2006-1143: THE INFLUENCE OF MATHEMATICS PREPARATION ON THE RETENTION AND ACADEMIC ACHIEVEMENT OF UNDERREPRESENTED ENGINEERING STUDENTS

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The Influence of Mathematics Preparation on the Retention and Academic Achievement of Underrepresented Engineering Students

Abstract

The Grove School of Engineering (SOE) at the City College of New York (CCNY) is an urban institution of higher learning. One of the School's missions is to provide education to a highly diverse student body, including traditionally underrepresented minorities, women, working adults, and immigrants in the greater New York metropolitan area. The admissions criteria of the School of Engineering are under continuous review and one of the purposes of this study is to provide data to support decisions about those criteria. We wish to determine what actually influences the success or failure of an engineering student. This will help the School to develop more effective tools to increase retention and academic achievement. This paper focuses on the impact of math preparation on academic achievement and retention among students in the cohort of fall 1999. Special attention is paid to transfer students and predictors of retention and academic achievement that are specific to transfer students, such as the number of transfer credits in subjects relevant to engineering, possession of an associate degree, and the nature of the transferring institution. The results show that the number of credits in math and science and previous GPA are the strongest predictors of retention and academic achievement among transfers in the School of Engineering.

1. Introduction

Like most engineering schools across the country, the Grove School of Engineering (SOE) at the City College of New York (CCNY) is engaged in the implementation of a process of continuous improvement in its engineering curriculum. As an urban commuting college, one of the School's missions is to provide education to a highly diverse student body, including traditionally underrepresented minorities, working adults, and immigrants in the metropolitan New York area. The breakdown of undergraduate ethnic groups from fall 1992-2001 at CCNY was: Black 29.6%, Hispanic 26.0% and Asian 13.5% and for fall 2001 women represented 20.1% of the college's engineering majors.

In the period under consideration in this paper, the School of Engineering offered six bachelor degrees, in civil engineering, chemical engineering, computer engineering, computer science, electrical engineering, and mechanical engineering. All six engineering programs require the mathematics sequence calculus I, II and III, differential equations and linear algebra, the first four with a grade of C or better. The prerequisite to enroll in all upper freshman and sophomore level engineering courses is at least calculus I with a grade of C or better. With the exception of computer science, completion of the first calculus based physics course with a grade of C or better is also required. This makes satisfactory completion of calculus I the deciding requirement for progress in any engineering program.

Freshmen admission to City University (CUNY) colleges is based on high school grades, combined SAT scores and New York State Regents courses. Transfers are admissible to the School of Engineering when they have completed a CUNY Community College degree, regardless of their GPA and any math credits they may have completed. This is CUNY policy. All others need a 2.5 GPA or higher and at least pre-calculus with a grade of C or better. As of fall of 2005, all transfer students to engineering need at least a GPA of 2.5 or better.

The level of math at which freshmen and transfers can start, is determined by an extra placement test for those intending to major in science or engineering, but if students have completed at least pre-calculus with a grade of C or better, or have taken math advanced placement (AP) exams with a grade of 4 or better, they can start at the next level of math. Depending on the results of the placement test, students can be placed in fundamentals of algebra (math 80), college algebra and trigonometry (math 190), pre-calculus (math 195), or calculus I (math 201). Students who do not satisfy the admissions criteria are placed in the School of Liberal Arts and Science (or were coded as ‘undecided engineering’ in the past), until they fulfill the admissions criteria.

2. Research Questions

The admissions criteria of the School of Engineering are under continuous review and one of the purposes of this study is to provide data to support “decision making” about admissions criteria. For this we need more information about the entry characteristics of our engineering students and the extent to which entry characteristics, especially math preparation, predict retention and academic achievement.

The general question can be subdivided into four questions:

1. What are the entry characteristics of engineering students at City College?
2. At what level of math do engineering freshmen and transfers start in City College?
3. How do transfer students compare to freshmen on academic achievement and retention, given a certain math starting level?
4. What is the relative influence of math starting level and other student entry characteristics on academic achievement and retention?

3. Theoretical Context

This section describes theoretical considerations about retention (also called persistence), in particular Tinto's model [1, 2, 3] and findings from empirical research on transfer students and engineering students. It provides a context for the interpretation and discussion of our findings.

3a. Tinto's model of persistence

A well-known model of persistence (retention, or its counterpart, attrition) is that of Tinto. His model hypothesizes that the initial decision to commit to a program in a particular institution of higher education is influenced by a student's family background, skills, abilities, and prior schooling. The initial goals and commitments are directly and indirectly influenced by the interaction with the institutional environment, leading to the decision to continue the program or do something else instead, (e.g., transfer to another program and/or institution, or withdraw temporarily or permanently from higher education). Sometimes students are forced to leave their program of choice because of academic failure and then they may either transfer to a less demanding program, (e.g., from a 4-year to a 2-year program, or drop out of higher education altogether). A recent version of Tinto's model [4] adds external commitments that influence both the initial goals and commitments of a student (e.g., the opportunity to receive financial aid), and the decision to continue or not (e.g., job responsibilities that interfere too much with class attendance). The inclusion of external commitments as possible predictors of persistence is particularly important for transfer students and adult students in general, since this category often has job and family responsibilities. External commitments can be incentives to seek a degree in higher education (e.g., better career opportunities and higher salary to provide for dependents), but they can also form impediments (e.g., scheduling conflicts, lack of time for studying). The institutional interactions in Tinto's model encompass students' academic achievements and learning experiences and their interactions with faculty and peers, which in turn determine the extent to which they experience academic and social integration. This sense of belonging and the perceived and actual quality of learning, together with any external commitments, lead to a revision of the initial goals and commitments, and to the decision to stay or leave. This decision making process is a continuous process, because student characteristics and institutional and external environments can and do change over time.

3.b Transfer students

In general, about 23 percent of students nationwide leave their initial program voluntarily [5]. Including academic dismissal, nationwide attrition from higher education has been consistently around 50 percent for several decades [6, 7]. Of all students in the United Stated who began their postsecondary education in the academic year 1995-96, 32 percent had transferred once or more to another institution as of 2001 [8]. For public 4-year institutions this figure is 27 percent. From the figures of Peter et al., it could also be derived that of the transfer students entering an institution of higher education with one previous school, 24 percent will transfer out again. Of those entering an institution of higher education with two previous schools, 9 percent will transfer out again. Peter et al. mention a number of reasons to transfer, such as academic difficulties, the perception that the other institution is a better match, dissatisfaction with the first institution, economic reasons, better scheduling opportunities elsewhere, and moving to another part of the country. As 'persistence risk factors' associated with attending two or more institutions, Peter and et al. mention a set of interrelated factors, such as parenthood, full-time work in the first year of enrollment, financial independence from caregivers (i.e., student has to provide for his/her higher education financially), delaying enrollment between high school and college, and a GPA of 2.25 and lower.

3.c Engineering students

In a study of retention among engineering students in the cohorts 1987 through 2000 in eight colleges of engineering, the cohorts 1987 through 1994 were found to have graduation rates as of 1998 varying from 25 percent to 54 percent, depending on institution [9]. Only matriculated students were included in the calculation of graduation rates. No distinction was made between first-time freshmen and transfer students. Retention was defined as either having graduated or still being in an engineering program as of the last year of the study, for cohorts 1987-1998 (or 1999 or 2000 for some schools). Retention rates varied from 37 percent to 65 percent. Zhang et al. measured the dependence of graduation and retention on six independent variables: ethnicity, gender, high school GPA, SAT math score, SAT verbal score, and citizenship status. Using logistic regression, they found that graduation in all schools was positively correlated with high school GPA and math SAT scores, and sometimes, but not consistently, with gender, ethnicity, and citizenship. Retention was significantly correlated with all six predictors under consideration, but only consistently positively with high school GPA and SAT math scores. In one institution, nonresident aliens (international students) did better than resident aliens, and in another, citizens did better than nonresident aliens. Being a woman or Black sometimes was positively correlated with retention, and sometimes negatively, depending on the institution.

A study among Black engineering students with an instrument using person-environment interaction theory found wide variations in graduation rates among institutions [10]. Higher graduation rates were consistently associated with lower perceptions of racism and discrimination and with higher institutional commitment. Not statistically significantly related to graduation rates were perceptions of classroom experiences, faculty and staff interactions, student support services, peer interaction, student effort, and goal commitment. This study did not include academic achievement such as grades and GPA, and did not distinguish between freshmen and transfers. According to a survey performed by MathSoft among 4700 professors, faculty in engineering and related fields attribute attrition in the first place to difficulty in mastering math (43%), followed by poor study habits and social distractions (34%) [11]. Factors mentioned less often are difficulty in mastering subjects other than math (10%), and personal choice (8%).

4. Method

This section describes the groups of students we studied, the variables under consideration, the data sources, and the analyses we applied.

4a. The students

We studied the entire cohort of engineering students that started in the fall of 1999 (including those who started in the summer of 1999). We oversampled transfers to allow comparison between subgroups, e.g., transfers from 2-year, 4-year, and foreign institutions. We used the SPSS sampling procedure for random sampling (SPSS: Statistical Package for the Social Sciences).

After identifying the cohort and drawing the samples, the information for each student was checked for accuracy and corrected, if necessary. After corrections, there were 194 (58%) freshmen and 142 (42%) transfers in the cohort of fall 1999. A number of initial transfers actually turned out to be freshmen, or second degree students. At present we do not consider second degree students, but we may do so in further studies. Some initial freshmen were actually transfers. Section 4c., about data sources, provides more information about the type of corrections that were necessary.

Included in the cohort of fall 1999 are the students who *intended* to be in engineering at any time during their stay at City College, based on their major code, and/or the courses they had taken, and/or their intended major in applying to CCNY. This does not mean that all students were ready to start in an engineering program upon admission to CCNY. We define as 'engineering students' those students who can enter into an engineering program without having to take extracurricular preliminary math courses first, i.e. students who can start in calculus I in their first semester. Students who intended to go into engineering, but who tested into preliminary math courses are called 'prospective engineering students'.

4b. Entry characteristics and outcome variables

The entry characteristics that we considered possibly relevant to academic achievement and retention in the School of Engineering are:

1. Freshman or Transfer status.
2. SEEK status (SEEK = Search for Elevation, Education and Knowledge, a program for economically and academically disadvantaged students).
3. For transfers, number of previous schools, associate degree, transferring from a 2-year, 4-year, or foreign institution.
4. Level of placement in mathematics (math starting level). This is a variable with values 1 for the lowest level of math (fundamentals of algebra), to 5 for the highest level, calculus II and higher.
5. Number of transfer credits in the engineering mathematics sequence, physics, other sciences, engineering courses and English and liberal arts. The credits had to be transferable toward the intended major. Credits outside of the major were not counted.
6. Cumulative GPA in previous school(s) (previous GPA).
7. Age.
8. Gender.
9. Ethnicity. White, Black, Hispanic, or Asian. There were no American Indians and Pacific Islanders among the engineering students we studied, and only one Puerto Rican, whom we classified under 'Hispanic'. Many students did not provide their ethnicity.

The outcome variables under consideration are:

1. Most recent cumulative GPA at CCNY as of the spring of 2005, either at graduation, at leaving CCNY, or after finishing the fall 2004 semester. Grades are measured on a scale of 0 = failing (F), 1 = poor (D), 2 = satisfactory (C), 3 = good (B), to 4 = excellent (A).
2. Study progress, defined as the number of credits completed per semester.
3. Retention, a two-valued variable, defined as: Graduated from the School of Engineering or still in the School of Engineering as of the spring of 2005, vs. having left the School of Engineering.

4c. Data sources

The main data sources we used were:

1. The Student Information Management System (SIMS) at the City College of New York. SIMS contains students' transcripts at CCNY, including information about GPA, transferred courses, high school grades, testing results, intended major, and person characteristics such as gender, age, ethnicity, etc.
2. The University Application Processing Center (UAPC) web site. UAPC contains documents such as students' application forms to CUNY schools, transcripts and diploma's from previous colleges and high school, and transfer credit evaluations.

Our primary data source was SIMS. Occasionally, the information in SIMS was not complete or appeared to be incorrect. For example, for some transfer students there were no transfer information in SIMS available, i.e., neither transferring institution nor transfer credit evaluation. UAPC could often provide this information, but sometimes the information simply had to be coded as 'missing'. This was most often the case for students who had left CCNY and the School of Engineering before their transfer credit evaluation was completed. Finally, analyses were conducted with SPSS. We used descriptive statistics, discriminant analysis (to predict retention) and multiple regression (to predict GPA and study progress).

5. Results

This section presents the results for the cohort of fall 1999 for both transfers and freshmen, such as, descriptives and predictions of retention, GPA, and study progress as of the semester of spring 2005.

5a. Demographics and transferring schools

Table 1-a shows the distribution of entry characteristics shared by freshmen and transfers.
Eighty percent of the students in engineering is female, and there is no significant difference between transfers and freshmen in gender composition. Engineering students are as diverse as City College students in general, with about equal percentages of Black (32%), Hispanic (29%) and Asian (28%) students and a lower percentage of White (12%) students. Freshmen have a somewhat lower proportion of White students and a somewhat higher proportion of Asian students than transfers.

Computer science students dominate among the engineering majors, with half of all freshmen and 37 percent of all transfers. The second largest program is electrical engineering, with 21 percent of all engineering students. The rest of the students can be found in civil engineering (10%), chemical engineering (8%), computer engineering (4%), and mechanical engineering (15%). Transfers appear a bit more drawn toward the smaller programs and freshmen to the large program of computer science.

Transfers are on average five years older than freshmen, which implies that they may have more competing responsibilities than freshmen, such as being married, having children, and/or part- or full-time jobs (Peter et al., 2005). On the other hand, they may be more mature than first time freshmen, more certain of what they want, and better time managers. Freshmen may have more time to spend on their studies, more options for financial support, and more opportunities to engage in 'student life' and interaction with faculty outside of class, which is hypothesized to contribute to retention (Tinto, 1997, 2003; Brown et al., 2005).

Table 1-b provides information about previous GPA of transfer students, transferable credits toward the chosen engineering major, and the previous schools attended. CUNY 2-year colleges are the main providers of transfers to the School of Engineering, providing 43 percent of all transfer students. The second largest group of transfers comes from foreign institutions (22%), most often from engineering programs that prepare for the equivalent of a bachelor or master degree. Non-CUNY American 4-year colleges form the next largest group, with 17 percent of the transfers, followed by CUNY 4-year colleges (11%). Finally, American non-CUNY 2-yr colleges provide about 7 percent of engineering transfers. Some students attended more than one school before transferring to the School of Engineering, and we defined their main transfer institution as the school in which they obtained most credits. Nineteen percent of transfer students visited two or more colleges before coming to the School of Engineering. Of the students who transferred from a 2-year college, 51 percent obtained an associate degree, compared to 61 percent in the cross-sectional sample. Credits are transferable if a course is at least equivalent in topics and academic level, and the student passed the course with a minimum grade of C. Transfer students have on average 7.0 transferable math credits, 3.5 physics credits, 4.8 credits in science courses other than physics, 4.7 credits in engineering discipline specific courses (professional courses), 1.1 credits in general engineering courses, and 10.1 credits in English and liberal arts courses. The standard deviation is large, which means there is a large variation among transfers in the number of transfer credits they received.

5b. The entry level of math for transfers and freshmen

The lower part of table 1-a shows the percentages of (prospective) engineering students by level of math placement. The difference between freshmen and transfers is large and significant. Only 41 percent of the freshmen can start in calculus I or higher, vs. 84 percent of the transfers (_^{2} = 62.9, *df* = 1, $p < .0005$). When we consider the separate math courses and the percentages of freshmen and transfers starting in those courses, the differences become even more pronounced (_^{2} =138.6, *df* = 4, $p < .0005$). As much as 39 percent of freshmen have to start at the two lowest levels, fundamentals of algebra and college algebra, which precludes them from taking any science or engineering courses in the engineering programs. Ten percent of transfer students have to start at the two lowest levels. This group of students is advised to take summer workshops and courses administered by the Office of Freshmen Year Programs, to catch up with their math and to prepare them for higher level courses. Forty percent of this group eventually passes calculus I and is able to continue in engineering. Students who can start in precalculus can take at least some science (college chemistry I) and the introductory 1-credit course engineering design I, and they lose less time, especially if they take one or more math courses in the summer. Two thirds of the transfers could start at calculus II or higher, whereas only 7 percent of freshmen took the AP- or A- level exams that would have enabled them to do so.
All in all, transfer students as a group are significantly better prepared in math than freshmen.

5c. Retention and academic achievement among freshmen and transfers

Table 2 shows retention and academic achievement among all transfers and freshmen in the cohort of fall 1999, and among those who could start in calculus I in their first semester. Of all (prospective) engineering students, 54 percent of freshmen and 47 percent of transfers had left City College in the spring of 2005 or earlier. Fourteen percent of freshmen and 9 percent of transfers were still in the School of Engineering in the spring of 2005 and a cursory glance at their transcripts indicated that most of them were likely to graduate in the near future. A small number were in danger of dismissal, even after almost six years in the School of Engineering.
Of the freshmen, 24 percent were graduated from SOE, vs. 37 percent of the transfers. The higher graduation rate among transfers can in part be attributed to the transfer credits they bring toward the degree. Eight percent of freshmen and 7 percent of transfers continued in other majors at CCNY, and most of them appear to be able to graduate in their second major.

When we narrow retention to the School of Engineering, 61 percent of freshmen and 54 percent of transfers have left the School of Engineering by the spring of 2005, and the rest was either graduated by that time, or still in the School of Engineering. Narrowing further to the students who are ready to take calculus I or higher at entry, retention improves considerably. Of the freshmen 48 percent had left the School of Engineering, of the transfers 50 percent. For transfers the difference in retention between those who can start in calculus I and those who cannot is small, because the majority of transfers could start in calculus I or higher to begin with. The findings for 'calculus-ready' students reflect the national average [4], and they are in the middle of the range of retention rates for engineering students reported earlier [9].

Academic achievement and study progress (credits obtained per semester) show the same pattern as retention. They are lower for the whole group of (prospective) engineering freshmen and transfers and higher for those who could start in calculus I or higher, especially among freshmen. Freshmen starting in calculus I or higher had obtained a cumulative GPA of 2.73 in their last semester and had an average study progress of 11.9 credits per semester. Transfers had a lower cumulative GPA (2.45 on average) and lower study progress (9.7 credits per semester) than freshmen.

The results show that, although retention among 'calculus-ready' transfers is the same as among 'calculus-ready' freshmen, they have a somewhat lower GPA and study progress, which could play into a perception among some engineering faculty that their math background might not be as good as that of freshmen. We think other explanations might be more valid, e.g., transfers have to balance study, family, and job more often than freshmen, and the lower GPA and study progress may reflect a tradeoff between competing responsibilities. Also, transfers might leave the School of Engineering for different reasons than freshmen (e.g., less because of a lack of math abilities, and more because of a lack of time and/or money).

5d. *Predictors of academic achievement and retention*

To predict retention and academic achievement from the entry characteristics of (prospective) engineering students, we first determined the association between predictors and outcomes. Only potential predictors that show a significant ($p < .01$) and relevant ($\geq .20$) association with a particular outcome were entered into a discriminant analysis of retention, or a regression analysis of GPA and study progress, to prevent performing analyses with a large number of variables on a small number of cases. As a measure of association with retention, we used the (canonical) correlation associated with Wilk's Lambda in discriminant analyses with the entry characteristic as independent and retention as the grouping variable with values 0 (left SOE) and 1 (still in, or graduated from SOE). As measures of association with GPA and study progress (credits completed per semester) we used ANOVA's Eta for nominal predictors (e.g., gender, possession of an associate degree) and Pearson's *r* for predictors measured on a scale (e.g., age, previous GPA). Table 3 shows an overview of retention, GPA and study progress by entry characteristic. We identified five significant and relevant predictors for freshmen, and ten such predictors for transfers.

For freshmen, the five predictors are:

1. Math entry level, a variable with five values from 1, fundamentals of algebra, to 5, calculus II (there were no freshmen that could enter in calculus III or higher).
2. Gender.
3. Majoring in computer science (yes/no).
4. Majoring in electrical engineering (yes/no).
5. Majoring in chemical engineering (yes/no).

For transfers, the ten predictors are:

1. Number of math credits transferred.
2. Number of physics credits transferred.
3. Number of science credits (except physics) transferred.
4. Number of professional engineering credits transferred.
5. Number of general engineering credits transferred.
6. Majoring in computer science.
7. Majoring in electrical engineering.
8. Transferring from a foreign college.
9. Transferring from an American 4-year college.
10. Previous cumulative GPA from transferring school(s).

The number of predictors for transfers could be reduced further by adding the numbers of transferred math, physics and science credits, because these were highly correlated among each other and actually formed a scale 'MPS credits', with reliability Cronbach's _ = .78 (including the numbers of transfer credits in the other subjects reduced Cronbach's _). The number of general engineering credits was not included in further analyses, because there were only few students that received a small number of transfer credits for general engineering courses. The variables 'Majoring in computer science' and 'Majoring in electrical engineering', that have an opposite effect on retention (CSc negative in regard to non-CSc majors, and EE positive in regard to non-EE majors), were translated into one variable 'Major' with values 0 for CSc, 2 for EE, and 1 for the rest of the majors.

This leaves six possibly relevant predictors for transfers:

1. Number of math, physics and science Credits (MPS Credits).
2. Major
3. Number of professional engineering credits.
4. Transferring from a foreign college.
5. Transferring from a 4-year American college.
6. Previous cumulative GPA.

Table 4 shows the results of the stepwise discriminant analysis with retention as the grouping variable, and MPS credits, professional credits, previous GPA, major, USA 4-year college, and foreign college as predictors. The entry characteristics that best predict retention among transfers are MPS credits, previous GPA, and major. They are all positively associated with retention. The canonical correlation of the three predictors with retention is .51, with an eigenvalue of .35.

Table 5 shows the prediction of GPA and study progress for transfers by the same set of predictors. In a stepwise regression on GPA, the same three predictors remain as for retention, with the addition of transferring from a foreign college. Transferring from a foreign college is positively associated with the GPA obtained at City College. The four predictors together have a canonical correlation R = .63 with GPA, explaining 36 percent of the variance in GPA. Study progress is predicted by previous GPA, MPS credits, and transferring from a foreign college. Major plays no significant role anymore. R = .55, explaining 29 percent of the variance in study progress.

For freshmen, math entry level, major and being a woman best predict retention at the School of Engineering at City College. The canonical correlation with retention is .38, with an eigenvalue of .16. GPA is predicted by math entry level, being a woman and majoring in chemical engineering (R = .42, with an explained variance of .18). Study progress for freshmen was best predicted by math entry level and majoring in chemical engineering (R = .49, with an explained variance of .24). All predictors have a positive association with the criterion.

6. Conclusions and discussion

We used Tinto's model as a framework to identify possibly relevant predictors of retention, in particular those related to academic integration, and to keep in mind possibly relevant predictors that we do not address in this paper (e.g., those related to social integration and external factors).

Answering our research questions we can conclude that transfer students form about 40 percent of the student population of the School of Engineering. They are older, and therefore can be expected to experience other pressures and other needs than freshmen. Transfers come to City College better prepared in math than freshmen, and math preparation is the strongest predictor of retention for both transfers and freshmen. Within the same entry level of math (precalculus or lower vs. calculus I or higher), freshmen and transfers have the same retention rate, but transfers perform somewhat less than freshmen in GPA and have a lower study progress.

Predicting long-term retention and academic achievement from entry characteristics is relevant for policies regarding admission of students. When students have already entered the institution, more obvious predictors would be academic achievements and other student behavior while in the program. Program and institutional characteristics (e.g., the ones proposed by Tinto's model of persistence) would also come into play.

For an engineering program, an obvious admissions criterion would be a student's math placement results for freshmen, and previous achievements in mathematics (or math and science) for transfers, and our results indicate this to be an appropriate approach. This leaves open the question of what to do with students who do not (yet) meet the admissions criteria. After all, among the students starting at the lowest level of math, ten to fifteen percent eventually graduate in engineering. At present, this group is offered intensive pre-semester workshops to catch up in math. Whereas prospective engineering freshmen often have to leave engineering because of problems with math, the majority of transfers are well prepared in math upon entry of the School of Engineering. Transfers who can start in calculus 1 or higher, do as well in retention, but no better, than freshmen who can start in calculus I, and they have lower GPA's and complete less credits per semester than freshmen. Since transfers are more mature and therefore expected to be more focused and organized than freshmen, with more proven ability in math and science, one might expect that they would have higher retention rates and better academic achievements than freshmen. Anecdotal evidence from our contacts with transfers indicates that they often struggle with competing responsibilities that force them to make pragmatic choices between 'getting by' in their studies and fulfill their other commitments, or not study at all. It is not uncommon to encounter older students who with great determination take one or two courses each semester until they can graduate after eight to ten years or so, with a cumulative GPA close to 2.0. This does of course affect the average number of credits per semester and cumulative GPA for transfers.

Another topic of discussion is the question with respect to what group of students to define retention and graduation rates. The group that can start in calculus I, or both prospective and calculus-ready engineering students? We are inclined to think that retention and graduation rates should be calculated with respect to calculus-ready students.

In further research on predictors of retention and academic achievement we plan to include not only the previous GPA of transfers, but also the grades they obtained in the math and science courses they transferred. We also plan to analyze retention and academic achievement after one semester, one year, two years, etc. This would help us to identify 'at risk' students in each phase of the program.
Additional research into the personal and institutional variables that affect retention and academic achievement of students in general and transfers in particular would also be very useful. Data about a host of institutional variables are already being collected every semester since fall of 2001, as part of the School's ABET accreditation efforts, and they can provide aggregates on the program level of student satisfaction with learning, instruction, and student-faculty interaction, to name a few.

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TABLES

Characteristic	Freshmen (% of n=194)	Transfers (% of n=142)
Female	18	22
SEEK Student	20	3
Ethnicity [b]		
White, Non-Hispanic	6	17
Black, Non-Hispanic	34	30
Hispanic	28	29
Asian	32	24
Major [b]		
Civil Engineering	8	11
Chemical Engineering	4	11
Computer Engineering	3	4
Computer Science	50	37
Electrical Engineering	21	23
Mechanical Engineering	15	15
Age at Entry of CCNY (yrs) [a]	19.5	24.7
Math Entry Level [a]		
1=Fundamentals of Algebra	13	4
2=College Algebra	24	6
3=Pre-Calculus	23	7
4=Calculus I	34	17
5=Calculus II and higher	7	67
Start in Calc I or higher [a]	41	84

[a] Percentages or means for freshmen and transfers significantly different at $p < .0005$.
[b] Percentages for freshmen and transfers significantly different at $p < .05$.

Table 1-a. Entry Characteristics of Freshmen and Transfers in the Grove School of Engineering in the Fall of 1999

Characteristic	Average (n=142)	Standard Deviation
Previous GPA	2.88	0.68
Number of credits transferable to chosen engineering program		
Mathematics	7.0	5.8
Physics	3.5	3.8
Science, excl. physics	4.8	5.4
Professional	4.7	7.9
General Engineering	1.1	2.2
English and Liberal Arts	10.1	6.9
Math+Physics+Science	15.4	12.7
Main transferring institution		Percentage of n=142
CUNY 2-yr college		43
USA 2-yr college		7
CUNY 4-yr college		11
USA 4-yr college		17
Foreign college		22
Number of previous schools		
One		81
Two		13
Three		5
Four or more		1
Associate Degree [a]		25 (51)

[a] Percentages in parentheses based on subgroup mainly transfering from a 2-yr college.

Table 1-b. Entry Characteristics of Transfer Students in the Grove School of Engineering in the Fall of 1999

	All Students		Students starting at Calc I	
	Freshmen	Transfers	Freshmen	Transfers
Retention (percentages)				
Left City College (CCNY)	54	47	42	43
In School of Engineering (SOE)	14	9	5	8
Graduated from SOE	24	37	46	43
Other major in CCNY	4	1	3	2
Graduated from CCNY (not SOE)	4	6	5	5
Left School of Engineering	61	54	48	50
In or Graduated from SOE	39	47	52	50
Academic Achievement (averages)				
GPA at City College	2.41	2.39	2.73	2.45
GPA in Professional Courses	2.72	2.42	2.81	2.43
Credits per semester at CCNY	10.06	9.37	11.88	9.73

Table 2. Retention and Academic Achievement of CCNY School of Engineering Cohort Fall 1999 in Spring 2005.

	Retention		GPA at CCNY		Credits/Semester	
Predictor	Fresh	Trans	Fresh	Tran	Fresh	Trans
Start at Calc I	23**	18*	33****	14*	38****	18*
Math Entry Level (1)	24**	18*	40****	26*	47****	26*
Math transfer credits		30****		24**		23**
Physics transfer cred.		28***		25**		21*
Sci. transf. cred. (2)		26**		21*		19*
Prof. transfer credits		21*		10		7
Engr. transfer credits		28***		10		9
Engl,+Lib Arts cred.		10		5		8
MPS credits (3)		33****		36****		35****
Previous GPA		25**		36****		35****
Age	2	7	5	1	10	15
Female	22**	1	13	10	10	1
White, Non-Hispanic	11	16	11	11	6	6
Black, Non-Hispanic	16*	2	4	13	2	10
Hispanic	9	13	16*	3	17*	5
Asian	2	1	5	2	12	13
SEEK	6		7		12	
Civil Engr.	1	3	7	10	8	12
Chemical Engr.	7	3	20*	2	23***	5
Computer Engr.	16*	5	5	4	5	3
Computer Sci.	23***	39****	13	22**	10	15
Electrical Engr.	20**	24**	17*	33****	11	24**
Mechanical Engr.	1	5	7	3	6	3
CUNY 2-yr college		12		10		11
CUNY 4-yr college		2		14		18*
USA 2-yr college		5		5		3
USA 4-yr college		11		25**		22*
Foreign College		21*		25**		20*
Number prev. schls.		12		3		11
Associate Degree		4		3		11

Note. Retention: Correlation associated with Wilk's Lambda (x 100) for each predictor separately in a discriminant analysis. GPA and Credits/semester: ANOVA's Eta x 100 for two-valued predictors and Pearson's r x 100 for predictors measured on a scale. * $p < .05$. ** $p < .01$. *** $p < .001$. **** $p < .0005$.
(1) Math Entry has 5 levels: 1=fund. of algebra, 2=college algebra, 3=precalculus, 4=calculus I, 5=calculus II and higher.
(2) Sum of all transferred science credits toward the curriculum excluding physics credits. (3) Sum of all transferred math, physics and science credits toward the curriculum.

Table 3. Associations (abs. values) between Predictors and Outcomes of Retention and Academic Achievement

Step	Predictors in Discriminant Function	Wilk's Lambda x 100	Standardized Canonical Discriminant Function Coefficients x 100
		Transfers	
1	MPS Credits	87	70
2	Previous GPA	78	65
3	Major	74	69
		Freshmen	
1	Major	94	50
2	Math Entry Level	90	63
3	Female	86	56

Note. Canonical correlations are .51 (eigenvalue .35) for transfers and .38 (eigenvalue .16) for freshmen.

Table 4. Summary of Discriminant Analysis for Entry Characteristics Predicting Retention in Cohort Fall 1999

	GPA			Credits per Semester		
Predictor	*B*	*SE B*	beta	*B*	*SE B*	beta
			Transfers			
1. Previous GPA	.61	.11	.41****	2.94	.55	.41****
2. Major	.31	.09	.25***			
3. MPS Credits	.02	.01	.23**	0.11	.03	.29****
4. Foreign College	.44	.17	.20**	1.93	.87	.17*
			Freshmen			
1. Math Entry Level	.26	.05	.40****	1.49	0.22	.44****
2. Female	.29	.14	.14*			
3. Chemical Engineering	.58	.29	.13*	3.35	1.37	.16*

Note. * $p < .05$. ** $p < .01$. *** $p < .001$. **** $p < .0005$.
GPA: transfers R 2 = .36, freshmen R 2= .18, Study progress: transfers R 2 = .30, freshmen R 2 = .24.

Table 5. Summary of Stepwise Regression Analyses for Entry Characteristics Predicting Academic Achievements