introduction to engineering. The three-course cluster is the most common type. About 150 students take common sections of calculus and introduction to engineering and the remaining students take their courses independently. Finally, about 300 entering students have background in mathematics that permits them to begin second semester calculus. Fifty students take a cluster with common sections of second semester calculus and introduction to engineering. The remaining 250 students take their courses independently. Different cluster configurations

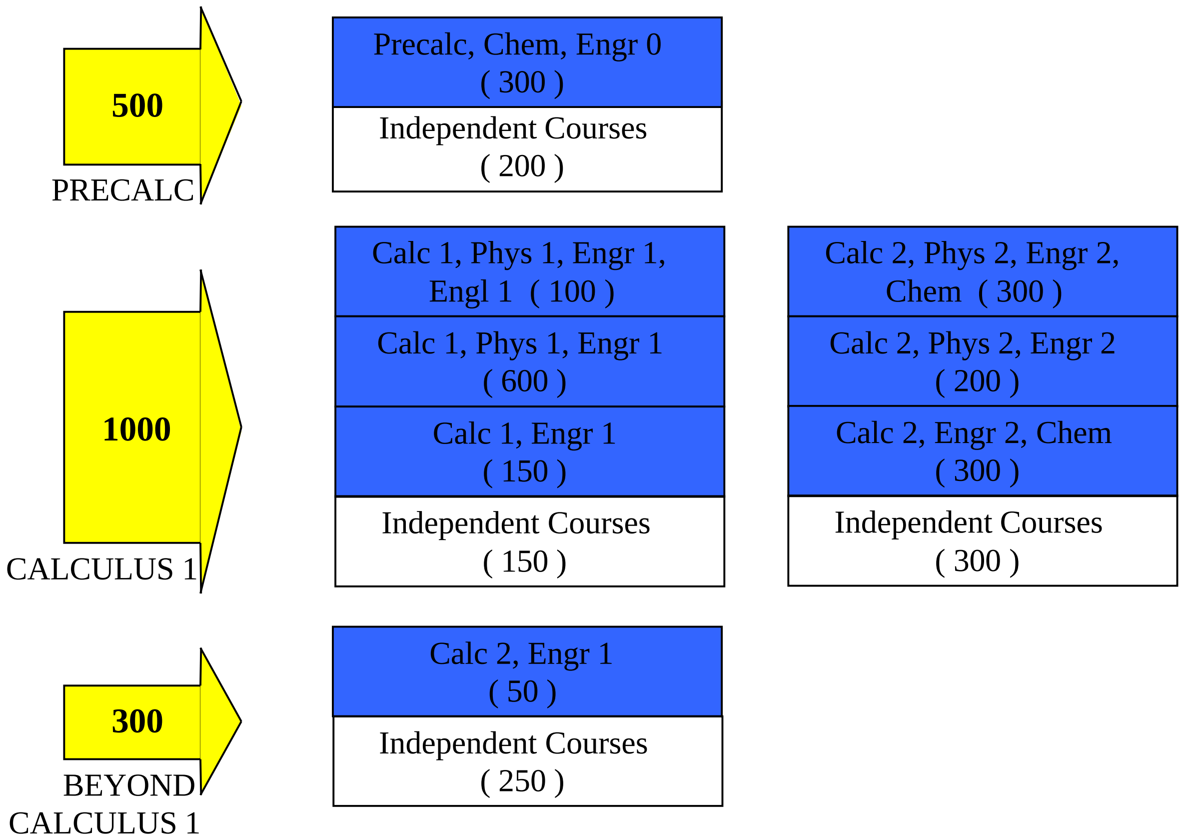

Figure 1. Cluster Structure for First-Year Engineering Curriculum at Texas A&M

accommodate the diverse needs of its entering students.

Student Teams

There are several reasons for using student teams as an integral part of the class. First, employers are requesting engineering graduates with improved skills and more experience in working within a team structure. Industry changed to team decisions because of their experience that more creative solutions to problems occurred in a team environment. Second, engineering programs applying for accreditation under Engineering Criteria 2000 of the Accreditation Board of Engineering and Technology (ABET) are asked to demonstrate that their graduates have "an ability to function on multi-disciplinary teams."[7] Third, developing team skills while still in college increases students' potential for improved academic performance and simultaneously provides important skills to prepare them for the workplace. Although true for certain traditional team-based courses such as the capstone design course, it is also true on a much wider scale, with today's interest in active learning theories of pedagogy. For example, faculty can effectively use student teams in many other active/cooperative learning activities besides projects.[8] Fourth, teams can provide social, emotional and academic support for their members. Interpersonal support is valuable for all students[6], but especially for women and underrepresented minorities. For example, Pascarella[9] suggests that peer support is an important factor in student persistence in school. She reports that students of color and women are often left out of the informal networks that occur outside the classroom so that teaming and small group work within the classroom builds an environment that helps all students belong. Together, these reasons have motivated the COE to integrate team training and learning experiences with teams into the first-year and sophomore curricula.

The first-year engineering classes at A&M provide at least six hours of team training and many more hours of practical experience in teaming for the students. Students work on several projects in teams and faculty members base a portion of the grade on the assignments submitted as a team. Faculty members in the sophomore engineering classes also offer a large range of team learning experiences.

Active/cooperative learning

Research clearly supports the widely accepted proposition that students need to do more than just listen to learn.[10] Despite this widely held and strongly supported proposition, a survey of U.S. professors found that lecturing is the mode of instruction in 89% of physical scientists and mathematicians.[11] The COE has made a concerted effort, for example, holding numerous workshops designed to assist faculty members incorporating active/cooperative learning into engineering learning communities. There are many definitions of both active learning and cooperative learning, but the TAMU model defines active learning as: students are involved in more activities than listening, such as reading, discussing, writing, problem solving, and higher-order thinking skills such as analysis, synthesis, evaluation. Cooperative learning consists of the students working in structured groups that enhance their own and other's learning. To truly be cooperative learning groups, the groups must have clear positive interdependence where members are personally and individually accountable and where the members hold each other accountable. The work in the COE builds on numerous projects across the world that aim at demonstrating the efficacy of cooperative learning and illustrating how it may be integrated into the classroom.

Superior efficacy of cooperative learning approaches has been documented in a variety of studies. Hake[12], in a study of almost 6000 students in physics mechanics courses, shows that the use of interactive engagement (IE) results in higher conceptual gains, as measured by pre- and post scores on the Force Concept Inventory[13, 14] than traditional lectures. In fact, the smallest gains by students in IE classes were comparable with the largest gains by students in classes with traditional lectures. A meta-analysis[15] of a number of studies on various forms of small-group learning shows that these approaches to teaching are quite effective in promoting greater academic achievement, more favorable attitudes toward learning, and increased persistence in science, mathematics, engineering, and technology (SMET) courses and programs. The meta-analysis supports more widespread implementation of small-group learning in undergraduate SMET courses. In a longitudinal study of chemical engineering students, Felder, Felder and Dietz[16] compared outcomes for an experimental group to those for students in a traditionally-taught comparison group. The experimental group outperformed the comparison group on a number of measures. The pedagogy examined in the study should be adaptable to any engineering curriculum at any institution since large classes were used and special classrooms were not required. In a study of design courses across the ECSEL coalition, Terenzini et. al.[17] reported that students in design courses that used “active and collaborative approaches to teaching design reported statistically significant advantages” in three areas: design, communication and group skills “when compared with … students, who were enrolled in conventionally taught courses.” “These reported learning gains, moreover, persisted even when controlling for relevant pre-course student characteristics (e.g., gender, race/ethnicity, parents’ education, high school grades, SAT scores, degree aspirations, and class year).”

In addition to studies showing improved learning outcomes, one of the major benefits for women students may be the change in the culture of the classroom. In studies by both Seymour and Hewitt[18] and Sandler[19], engineering and science classes fostered a competitive ethos that was discouraging for women. Since cooperative learning is based on positive interdependence instead of competitive interdependence, and since the studies suggest that women prefer a culture that fosters interdependence, women should prefer classes that emphasize cooperative learning. In fact, both studies suggest that active participation in class, class discussion, small group work, and cooperation will improve the learning environment for women.

Industry involvement

Very few students choose a major with a thorough understanding of the implications for the impact of their choice of major on what they will do after graduation. Student knowledge of the practice of engineering and possible careers paths for engineering graduates early in their collegiate careers is minimal at best. Without an accurate picture of the value of their major for life after graduation, students may find it difficult to justify to themselves the hours of study required for success in engineering and lose motivation when concepts are difficult to understand and progress is hard to ascertain. Although students have only vague ideas life after graduation as engineering majors, they chose engineering as a major with the intuitive understanding that engineers create artifacts. In addition to questions about how an engineering major will improve their choices after graduation, students often question the value of their first-year courses for the practice of engineering. As described in the Study of School-to-Work Initiatives report “Students form mental pictures of their futures from their knowledge and act accordingly. If employment is not part of that picture, or if the classroom seems unlikely to provide them with what they need to attain a job, then they are unlikely to have the motivation to participate actively in learning, or even to stay in school.”[20] Students believe that engineering is building a bridge, designing a computer chip, or creating new solutions to societal problems. Yet in the typical first year classroom, students study derivatives, integrals, Newton’s Laws of Motion and other topics that, for many students, appear to at best tangentially related to their mental pictures of engineering practice. Therefore, the COE decided helping students improve their understanding of engineering practice and the relevance of introductory mathematics, science and engineering to success as an engineer would positively impact retention and student progress toward graduation.

In addition, to positively impacting all students, general knowledge and research suggests that improving understanding of engineering practice and connections to introductory mathematics, science, and engineering courses would improve the learning environment for women. In a climate survey in engineering done in 1995-96, researchers confirmed at TAMU, that many more women than men come to engineering because they are good in mathematics and science. A counselor or teacher tells them to go “try” engineering, but the student does not typically have a depth of understanding of what engineers do. This is true for men and women, but many more of the men will persist through the curriculum with less career information than women.[21] For all these reasons, the COE invited industry to help address questions students have about engineering.

When the COE decided to invite industry to be a partner in the classroom, faculty members and staff established the following goals for this interaction: to show what engineers do; to demonstrate that engineers work in teams; to demonstrate the problem-solving process. Faculty members also stated that if industry involvement was to be valued, it would need to take place in the classroom, not as an evening or weekend session. Having the opportunity to learn from industry engineers and to experience how math, science, and engineering concepts go into solving real engineering problems increases understanding and connections between courses and career choice.

The COE uses three methods to build links between employers and students: 1) industry night discussions, 2) case studies, and 3) industry-sponsored workshops.

Industry Night Discussions – Students in the second semester engineering course attend Industry Night Discussions. The purpose of Industry Night is to share information about a particular industry in an effort to educate students about the different fields in engineering. The Industry Night presentations have multiple goals: 1) to excite the students about engineering; 2) to help them to make a commitment to engineering; 3) to provide engineering industrial information; 4) to talk about real world engineering problems; and 5) to provide information for students to aid in deciding majors.

Industry Case Studies - Case studies are an effort to demonstrate "real world" engineering; that engineers work in teams; and to demonstrate the problem-solving process to currently enrolled engineering students. Companies usually send a team of 2-8 engineers who spend their day with students in an engineering course, typically a first semester, freshman engineering course. This team typically presents a 15-20 minute overview of a problem encountered in their company or industry. Students break into assigned teams, generate possible solutions to the problem, and then student teams present their solutions to the class. In the discussion that follows, the industry team presents the solution selected at their company and reviews the major contributing factors to the decision. In addition, the students are able to enter into a question and answer period with engineers from industry about their work environment, greatest challenges, rewards, etc.[22]

Industry-Sponsored Workshops – When the LCs were established for all entering engineering students, teaming was integrated into the classroom. Teaming was new for many of the faculty as well as most of the entering high school students. When team conflicts arose, faculty members were uncomfortable facilitating the student team conflicts. When the issue of conflict in teams was raised with industry members, they reported that similar issues arose in industry. They suggested that workshops on diversity or valuing differences had been helpful in the workplace and might help in the classroom. So, COE asked industry trainers to come to the college and offer the workshops to the first year students. The workshops are highly interactive and typically have 70-80 in each workshop. The college typically hosts from 400-700 students each year.

Technology-enhanced classrooms

The use of technology, particularly information technology, for improving engineering education has been advocated by numerous people and groups. Moreover, the ways in which technology might be used in engineering education are numerous and diverse. Responding to the shift to learner-centered education, consider three categories of technology applications. In the first category, consumptive technology, students use technology to facilitate and extend their access to information. Applications that students use in this category include hypertext browsers, multimedia players, Java applets, and computer-graded assignments. In the second category, collaborative technology, students use technology to communicate and work with both the instructor and other members of their classes. Applications that students use in this category include e-mail, web forum, and instant messaging. In the third category, generative technology, students use technology as new tools to improve their efficiency and effectiveness in both learning and performing analysis and design. Improvements are wrought either by improving the efficiency with which students execute current tasks, for example using computers to symbolically or numerically solve an equation, or completely changing the way they approach design and analysis, for example designing a control system as a nonlinear optimization problem in the time domain instead of placing poles and zeros or shaping the frequency response. Applications that students use in this category include office productivity suites, programming languages, simulation packages, numerical manipulation systems, symbolic manipulation systems, computer-aided design packages, and laboratory systems. Within each category benefits to student learning and hindrances to adoption are similar. Therefore, decomposing applications of technology into these three categories facilitates productive conversations about improving engineering education through the use of technology.

Partner schools in the Foundation Coalition, including A&M, have concentrated on generative applications of technology. Each partner schools worked to create learning environments in which ubiquitous use of computers would be routine. Each institution built or remodeled classrooms so that students could use computers as a routine part of every class. At A&M, at least ten classrooms have been remodeled to provide one computer for every two students and to provide seating arrangements that facilitate the use of four-person student teams. Figure 2 shows two examples of remodeled classrooms in the COE. Students use applications including Microsoft Excel, Maple, and AutoCAD to gain facility in using these applications and to attack routinely problems in science, engineering and mathematics. Using computer tools offload routine manipulations and computations allow students to focus on the tasks for formulating the problem and evaluating the quality of the results. Further, the first-year engineering courses are taught in two, two-hour blocks of time each week. Two-hour classes provide time for team-based learning activities that make use of the computers in the classroom. While the students are engaged in team exercises, the faculty members, the graduate teaching assistants and the undergraduate peer teachers are present to help the teams.

Figure 2. Remodeled Classrooms at Texas A&M University

Undergraduate peer teachers

In the fall 2000, the Minority Engineering Program (MEP) and Women in Engineering, Science and Technology (WEST) programs worked with the LC faculty to pilot undergraduate peer teachers in the engineering classrooms. The goal of the peer teachers is to create community and belonging for all the students in the section, and especially those from underrepresented groups. These peer teachers also offered academic support in the evenings. The peer teachers are undergraduate students who had previously taken the ENGR 111/112 sequence. (ENGR 111/112, Foundations of Engineering I/II, is the two-semester sequence of first-year engineering courses required for all engineering majors. The two courses present a broad range of engineering topics include engineering design, engineering graphics, problem solving, computer applications and introductory topics in mechanics and thermodynamics. More information about the sequence can be found at http://engr111.tamu.edu and http://engr112.tamu.edu.) They are part of the teaching team that offers a section of either ENGR 111 or 112. The team consists of a faculty member who teaches the problem-solving and design components of the 11x sequence, a faculty member who teaches the graphics components of the 11x sequence, one graduate teaching assistant; and one undergraduate peer teacher. The peer teachers attended the engineering class; offered academic support two evenings a week on calculus, physics, chemistry and engineering; and served as mentors and guides for the first year students in their particular cluster.

In the fall 2000 pilot program, the peer teacher sections showed a difference in the overall section GPA (2.85 with peer teacher and 2.61 without peer teachers). One of the issues brought out in research is the isolation experienced by many under represented students in engineering. The clusters help the students belong and feel a commitment to other students and faculty. Peer teachers have been instrumental in creating this sense of belonging. One difference between the two groups (with and without peer teachers) surfaced from a survey given at the end of the fall semester. There was a positive, significant difference in how the students interacted with the faculty and graduate teaching assistants, interacted with their team members, their study habits and in their confidence and determination to become an engineer. This demonstrates the sense of community for all students. Impressed with comments from faculty and students alike, the college, in fall 2001, placed a peer teacher in every section of ENGR111, 112, and 150 (22 regular sections of 96 students and 2 honors sections of 50 students). (ENGR 150, Introduction to Engineering, is a one-credit, design oriented course that emphasizes preparation for an engineering major through projects that integrate mathematics, science and engineering. It is taken by every student who is also taking MATH150, Functions, Trigonometry and Linear Systems. Students who successfully complete ENGR150 and MATH 150 are eligible to take ENGR 111 and MATH 151, Calculus.)

Curriculum Integration

Another component of the learning communities effort in the COE is attempts to help students link concepts from different elements. The value of helping students establish links is supported by research from several different disciplines. In the neuroscience arena, Schacter[23] reports from results from two different studies conducted using functional magnetic resonance imaging (fMRI). In both, volunteers were placed in the fMRI tunnel, given objects to remember while monitoring brain activity, and then asked to recall the objects after they left the tunnel. One question was whether results from the fMRI scans could predict which objects the subjects would recall. The answer was affirmative. If two areas of the brain showed increased activity during the presentation of the object, then the subject would recall the object. The first area was the parahippocampal gyrus, which plays an important role in establishing long-term memory. The second area was the frontal lobe. In one study, subjects were given and asked to recall words while in the second study subjects were given and asked to recall pictures. When given words, increased activity in the left frontal lobe was required if subjects were going to recall words, while subjects who recalled pictures that were presented showed increased activity in the right frontal lobe. Activity in the frontal lobes appears to indicate that subjects were making connections between the object being presented and prior memories. Therefore, subjects who recalled an object had successfully elaborated knowledge about the object in terms of prior memories. These studies suggest that students must establish connections between topics being presented and other topics if they are to recall and apply the material.

In a qualitative study of student learning conducted at the University of California Berkeley, the researchers interviewed about 70 mechanical engineering students about their learning experiences in college. Although the researchers were aware of various integrated curricula that had been implemented across the country, they were interested in the student perspective of integration, as well as the pedagogical perspective. Data from the interviews tended to support the value of linking concepts. For example, "Of the 70 students interviewed, 60% commented on the benefit of linking concepts across disciplines."[24] So an entirely different research project also confirms the value of integration from a student perspective.

Finally, Rosser[25] and Sandler[19] both report differences between how men and women approach problems. Men tend to handle problems with a single correct or concrete answer comfortably, while women are better able to deal with complex problems and problems that are ambiguous. Rosser asserts that many of the first year courses are more directed to single correct or concrete answers, which favor the learning style of men. This is one of the reasons, she believes, that women with high GPAs may leave the major in the first year.

The A&M model builds connections between these subjects through closely aligning course topics and through the use of design projects. By integrating the topics from several subject areas in these projects the students are exposed to more complex and realistic problems.[26]

Faculty Team Teaching

There are two reasons team teaching is important to faculty and students in the new curricular model: 1) the same learning theory that says teaming is good for students, transfers to faculty teaming. They don't have to work alone and there is a peer to learn with and grow. The second reason is that if we want to change the environment for students, it is much more likely for a single faculty member's bias to come out if there are two personalities in the room. Faculty teams in the first-year engineering courses, one faculty member who concentrates on engineering graphics and one faculty member who concentrates on problem solving and engineering design, provide students with more than one personality to which they can relate.

Assessment and evaluation

Continuous improvement and data driven decisions are the goal of the assessment and evaluation plan. Faculty members know that evaluation must be comprehensive, on going, and support the goals of the program. This assessment also helped provide information to make the extensive change necessary to bring the FC pilot into existence for all the first year students. For example, the decision to expand and incorporate peer teachers into the LC model was a result of the faculty and student evaluations after the first two semesters. Comparative GPA analysis was also considered. Another example where assessment encouraged the college to change was the student comments about the industry case studies. During the second time in which case studies were offered students were asked, on the evaluation form, what else the college could do to enrich their first year experience. By far, most students requested more opportunities to visit with industry engineers. Based on their feedback, the college began the Industry Night program. Finally, the diversity workshops were also a result of faculty conversations about what was working in the classroom and where their frustrations lay. The conflict within the teams was mentioned many times. So, diversity workshops were solicited from industry. These examples illustrate how assessment, evaluation and feedback have improved the LC model.

There are several ways in which the impact of learning communities on students and faculty members can be explored. In this paper, three approaches will be employed. First, quantitative comparisons of student performance will be examined. Second, a large qualitative research project on the experiences of students and faculty members across the Foundation Coalition has recently been completed. A short summary of the project results on the experiences of students will be presented. Finally, experiences of faculty members who participated in the learning communities will be reviewed. The three perspectives provide a comprehensive review of engineering learning communities at A&M.

Quantitative Data

Since 1998-99, learning communities are offered to all of the entering engineering majors. As a result, comparison groups cannot be constructed so the impact of learning communities may be explored by examining the performance of students in the learning communities with respect to students in a matched comparison group. Therefore, another approach to examining the impact of learning communities is required.

For calculus-ready (in Figure 1, this is the largest group of students), first-time first-year students (FTFYS), we have placed the students into one of five categories.

1. LC2: Students who participated in learning communities for two semesters. These are students who enrolled in sections of the ENGR 111/112 (Foundations of Engineering I/II) that are clustered with calculus and/or physics classes. In analyzing student performance it is important to understand that in order to participate in a learning community for both Fall and Spring semesters, students must successfully complete each of the clustered classes in the Fall Semester.
2. Non-LC2: Students who never participated in learning communities, but successfully completed all of the science, mathematics and engineering classes that are a part of their Fall semester engineering curriculum. In terms of course experiences, students in this category should be roughly comparable to students in the first category.
3. LC1_interrupted: Students who participated in a learning community during the Fall semester, but did not successfully complete one or more of their courses in the Fall semester cluster so they would have been ineligible to participate in a learning community during Spring semester.
4. Non-LC1_interrupted: Students who never participated in the learning communities, but did not successfully complete all of the science, mathematics and engineering classes that are a part of the Fall semester engineering curriculum. In terms of course experiences, students in this category should be roughly comparable to students in the third category.
5. LC1: Students who participated in a learning community in the Fall semester and successfully completed all of their Fall semester courses, but did not participate in a learning community in the Spring semester. A group of students whose course experiences were comparable to these students was not constructed.

The demographics and performance of these five groups of students will be examined for the 1998-99, 1999-2000, and 2000-01 academic years. In addition to looking at all FTFYS for these academic years, the students will be examined by gender.

Tables A-1 through A-18 in the appendix provide the complete data for the three cohorts, 1998-99, 1999-2000, and 2000-01. Tables A-1 through A-9 look at the entire student body while Tables A-10 through A-18 look at the student body by gender. Tables A-1 through A-3 will be described more carefully since they provide the template for the remaining tables in the appendix. In Table A-1, entrance data (SAT Total, SAT Verbal, SAT Math and high school percentile) are presented to help understand the comparability of the different categories. In the section labeled "Academic Performance" grades of the various categories are compared. For readers unfamiliar with the acronyms used at A&M the following list describes the various grades that may be computed.

CGPA Spring 1999 – CGPA is the Cumulative Grade Point Average that a student has earned at the end of the first academic year. The GPA is computed using all the courses that a student has completed at the end of the first academic year.

CBK GPR – CBK refers to the Common Body of Knowledge. It is the set of courses that a student must complete in order to be considered for admission to a department as a sophomore. Engineering students enter the COE as first-year students, but they must be accepted to a department in order to enroll in their sophomore level courses. Admission decisions by department are based primarily on the Grade Point Rating (GPR) earned by the students in their CBK courses. CBK courses include courses in calculus, physics, chemistry, engineering, and English. So the CBK GPR is the number that departments use for their admission decisions.

GPA in 2xx courses – ENGR 2xx courses are a group of engineering science courses that engineering students take as sophomores. The GPA is computed by averaging the grades that students earn in these basic engineering science courses. The GPA in 2xx courses for the 2000-01 cohort is not yet available and has been omitted from the tables for this cohort.

GPA in 1xx courses – All engineering students take ENGR 111 and ENGR 112, Foundations of Engineering I and II, generally as first-year students. These two courses are part of the CBK courses and they form the hub of the clustered courses.

Number of semesters for progression to sophomore program – This is the number of semesters a student takes until he/she has successfully completed all of the CBK courses and may apply to a department.

CPGA at Progression – This is the Cumulative Grade Point Average that a student has earned at the point when the student has completed all of the CBK courses.

The last two rows of Table A-1 show the demographics of the student body in terms of gender and ethnicity.

Table A-2 shows retention for each of the five categories. First-year retention is the number and/or percentage of students who entered in 1998 and were enrolled at the beginning of the 1999-2000 academic year. Second-year retention is the number and/or percentage of students who entered in 1998 and were enrolled in the 2000-01 academic year. Table A-3 shows in more detail the number and/or percentage of students who completed their CBK courses and might apply to an engineering department in terms of academic years since the beginning of the Fall Semester 1998-99. The number as the reader moves across the row are not cumulative; instead, they show the number and/or percentage of students who completed their CBK courses at the end of the number of academic years shown in the column header. With descriptions of the first three tables in the appendix, the reader should be prepared to compare students in the different categories.

This paper will concentrate on comparisons of students in the two categories LC2 and Non-LC2. Theoretically, performances in terms of grades between the two groups should not be very different if the two groups are comparable in terms of their entering scores. Students in both categories take similar courses; both take ENGR 111 and ENGR 112 that emphasize student teams, routine use of technology, coordinated syllabi, and active/cooperative learning. The primary difference is that students in the LC2 category are clustered. They see each other in two or more classes and hopefully build a greater sense of community. The sense of community should contribute, not to higher grades, but to higher retention and more rapid progress toward graduation since they should continue to take courses required for graduation in the manner laid out in the catalog. Examining the data tends to confirm predictions of theory.

For the 1998 and 1999 cohorts, students in these two categories are very similar in terms of their entering data while students in Non-LC2 category have higher entering scores than students in the LC2 category. As a result, comparisons between the two categories for the 2000 cohort are more problematical. Comparison between grades earned by the two categories doesn't show much difference. In general, grades for the non-LC2 category are slightly higher, but the differences are not large. The exception is for the 2000 cohort, but here the grade differences could be explained by higher entering scores for the Non-LC2 category of the 2000 cohort. The most significant differences are in retention and rate of completion of the CBK requirements, especially for the 1998 and 1999 cohorts.

Table 1 shows retention comparisons between the two categories for the three different cohorts. For the 1998 and 1999 cohorts students in the LC2 categories, that is students who participated in learning communities for both semesters of their first year, were retained at much higher rate than students in the Non-LC2 categories, that is students who never participated in a learning community. The higher rates of retention hold despite the fact that students in the Non-LC2 earned higher grades than students in the LC2 category, although the grade differences, as noted above, are small. The opposite is true for the 2000 cohort; however, both retention rates are very high and also students in the Non-LC2 category had higher entering scores. It appears that learning communities contribute to higher retention.

Table 1. Comparison of Retention between LC2 and Non-LC2 Students

Cohort	**Category**	**First-Year Retention Percentage**	**Second-Year Retention Percentage**
1998 Cohort	LC2	90.70%	85.70%
	Non-LC2	84.20%	73.70%
1999 Cohort	LC2	92.90%	84.40%
	Non-LC2	83.00%	72.30%
2000 Cohort	LC2	93.40%	-
	Non-LC2	97.90%	-

Table 2 examines retention by gender. When broken down by gender, the same trends observed in Table 1 are also true when examined by gender. Both females and males in the LC2 category are retained at higher rates than their counterparts in the Non-LC2 category in the 1998 and 1998 cohorts. The trend is reversed in the 2000 cohort for reasons similar to the ones noted above.

Females are retained at lower rates than males for both categories and across all three cohorts; however, the retention percentages are very encouraging.

Table 2. Comparison by Gender of Retention between LC2 and Non-LC2 Students

Cohort	**Gender**	**Category**	**First-Year Retention Percentage**	**Second-Year Retention Percentage**
1998 Cohort	Female	LC2	88.2%	80.9%
		Non-LC2	82.6%	69.6%
	Male	LC2	91.3%	87%
		Non-LC2	84.7%	75%
1999 Cohort	Female	LC2	98.3%	79.3%
		Non-LC2	85.7%	66.7%
	Male	LC2	91.8%	85.4%
		Non-LC2	80.8%	76.9%
2000 Cohort	Female	LC2	92.4%	-
		Non-LC2	100%	-
	Male	LC2	93.7%	-
		Non-LC2	97.1%	-

Examining Tables A-3, A-6 and A-9 shows that communities positively impact the rate at which students complete their CBK courses and may apply for admission to a department. Comparing the percentage lines for LC2 and Non-LC2 shows that at each point in time after initial enrollment a higher percentage of students are prepared for admission for a department. Tables A-12, A-15 and A-18 show that the increase also hold true for comparisons by gender. The only place where the difference is reversed is for female students in the 2000 cohort and here the difference is small. Interestingly, the percentage of female students who are prepared for admission to a department is higher than the corresponding percentage of male students in both the LC2 and Non-LC2 categories. So it appears that learning communities also positive impact the rate at which students progress through their curricula.

Qualitative Data on Student Experiences in Learning Communities

A recent qualitative study of the experience of inclusive learning communities in five of the six member institutions of the Foundation Coalition[26] showed the value of this concept on several levels. The impact on student learning was especially dramatic. Students spoke at length about learning to work in teams, and they valued this experience highly in spite of difficulties they encountered in working together. They also talked about learning how they learn best, which for everyone was a discovery process, though most agreed that memorization was no longer sufficient and that application of concepts was essential. Especially significant was the extent to which they learned to use one another as resources. When they needed help learning difficult material, their typical pattern was to turn first to their team members or to other students in their cohort. If that didn't work, they would seek out a TA or tutor; the professor was usually approached last. Other students were effective teachers, they were readily available, and there was less risk—as one student said, "[You] are definitely more willing to ask a dumb question to someone your own age [rather] than to a professor" (p.29). They also spoke about the value of the learning itself: "Sometimes reading the book, it doesn't sink in. Asking your prof, it doesn't sink in. Sometimes just one of your peers explaining it to you and you get it, maybe because they're on your level" (p.29). The professors understood this and one summarized the situation well:

> The peer teacher probably was the most successful way of reaching the students, in my opinion. I hold office hours, but very rarely do students come. I don't fully know why; I don't think I'm an intimidating person. Maybe they see that since I'm a grade-giver that if they express their ignorance that I will remember and so they tend not to want to come to me for help. But they seem very willing to go to a student of their own age, even more so than a graduate student. So what Julie, the peer teacher, did was she would hold help sessions twice a week…typically for an hour or maybe an hour and a half. And students, maybe 20 or 30 students would come to the sessions out of 100….Judging from her comments and the students' comments, it seemed to be a very effective way to help students. (p.30)

The students described two different types of learning. First, they learn how to survive in college, and central to that is developing self-discipline and time-management skills. The second type of learning is conceptual, what several students called learning "to think like engineers." Two students describe what this means:

> Just thinking through things a lot different, different strategies and attacking problems from different angles. You know, looking at a problem from three or four different views before trying to jump at a solution. That's something big that's changed [for me].

> I would start by thinking about the problem, what it really is, understanding the whole problem, and then trying to think about possible ways to get to the solution. (p.37)

It is clear that thinking like an engineer involves understanding how things work, developing skills of critical analysis, and applying all this to solve problems in multiple ways.

The other major benefit of inclusive learning communities that this study found was the social support that students had from one another. They valued the cohort structure because it enabled them to make friends easily, and this provided the support they needed to make it through the program. As one student said, "Instead of just me against the world, it's like me and my twenty friends against the world! Together we stand, divided we fall" (p.41). By having two or three courses with the same group, they create for themselves a significant support group.

Despite the positive impacts of clustering, student teams, active/cooperative learning, and integration, the situation for women and minorities in this study, however, was less sanguine. While they too reported social benefits from being in a cohort, the women reported a significant amount of gender discrimination from male students. This was located primarily in the teams. Revuelto et. al.[27] describe this (p.45):

A frequent problem on the teams was the assumption that the women couldn't do the actual work and that they should write the report instead. A typical comment from the men on the team would be "We need the report done…Hey, go do the skirt work." The women we spoke to had no interest in filling this stereotypical role, but sometimes they were pressured into it. One woman told this story:

> Al and Steve did most of it. And I kept calling…and I would [say], "Steve, let me in on this, tell me when you're going down [to the lab]."…He's Mr. Perfectionist…if it's not done his way, then it's the wrong way….It wasn't like they were excluding me—they weren't purposely excluding me—but it was making me feel bad at the same time, where like they could be there and I couldn't get there in time, and granted as much as I tried to put into it, they were like "Well, since we did this, you can write the report." And by then you have to, because you haven't done anything else.

A common way many of the women coped with this discrimination was to continually prove themselves. One woman described this well:

> In the beginning I felt like you have to kind of prove yourself, because in my group, anything I said, the guys were like "That's not efficient," or "We're going to go with this idea." And I was just like, "What?" And then my professor would say something just like what I had said, and they would just dismiss it. But then after that first round of tests, when I kicked their butts, then they started listening to me. After that, everything was OK. But you kind of have to show them what you're made of. (p.45)

The downside of this strategy, however, is that the women students are less free to ask questions because doing so meant they risked being labeled "the dumb girl."

Faculty Experiences

In addition to the impact on students, faculty members are impacted by learning communities. In this section, engineering faculty members describe their experiences teaching in clustered classes. In addition, the qualitative research study[26] interviewed faculty members and synthesized a story of faculty members participating in learning communities.

Faculties participating in LC-based engineering courses recount several benefits of the programs. Active learning, teaming of instructors, student teaming and clustered courses were often cited as having marked benefits in freshman engineering classes. Active learning assignments greatly enhanced student-faculty, as well as student-student, interaction. Classroom activities allowed faculty members to move about the classroom interacting with small student teams or individual students. This enhanced student-faculty interaction created a substantially more nurturing environment than a standard lecture format would allow, especially in a class of nearly 100 students. In addition, the ability to interact with students one-on-one or in small teams increased participation and questions from quiet, shy students who might not speak out in front of the class as a whole.

Student-faculty interaction was further enhanced by use of teaching teams consisting of a problem solving faculty, a graphics faculty, a graduate teaching assistant, and an undergraduate peer teacher. With an instruction team of four in a class of 100, the student-instructor ratio was only 25:1. Use of instruction teams required coordination and communications not necessary in single instructor courses. However, the extra work required was not substantial and the overall benefits to the classroom environment were substantially more than the cost.

Finally, the use of student teams in the classroom and clustering of students in several classes enhanced the classroom environment in the freshman engineering course. Teaming and clustering provided a vehicle for community formation. Because of day-to-day contact these students had through their common course schedule or with teams in individual courses, they knew each other far better than they normally would have. Rather than getting to know 3 or 4 students in each of their classes, these students knew nearly 100 other students. Consequently, substantially greater student-student interaction occurred in all of the courses involved in the cluster.

The study by Revuelto et al. [26] also included faculty, and the reports of their experience are mixed. Faculty spoke about the collaboration involved in this curriculum, and the degree that faculty did this varied widely. It was more common early in the development phase and in smaller programs; in the more established and larger programs it was less in evidence. When faculty discussed the benefits they received from teaching in the program, however, they talked about enjoying working with other faculty, especially those from different disciplines. They found it intellectually stimulating, and they liked learning to teach using active and collaborative learning.

A major theme in this study, however, was the cost to faculty of working in this curriculum, especially at Research I institutions. One professor summed up the situation:

> If you put time into this, you're not getting rewarded like anywhere near the same as if you put the time into getting a research grant or writing a publication. It's one of the things you do because you think it's part of your job and you find it rewarding and you're willing to make the sacrifice. (p.53)

The concept of integration received the most negative comments, and one professor drew this conclusion:

> The curriculum integration we found very expensive. It's hard to get the faculty to spend the required amount of time to really intermix the subjects. It's a noble goal, and I still think that it's a good thing to do, but I don't think that most university professors really have the time or can be rewarded for doing curriculum integration right. And it's my belief that it's fallen by the wayside, just naturally. But, this serendipitous result, which is the cohort scheduling, I think it really surprised people when we discovered that the students in our classes had a much better *esprit de corps*, much better moral….I think [cohorting] is [the Foundation Coalition's] biggest contribution so far. (p.54)

Revuelto et al. [27] essentially agreed with this conclusion.

Conclusions

Development and implementation of learning communities in the Dwight Look College of Engineering at Texas A&M University has drawn on an enormous breadth of learning theory and practical pedagogical practice, including four years of a pilot curriculum initiated under the auspices of the Foundation Coalition. Many of the components of the learning communities theoretically should positive impact learning and learning experiences for students, especially women. Both quantitative data and qualitative data indicate positive impact on student retention, student progress, and student learning, both for all students who participate in learning communities and women engineering students. However, challenges in improving the learning environments for women students remain. The most crucial challenge is changing attitudes and behavior of male students toward women. For faculty members, the most pressing challenge is balancing potential benefits of tighter integration between classes with the costs, particularly time, associated with tighter integration. Hopefully, this paper has provided valuable information for others considering implementation of learning communities.

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Appendix

Table A-1. Comparison of Five Student Groups for FTFYS that Entered in Fall 1998

1998 Cohort		LC2 (N=321)	Non-LC2 (N=95)	LC1_interrupted (N=243)	Non-LC1_interuppted (N=128)	LC1 (N=121)
SAT Total	*Mean*	1247.6	1250.99	1214.68	1223.5	1262.76
	Median	1240	1240	1210	1220	1250
	Std. Dev.	108.62	129.8	109.38	111.16	102.38
	Range	680	640	600	520	520
SAT Verbal	*Mean*	588.23	588.9	581.42	587.15	603.71
	Median	590	590	580	590	590
	Std. Dev.	74.84	87.34	71.9	72.98	73.55
	Range	460	420	430	340	420
SAT Math	*Mean*	659.37	662.09	633.26	663.34	659.05
	Median	660	660	640	640	660
	Std. Dev.	56.35	61.2	59.47	57.68	55.51
	Range	340	300	320	300	280
High School Percentile	*Mean*	87.56	89.14	85.45	84.24	88.19
	Median	92	95	90	88	92
	Std. Dev.	12.58	12.01	12.62	14.71	11.62
	Range	60	50	64	77	67
Academic Performance						
CGPA Spring 99	*Mean*	2.816	2.882	2.216	2.175	2.822
	Median	2.852	2.852	2.229	2.222	2.826
	Std. Dev.	0.6	0.728	0.666	0.691	0.641
	Range	3.13	2.57	3.71	3.34	2.85
CBK GPR	*Mean*	2.871	2.946	2.185	2.074	2.857
	Median	2.875	3	2.3	2.2	2.8
	Std. Dev.	0.624	0.745	0.89	1	0.649
	Range	3.25	3.25	4	4	3.17
GPA in 2XX Courses	*Mean*	2.715	2.89	2.363	2.325	2.708
	Median	2.75	3	2.5	2.33	2.75
	Std. Dev.	0.741	0.843	0.832	0.938	0.814
	Range	4	3	3.5	4	4
GPA in 1XX Courses	*Mean*	2.822	2.854	2.233	2.288	2.808
	Median	3	3	2	2	3
	Std. Dev.	0.598	0.674	0.742	0.831	0.71
	Range	3	3	4	4	3.5
Number of Semesters for Progression to Sophomore Program	*Mean*	3.614	4.069	5.46	5.354	4
	Median	3	3	6	6	3
	Std. Dev.	1.2	1.77	1.8	1.37	1.46
	Range	8	8	8	4	8
CGPA At Progression	*Mean*	2.991	3.082	2.629	2.656	3.032
	Median	2.95	3.107	2.605	2.533	3
	Std. Dev.	0.49	0.6	0.42	0.44	0.5
	Range	2.23	2.41	2.2	2.03	2.63
Demography (Frequencies)						
Gender	*Male*	253	72	189	104	98
	Female	68	23	54	24	23
Ethnicity[1]	*Minority*	25	10	34	15	11
	Non Minority	296	82	207	109	104

[1] Data for ethnicity is obtained from optional self-report from students. In some cases, students did not provide the data. As a result the sum of the minority and non-minority rows may be less than N.

Table A-2. Retention for 1998 Cohort

First Year Retention

Comparison Groups		Not Retained	Retained	Total
LC2	N	30	291	321
	%	9.30	90.70	100
Non-LC2	N	15	80	95
	%	15.80	84.20	100
LC1_interrupted	N	143	100	243
	%	58.80	41.20	100
Non-LC1_interrupted	N	80	48	128
	%	62.50	37.50	100
LC1	N	15	106	121
	%	12.4	87.6	100
Total	N	283	625	908
	%	31.20	68.80	100

Second Year Retention

Comparison Groups		Not Retained	Retained	Total
LC2	N	46	275	321
	%	14.30	85.70	100
Non-LC2	N	25	70	95
	%	26.30	73.70	100
LC1_interrupted	N	154	89	243
	%	63.40	36.60	100
Non-LC1_interrupted	N	94	34	128
	%	73.40	26.60	100
LC1	N	25	96	121
	%	20.70	79.30	100
Total	N	344	564	908
	%	37.90	62.10	100

Table A-3. Time Until Progression to Upper Division for 1998 Cohort

Comparison Groups		1 Year	1.5 Years	2 Years	2.5 Years	Not Prog.
LC2 (N=321)	N	177	63	26	6	49
	%	55.14	19.63	8.10	1.87	15.26
Non-LC2 (N=95)	N	40	14	9	5	26
	%	42.11	14.74	9.47	5.26	27.37
LC1_interrupted (N=243)	N	7	26	21	16	173
	%	2.88	10.70	8.64	6.58	71.19
Non-LC1_interrupted (N=128)	N	2	10	10	9	97
	%	1.56	7.81	7.81	7.03	75.78
LC1 (N=121)	N	49	25	16	4	27
	%	40.50	20.66	13.22	3.31	22.31
Total (N=908)	N	275	138	82	40	373
	%	30.29	15.20	9.03	4.41	41.08

Table A-4: Comparison of Five Student Groups for FTFYS that Entered in Fall 1999

1999 Cohort		LC2 (N=326)	Non-LC2 (N=47)	LC1_interrupted (N=200)	Non-LC1_interrupted (N=54)	LC1 (N=98)
SAT Total	*Mean*	1242.53	1278	1219.51	1217.5	1258.26
	Median	1240	1290	1220	1220	1270
	Std. Dev.	101.87	132.64	129.19	133.65	114.49
	Range	620	650	720	570	600
SAT Verbal	*Mean*	584.46	604.22	584.22	574.04	599.46
	Median	580	600	590	565	600
	Std. Dev.	64.99	80.41	76.5	87.7	78.55
	Range	380	340	490	350	370
SAT Math	*Mean*	658.08	673.78	635.3	643.46	658.8
	Median	660	690	640	640	660
	Std. Dev.	59.22	68.07	68.49	62.59	62.32
	Range	330	310	390	280	340
High School Percentile	*Mean*	89.56	92.87	85.11	90.37	90.85
	Median	92.5	96	90	93	94
	Std. Dev.	10.65	8.29	13.9	9.96	9.46
	Range	90	35	73	49	47
Academic Performance						
CGPA Spring 00	*Mean*	2.904	2.969	2.154	2.297	2.842
	Median	2.963	3.115	2.2	2.49	2.853
	Std. Dev.	0.599	0.75	0.719	0.942	0.647
	Range	3.3	2.95	3.5	3.76	2.65
CBK GPR	*Mean*	2.945	2.983	2.107	2.185	2.875
	Median	3	3.1	2.33	2.4	2.9
	Std. Dev.	0.602	0.728	0.914	1.226	0.669
	Range	3.67	2.5	4	4	2.9
GPA in 2XX Courses	*Mean*	2.737	2.814	2.488	2.285	2.811
	Median	3	3	2.5	2.5	3
	Std. Dev.	0.822	1.026	0.691	1.728	0.8
	Range	4	4	2.5	4	3
GPA in 1XX Courses	*Mean*	2.923	2.902	2.279	2.087	2.842
	Median	3	3	2	2	3
	Std. Dev.	0.6	0.637	0.822	1.071	0.556
	Range	3	2.5	4	4	2.5
Number of Semesters for Progression	*Mean*	3.592	3.727	4.421	4.33	3.788
	Median	3	3	4	4	4
	Std. Dev.	0.932	1.039	1.368	1.447	1.013
	Range	4	4	6	5	4
CGPA At Progression	*Mean*	3.08	3.259	2.665	2.859	3.082
	Median	3.035	3.344	2.648	2.976	3.121
	Std. Dev.	0.457	0.575	0.518	0.473	0.523
	Range	1.94	2.11	2.12	1.81	2.19
Demography (Frequencies)						
Gender	*Male*	268	26	150	39	82
	Female	58	21	50	15	16
Ethnicity[2]	*Minority*	29	5	32	12	12
	Non-Minority	297	40	167	42	79

[2] Data for ethnicity is obtained from optional self-report from students. In some cases, students did not provide the data. As a result the sum of the minority and non-minority rows may be less than N.

Table A-5. Retention for 1999 Cohort

1st Year Retention FTF Within Dataset				
Comparison Groups		Not Retained	Retained	Total
LC2	N	23	303	326
	%	7.10	92.90	100
Non-LC2	N	8	39	47
	%	17.00	83.00	100
LC1_interrupted	N	133	67	200
	%	66.50	33.50	100
Non-LC1_interrupted	N	35	19	54
	%	64.80	35.20	100
LC1	N	10	88	98
	%	10.2	89.8	100
Total	N	209	516	725
	%	28.80	71.20	100

2nd Year Retention FTF Within Dataset				
Comparison Groups		Not Retained	Retained	Total
LC2	N	51	275	326
	%	15.60	84.40	100
Non-LC2	N	13	34	47
	%	27.70	72.30	100
LC1_interrupted	N	145	55	200
	%	72.50	27.50	100
Non-LC1_interrupted	N	37	17	54
	%	68.50	31.50	100
LC1	N	23	75	98
	%	23.50	76.50	100
Total	N	269	456	725
	%	37.10	62.90	100

Table A-6. Time Until Progression to Upper Division for 1999 Cohort

Comparison Groups		1 Year	1.5 Years	2 Years	Not Prog
LC2 (N=326)	N	149	76	28	73
	%	45.71	23.31	8.59	22.39
Non-LC2 (N=47)	N	17	11	5	14
	%	36.17	23.40	10.64	29.79
LC1_interrupted (N=200)	N	2	21	14	162
	%	1.00	10.50	7.00	81.00
Non-LC1_interrupted (N=54)	N	3	7	5	39
	%	5.56	12.96	9.26	72.22
LC1 (N=98)	N	32	29	10	27
	%	32.65	29.59	10.20	27.55
Total (N=725)	N	203	144	62	315
	%	28.00	19.86	8.55	43.45

Table A-7: Comparison of Five Student Groups for FTFYS that Entered in Fall 2000

2000 Cohort		LC2 (N=305)	Non-LC2 (N=47)	LC1_interrupted (N=194)	Non-LC1_interrupted (N=56)	LC1 (N=113)
SAT Total	*Mean*	1245.2	1300.48	1212.08	1242.04	1278
	Median	1255	1330	1220	1225	1290
	Std. Dev.	100.61	115.34	117.46	150.29	118.18
	Range	570	470	610	750	570
SAT Verbal	*Mean*	585.77	629.52	583.39	589.81	611.14
	Median	580	645	590	585	620
	Std. Dev.	66.39	76.79	77.11	95.63	79.96
	Range	400	340	410	420	380
SAT Math	*Mean*	659.43	670.95	628.69	652.22	666.86
	Median	660	675	630	650	670
	Std. Dev.	53.91	60.72	61.7	69.87	59
	Range	340	270	340	370	270
High School Percentile	*Mean*	90.6	95.86	87.03	86.41	90.78
	Median	93	97	91	91	92
	Std. Dev.	8.42	4.29	11.42	11.44	9.18
	Range	46	21	57	41	51
Academic Performance						
CGPA Spring 01	*Mean*	2.889	3.141	2.057	2.349	2.939
	Median	2.888	3.32	2.125	2.333	3.071
	Std. Dev.	0.608	0.669	0.749	0.906	0.708
	Range	3.036	2.334	3.68	3.77	2.96
CBK GPR	*Mean*	2.868	3.072	1.861	2.354	2.912
	Median	2.875	3.125	2	2.125	2.95
	Std. Dev.	0.655	0.72	0.927	1.005	0.723
	Range	3	2.6	4	3.67	2.83
GPA in 2XX Courses	*Mean*	-	-	-	-	4
	Median	-	-	-	-	4
	Std. Dev.	-	-	-	-	-
	Range	-	-	-	-	0
GPA in 1XX Courses	*Mean*	2.93	3.01	2.18	2.169	2.869
	Median	3	3	2	2	3
	Std. Dev.	0.587	0.645	0.892	0.89	0.677
	Range	2.5	2.5	4	4	2.5
Number of Semesters for Progression	*Mean*	2.896	2.954	3	3	2.786
	Median	3	3	3	3	3
	Std. Dev.	0.445	0.213	-	0	0.58
	Range	2	1	0	0	2
CGPA At Progression	*Mean*	3.146	3.377	2.597	4	3.232
	Median	3.148	3.548	2.24	4	3.192
	Std. Dev.	0.487	0.592	0.627	0	0.498
	Range	2.08	1.82	1.09	0	2.16
Demography (Frequencies)						
Gender	*Male*	239	34	136	41	85
	Female	66	13	58	15	28
Ethnicity[3]	*Minority*	48	3	41	8	11
	Non-Minority	256	43	193	45	94

[3] Data for ethnicity is obtained from optional self-report from students. In some cases, students did not provide the data. As a result the sum of the minority and non-minority rows may be less than N.

Table A-8. Retention for 2000 Cohort

1st Year Retention FTF Within Dataset				
Comparison Groups		Not Retained	Retained	Total
LC2	N	20	285	305
	%	6.60	93.40	100
Non-LC2	N	1	46	47
	%	2.10	97.90	100
LC1_interrupted	N	124	70	194
	%	63.90	36.10	100
Non-LC1_interrupted	N	29	27	56
	%	51.80	48.20	100
LC1	N	10	103	113
	%	8.8	91.2	100
Total	N	184	531	715
	%	25.70	74.30	100

Table A-9. Time Until Progression to Upper Division for 2000 Cohort

Upper Division Progression			
Comparison Groups		1 Year	Not Prog
LC2 (N=305)	N	154	151
	%	50.49	49.51
Non-LC2 (N=47)	N	22	25
	%	46.81	53.19
LC1_interrupted (N=194)	N	1	193
	%	0.52	99.48
Non-LC1_interrupted (N=56)	N	2	54
	%	3.57	96.43
LC1 (N=113)	N	61	52
	%	53.98	46.02
Total (N=715)	N	240	475
	%	33.57	66.43

Table A-10: Comparison of Five Student Groups by Gender for FTFYS that Entered in Fall 1998

1998 Cohort		LC2		Non-LC2		LC1_interrupted		Non-LC1_interrupted		LC1	
		Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
SAT Total	*Mean*	1245.7	1254.3	1254.2	1240.9	1220.4	1194.6	1229.3	1199.17	1268.3	1241.8
	Median	1240	1250	1240	1275	1210	1190	1220	1190	1250	1240
	Std. Dev.	108.93	108.07	130.69	129.43	104.18	124.84	106.77	127.28	105.71	87.7
	Range	680	510	640	450	560	560	520	370	520	390
SAT Verbal	*Mean*	582.92	607.81	593.91	573.18	583.15	575.38	587.17	587.08	605.3	597.73
	Median	580	605	590	575	580	570	600	570	590	610
	Std. Dev.	74.03	75.14	88.39	83.97	69.59	79.84	70.16	85.29	75.7	66.11
	Range	440	370	420	270	430	360	340	310	420	290
SAT Math	*Mean*	662.84	646.56	660.29	667.73	637.29	619.23	642.22	612.08	663.01	644.09
	Median	660	660	660	660	640	615	640	625	660	640
	Std. Dev.	54.93	60.06	59.78	66.61	60.12	55.44	54.2	66.07	53.3	62.23
	Range	340	280	300	280	320	240	270	260	270	280
High School Percentile	*Mean*	85.61	94.72	87.78	93.17	84.23	89.78	83.9	85.63	86.86	94
	Median	90	97	94	98	88	94	88	87	90	95
	Std. Dev.	13.19	6.04	12.69	8.76	13.16	9.35	15.31	12.11	12.33	4.58
	Range	60	32	50	30	64	40	77	47	67	19
Academic Performance											
CGPA Spring 99	*Mean*	2.845	2.919	2.824	3.065	2.151	2.535	2.179	2.15	2.776	3.016
	Median	2.852	2.932	2.839	2.897	2.203	2.345	2.207	2.222	2.818	2.897
	Std. Dev.	0.614	0.544	0.753	0.621	0.667	0.573	0.684	0.769	0.654	0.553
	Range	3.13	2.267	2.572	2.04	3.714	2.199	3.063	2.83	2.857	1.899
CBK GPR	*Mean*	2.881	2.836	2.902	3.063	2.089	2.941	2	2.455	2.849	2.884
	Median	2.875	2.8	3	3	2.3	2.6	2.2	2.312	2.837	2.625
	Std. Dev.	0.633	0.594	0.772	0.67	0.876	0.876	1.03	0.809	0.65	0.658
	Range	3.25	2.5	3.25	2.33	4	3.67	4	2.67	3.17	2
GPA in 2XX Courses	*Mean*	2.707	2.747	3.009	2.527	2.411	2.185	2.307	2.444	2.698	2.75
	Median	2.75	3	3	2	2.666	2	2.333	2.333	2.75	2.5
	Std. Dev.	0.762	0.664	0.735	1.06	0.878	0.642	0.998	0.509	0.839	0.73
	Range	4	3	3	3	3.5	1.5	4	1	4	2.5
GPA in 1XX Courses	*Mean*	2.816	2.845	2.814	2.978	2.188	2.384	2.263	2.391	2.762	3
	Median	3	3	3	3	2	2	2	2	3	3
	Std. Dev.	0.6	0.593	0.697	0.593	0.729	0.774	0.836	0.825	0.718	0.657
	Range	3	2.5	3	2	4	3	4	4	3.5	2
Number of Semesters for Progression	*Mean*	3.657	3.446	4.214	3.562	5.515	5.214	5.5	4	4.013	3.947
	Median	3	3	3	3	6	4	6	4	3	4
	Std. Dev.	1.198	1.234	1.855	1.412	1.772	2	1.374	0	1.551	1.078
	Range	8	8	8	6	8	6	4	0	8	3
CGPA At Progression	*Mean*	2.982	3.026	3.031	3.245	2.612	2.689	2.643	2.783	3.021	3.077
	Median	2.931	3	3.107	3.119	2.551	2.791	2.531	2.783	3.033	2.955
	Std. Dev.	0.492	0.482	0.61	0.548	0.416	0.444	0.453	0.457	0.498	0.518
	Range	2.23	2.21	2.41	1.64	1.99	1.88	2.03	0.91	*2.63*	1.92
Demography (Frequencies)											
Ethnicity[4]	*Minority*	18	7	8	2	25	9	8	7	10	1
	Non-Minority	235	61	61	21	162	45	92	17	83	21

[4] Data for ethnicity is obtained from optional self-report from students. In some cases, students did not provide the data. As a result the sum of the minority and non-minority rows may be less than N.

Table A-11 Retention by Gender for 1998 Cohort

Groups			1 Year	2 Year	Total N
LC2	*Male*	N	231	220	253
		%	91.3	87	100
	Female	N	60	55	68
		%	88.2	80.9	100
Non-LC2	*Male*	N	61	54	72
		%	84.7	75	100
	Female	N	19	16	23
		%	82.6	69.6	100
LC1_interrupted	*Male*	N	82	72	189
		%	43.4	38.1	100
	Female	N	18	17	54
		%	33.3	31.5	100
Non-LC1_interrupted	*Male*	N	41	30	104
		%	39.4	28.8	100
	Female	N	7	4	24
		%	29.2	16.7	100
LC1	*Male*	N	86	76	98
		%	87.8	77.6	100
	Female	N	20	20	23
		%	87	87	100

Table A-12 Time until Progression to Upper Division for 1998 Cohort

Groups			1 Year	1.5 Years	2 Years	2.5 Years
LC2	*Male*	N	137	53	21	6
		%	54.15	20.95	8.30	2.37
	Female	N	40	10	5	0
		%	58.82	14.71	7.35	0.00
Non-LC2	*Male*	N	29	12	7	4
		%	40.28	16.67	9.72	5.56
	Female	N	11	2	2	1
		%	47.83	8.70	8.70	4.35
LC1_interrupted	*Male*	N	5	20	19	15
		%	2.65	10.58	10.05	7.94
	Female	N	2	6	2	1
		%	3.70	11.11	3.70	1.85
Non-LC1_interrupted	*Male*	N	2	7	10	9
		%	1.92	6.73	9.62	8.65
	Female	N	0	3	0	0
		%	0.00	12.50	0.00	0.00
LC1	*Male*	N	41	18	12	4
		%	41.84	18.37	12.24	4.08
	Female	N	8	7	4	0
		%	34.78	30.43	17.39	0.00

Table A-13: Comparison of Five Student Groups by Gender for FTFYS that Entered in Fall 1999

1999 Cohort		LC2		Non-LC2		LC1_interrupted		Non-LC1_interrupted		LC1	
		Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
SAT Total	*Mean*	1246.5	1224.1	1277.3	1278.95	1230.2	1186.9	1213.16	1229.2	1258.0	1259.3
	Median	1240	1220	1285	1290	1230	1200	1215	1240	1270	1275
	Std. Dev.	98.54	115.03	126.79	143.79	123.93	140.35	136.09	131	117.78	100.76
	Range	600	560	550	560	720	630	570	440	600	360
SAT Verbal	*Mean*	585.27	580.71	596.15	615.26	586.83	576.3	570.79	582.86	595.26	619.38
	Median	580	585	590	600	590	575	560	585	600	610
	Std. Dev.	63.25	72.91	75.9	87.07	77.14	74.78	86.1	94.66	82.08	56.86
	Range	380	370	300	310	490	300	350	320	370	190
SAT Math	*Mean*	661.29	643.39	681.15	663.68	643.45	610.65	642.37	646.43	662.76	640
	Median	665	645	690	680	650	620	640	645	660	640
	Std. Dev.	57.66	64.42	66.89	70.18	63.1	78.36	65.65	55.55	63.09	56.57
	Range	310	300	290	290	370	360	280	160	340	200
High School Percentile	*Mean*	89.06	91.79	93.54	92	84.14	87.96	89.03	93.93	90.13	94.06
	Median	92	95	95	96.5	87	95	93	94.5	93	96
	Std. Dev.	10.93	9.04	6.69	10.13	12.93	16.24	10.99	5.37	9.74	7.51
	Range	90	36	30	35	67	73	49	20	47	31
Academic Performance											
CGPA Spring 99	*Mean*	2.897	2.935	2.984	2.951	2.125	2.272	2.249	2.471	2.814	2.985
	Median	2.963	2.98	3.02	3.217	2.217	2.169	2.437	2.52	2.827	2.912
	Std. Dev.	0.597	0.612	0.681	0.845	0.713	0.746	0.983	0.83	0.671	0.502
	Range	3.305	2.579	2.273	2.955	3.5	3.031	3.692	2.224	2.656	1.776
CBK GPR	*Mean*	2.937	2.984	3.097	2.858	2.009	2.375	1.846	2.863	2.855	2.961
	Median	3	3	3.1	3.1	2.2	2.464	2.291	2.733	2.9	3.125
	Std. Dev.	0.606	0.589	0.59	0.853	0.881	0.961	1.263	0.836	0.689	0.585
	Range	3.67	2.25	2	2.5	4	4	4	3	2.9	2.13
GPA in 2XX Courses	*Mean*	2.76	2.646	2.989	2.533	2.448	2.75	2.083	3.5	2.788	2.884
	Median	3	3	3	3	2.5	2.75	2.25	3.5	3	3
	Std. Dev.	0.81	0.873	1.084	0.908	0.73	0.353	1.8	-	0.843	0.674
	Range	4	4	4	2.5	2.5	0.5	4	0	3	2
GPA in 1XX Courses	*Mean*	2.931	2.887	2.94	2.857	2.187	2.569	1.937	2.428	2.822	2.937
	Median	3	3	3	3	2	3	2	2	3	3
	Std. Dev.	0.602	0.592	0.546	0.744	0.764	0.935	1.162	0.755	0.566	0.512
	Range	3	2	2	2.5	4	4	4	3	2.5	2
Number of Semesters for Progression	*Mean*	3.617	3.489	3.85	3.538	4.266	5	4.09	5	3.754	3.928
	Median	3	3	4	3	4	5	4	5	4	4
	Std. Dev.	0.936	0.915	1.04	1.05	1.412	1.069	1.513	1.154	1.057	0.828
	Range	4	4	3	4	6	2	5	2	4	3
CGPA At Progression	*Mean*	3.083	3.066	3.18	3.365	2.654	2.705	2.859	2.86	3.085	3.068
	Median	3.042	3.034	3.132	3.466	2.642	2.675	2.972	2.981	3.121	3.082
	Std. Dev.	0.438	0.535	0.576	0.576	0.532	0.495	0.523	0.29	0.536	0.482
	Range	1.94	1.88	2.11	2.07	2.12	1.27	1.81	0.54	*2.19*	1.81
Demography (Frequencies)											
Ethnicity[5]	*Minority*	19	10	0	5	16	16	9	3	10	2
	Non-Minority	249	48	25	15	133	34	30	12	65	14

[5] Data for ethnicity is obtained from optional self-report from students. In some cases, students did not provide the data. As a result the sum of the minority and non-minority rows may be less than N.

Table A-14 Retention by Gender for 1999 Cohort

Groups			1 Year	2 Year	Total N
LC2	*Male*	N	246	229	268
		%	91.8	85.4	100
	Female	N	57	46	58
		%	98.3	79.3	100
Non-LC2	*Male*	N	21	20	26
		%	80.8	76.9	100
	Female	N	18	14	21
		%	85.7	66.7	100
LC1_interrupted	*Male*	N	54	45	150
		%	36	30	100
	Female	N	13	10	50
		%	26	20	100
Non-LC1_interrupted	*Male*	N	15	13	39
		%	38.5	33.3	100
	Female	N	4	4	15
		%	26.7	26.7	100
LC1	*Male*	N	74	61	82
		%	90.2	74.4	100
	Female	N	14	14	16
		%	87.5	87.5	100

Table A-15 Time Until Progression to Upper Division for 1999 Cohort

Groups			1 Year	1.5 Years	2 Years
LC2	*Male*	N	116	65	23
		%	43.28	24.25	8.58
	Female	N	33	11	5
		%	56.90	18.97	8.62
Non-LC2	*Male*	N	9	8	3
		%	34.62	30.77	11.54
	Female	N	8	3	2
		%	38.10	14.29	9.52
LC1_interrupted	*Male*	N	2	17	10
		%	1.33	11.33	6.67
	Female	N	0	4	4
		%	0.00	8.00	8.00
Non-LC1_interrupted	*Male*	N	3	5	3
		%	7.69	12.82	7.69
	Female	N	0	2	2
		%	0.00	13.33	13.33
LC1	*Male*	N	28	21	8
		%	34.15	25.61	9.76
	Female	N	4	8	2
		%	25.00	50.00	12.50

Table A-16: Comparison of Five Student Groups by Gender for FTFYS that Entered in Fall 2000

2000 Cohort		LC2		Non-LC2		LC1_interrupted		Non-LC1_interrupted		LC1	
		Male	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
SAT Total	*Mean*	1245.3	1244.7	1302.0	1296.92	1218.1	1197.1	1251.0	1218.67	1275.8	1284.6
	Median	1260	1250	1330	1280	1225	1210	1250	1210	1290	1290
	Std. Dev.	98.85	107.56	96.89	153.37	114.29	124.77	150.85	151.42	117.77	121.5
	Range	570	520	370	440	600	580	750	560	570	490
SAT Verbal	*Mean*	583.62	593.54	632.76	622.31	583.92	582.08	597.44	570	607.22	623.08
	Median	580	590	660	610	590	580	600	560	610	630
	Std. Dev.	67.28	62.93	70.55	91.94	76.4	79.57	101.09	79.37	80.45	78.78
	Range	400	300	290	330	410	380	420	290	380	250
SAT Math	*Mean*	661.7	651.23	669.31	674.62	634.23	615.09	653.59	648.67	668.61	661.54
	Median	670	650	680	640	630	620	650	640	670	655
	Std. Dev.	50.84	63.58	56.56	71.49	60.69	62.62	65.75	82.02	56.95	65.77
	Range	270	340	230	220	320	310	340	290	270	270
High School Percentile	*Mean*	89.73	93.9	95.53	96.62	86.23	88.96	84.98	90.5	89.85	93.48
	Median	92	95	97	98	90	91	91	91.5	92	97
	Std. Dev.	8.7	6.33	4.34	4.23	12.31	8.75	12.17	8.06	9.47	7.89
	Range	46	39	21	13	57	34	41	31	51	30
Academic Performance											
CGPA Spring 99	*Mean*	2.874	2.946	3.069	3.329	1.998	2.217	2.289	2.677	2.912	3.02
	Median	2.857	3	3.25	3.612	2.074	2.23	2.296	2.536	3.037	3.078
	Std. Dev.	0.599	0.64	0.687	0.602	0.761	0.703	0.942	0.645	0.739	0.608
	Range	3.036	2.5	2.334	1.709	3.688	2.6	3.77	1.677	2.96	2.75
CBK GPR	*Mean*	2.853	2.922	2.982	3.315	1.766	2.118	2.281	2.506	2.871	3.034
	Median	2.875	2.887	3.062	3.416	2	2.333	2	2.309	2.854	3
	Std. Dev.	0.652	0.667	0.754	0.582	0.95	0.819	1.044	0.936	0.778	0.521
	Range	3	2.67	2.6	1.83	4	3.29	3.67	2.67	2.83	2.33
GPA in 2XX Courses	*Mean*	-	-	-	-	-	-	-	-	-	4
	Median	-	-	-	-	-	-	-	-	-	4
	Std. Dev.	-	-	-	-	-	-	-	-	-	-
	Range	-	-	-	-	-	-	-	-	-	0
GPA in 1XX Courses	*Mean*	2.923	2.953	2.969	3.115	2.173	2.197	2.109	2.333	2.868	2.87
	Median	3	3	3	3.5	2	2	2	2	3	3
	Std. Dev.	0.593	0.568	0.624	0.711	0.896	0.891	0.945	0.723	0.692	0.644
	Range	2.5	2	2	2.5	4	4	4	3	2.5	2.5
GPA Delta	*Mean*	-	-	-	-	-	-	-	-	-	1.5
	Median	-	-	-	-	-	-	-	-	-	1.5
	Std. Dev.	-	-	-	-	-	-	-	-	-	-
	Range	-	-	-	-	-	-	-	-	-	0
Number of Semesters for Progression	*Mean*	2.894	2.9	3	2.875	3	-	3	-	2.725	2.904
	Median	3	3	3	3	3	-	3	-	3	3
	Std. Dev.	0.448	0.441	0	0.353	-	-	0	-	0.64	0.436
	Range	2	2	0	1	0	-	0	-	2	2
CGPA At Progression	*Mean*	3.167	3.089	3.325	3.487	2.78	2.23	4	-	3.33	3.049
	Median	3.15	3.112	3.545	3.751	2.78	2.23	4	-	3.296	3.078
	Std. Dev.	0.457	0.563	0.615	0.561	0.764	-	0	-	0.469	0.51
	Range	2	2.08	1.82	1.23	1.08	0	0	-	*1.56*	2.01
Demography (Frequencies)											
Ethnicity[6]	*Minority*	41	7	3	0	28	13	4	4	9	2
	Non-Minority	197	59	30	13	107	45	34	11	69	25

[6] Data for ethnicity is obtained from optional self-report from students. In some cases, students did not provide the data. As a result the sum of the minority and non-minority rows may be less than N.

Table A-17 Retention by Gender for 2000 Cohort

Groups			1 Year	Total N
LC2	*Male*	N	224	239
		%	93.7	100
	Female	N	61	66
		%	92.4	100
Non-LC2	*Male*	N	33	34
		%	97.1	100
	Female	N	13	13
		%	100	100
LC1_interrupted	*Male*	N	51	136
		%	37.5	100
	Female	N	19	58
		%	32.8	100
Non-LC1_interrupted	*Male*	N	23	41
		%	56.1	100
	Female	N	4	15
		%	26.7	100
LC1	*Male*	N	77	85
		%	90.6	100
	Female	N	26	28
		%	92.9	100

Table A-18 Time Until Upper Division Progression for 2000 Cohort

Groups			1 Year
LC2	*Male*	N	114
		%	47.70
	Female	N	40
		%	60.61
Non-LC2	*Male*	N	14
		%	41.18
	Female	N	8
		%	61.54
LC1_interrupted	*Male*	N	1
		%	0.74
	Female	N	0
		%	0.00
Non-LC1_interrupted	*Male*	N	2
		%	4.88
	Female	N	0
		%	0.00
LC1	*Male*	N	40
		%	47.06
	Female	N	21
		%	75.00