

AC 2010-1788: ANALYSIS OF FRESHMAN-TO-SOPHOMORE RETENTION IN YEAR TWO OF A FIRST-YEAR ENGINEERING PROGRAM

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Dr. Cassady is Director of the Freshman Engineering Program and Professor of Industrial Engineering at the University of Arkansas, where he has served on the faculty since August, 2000. Prior to joining the University of Arkansas faculty, he was an Assistant Professor of Industrial Engineering at Mississippi State University (1996-2000). As Director of Freshman Engineering, he is responsible for overseeing the development and operation of both the academic and student services components of this first-year experience program for College of Engineering students. This program was introduced during the 2007-2008 academic year. Dr. Cassady is an elected member of the University of Arkansas Teaching Academy, and he has received numerous teaching awards including the Charles and Nadine Baum Faculty Teaching Award from the University of Arkansas (2006) and the inaugural Imhoff Outstanding Teacher Award from the College of Engineering (2005). Dr. Cassady is a Fellow of SRE, a Senior Member of IIE and a member of Tau Beta Pi, Alpha Pi Mu, and ASEE. Dr. Cassady received his B.S., M.S. and Ph.D., all in Industrial and Systems Engineering, from Virginia Tech.

Gigi Secuban, University of Arkansas

Gigi Secuban currently serves as Manager of the Freshman Engineering Center in the College of Engineering at the University of Arkansas. In this role, she is administratively responsible for the management of a 5,500 square foot center as well as directing the college's orientation program, tutoring resources for first-year students, chair of the undergraduate research symposium and coordinator for sophomore retention initiatives. Gigi previously served as the first female and first Asian American Director of the Multicultural Center at the University of Arkansas. In addition to her campus experience, Gigi has held multiple positions on the regional and national level for NASPA (National Association of Student Personnel Administrators). Gigi's past work experiences include serving as the Director of Student Affairs and Diversity in the College of Education and Health Professions and Assistant Director of Admissions. She earned a bachelor's degree in psychology and a master of science in health science, both from the University of Arkansas. She is currently pursuing her doctorate in Higher Education Leadership. Her future plans include continuing to serve students in a senior leadership role at a four-year public land-grant university.

Analysis of Freshman-to-Sophomore Retention in Year Two of a First-Year Engineering Program

Abstract

During the 2007-2008 academic year, the University of Arkansas implemented the Freshman Engineering Program (FEP), a new first-year experience program for engineering students. The FEP was originally proposed to the engineering faculty as an effort to improve the retention of new engineering students from their freshman to their sophomore years. As a result, the activities of the Academic and Student Services Sub-Programs executed by the faculty and staff of the FEP are all intended to improve students' likelihood of academic success and/or to increase students' desire to pursue an engineering degree. Since improving freshman-to-sophomore retention was a primary goal of the FEP, a significant amount of data has been collected on each of the 763 students enrolled in the first two FEP cohorts. This data includes demographic information, ACT (or similar) scores, high school GPA, AP (or similar) scores, first-semester class schedule and grades, second-semester enrollment data, second-semester class schedule and grades, third-semester enrollment data, and information related to the process used by students in selecting their engineering major for the sophomore year. Our primary objective in constructing and analyzing this data set is to identify intervention programs that will promote increased retention rates for these students. In this paper, we present what we view to be the most interesting results of our analysis of this data. These results primarily include tabulated counts from selected categories of the data. In the second year of our program (2008-2009), we implemented several intervention programs related to our students' performance in their first-semester mathematics courses. Therefore, the performance of our second cohort in their first-semester mathematics courses is a focus of our paper. We also present a brief synopsis of the activities of the activities associated with the execution of the Academic and Student Services Sub-Programs of the FEP.

The Freshman Engineering Program at the University of Arkansas

During the 2007-2008 academic year, the University of Arkansas implemented the Freshman Engineering Program (FEP), a new first-year experience program for College of Engineering (CoE) students at the University of Arkansas. The mission of the FEP is to nurture the academic success, professional development, and individual growth of first-year engineering students by establishing the foundation for their excellence in the study and practice of engineering.

The FEP strives to be a national model for the first-year experience in engineering. In support of this vision, we strive to provide first-year engineering students with

- engaging and high-quality instruction in coursework that is relevant to the modern engineering student and is appropriate based on their individual K-12 preparation,
- meaningful experience in applying the engineering problem-solving approach and communicating their solutions to engineering problems,
- meaningful experience on diverse teams in applying the engineering design process and communicating their designs,

- the essential and motivating information about the engineering disciplines so that they make an informed choice about their engineering major, are capable of functioning on multi-disciplinary engineering teams, and appreciate the role of engineering in modern society, and
- proactive and high-quality academic advising, professional development opportunities, peer mentoring, and peer tutoring,

and we strive to produce a large proportion of first-year engineering students who, one year after enrolling at the University of Arkansas, are

- highly motivated and academically prepared to pursue an undergraduate engineering degree at the University of Arkansas,
- knowledgeable of the responsibilities and opportunities associated with being an undergraduate engineering student,
- advocates for the modern engineering profession, the Freshman Engineering Program, the College of Engineering, and the University of Arkansas, and
- engaged in the College of Engineering and university communities.

The FEP is executed via two interdependent sub-programs – the Freshman Engineering Academic Program (FEAP) and the Freshman Engineering Student Services Program (FESSP). These sub-programs are executed by a faculty Director, two full-time professional staff members, one full-time instructor, seven graduate teaching assistants (one from each CoE academic department – note that the Computer Engineering and Computer Science degrees are offered by a single department, Computer Science and Computer Engineering), approximately thirty peer mentors who are undergraduate CoE students, and several undergraduate math and science tutors.

The Freshman Engineering Academic Program

The FEAP is a two-semester, thirty-credit-hour program. The required courses in the Fall Semester are:

GNEG 1111 Introduction to Engineering I
 MATH 2554 Calculus I
 CHEM 1103 University Chemistry I
 PHYS 2054 University Physics I
 ENGL 1013 Composition I

Note that the scheme used at the University of Arkansas to number courses is such that the fourth digit in a course number corresponds to the number of semester credit hours for the course.

The required courses in the Spring Semester are:

GNEG 1121 Introduction to Engineering II
 MATH 2564 Calculus II
 ENGL 1023 Composition II
 Freshman Engineering Science Elective (4 credit hours)

University Core Elective (3 credit hours)

For the Freshman Engineering Science Elective, FEP students choose between CHEM 1123/1121L University Chemistry II (with laboratory) and PHYS 2074 University Physics II. This selection has no impact on the students' selected CoE major at the conclusion of their first year.

The University Core Elective can be any course that satisfies one of the requirements of the University of Arkansas core curriculum in the social sciences, humanities, and fine arts.

Like similar students at many of our peer institutions, a significant number of FEP students do not have the mathematics ACT score (26 or greater in the 2007-2008 academic year, 27 or greater in the 2008-2009 academic year) required to enroll in MATH 2554 as a new freshman. Most of these students qualify to take MATH 1285 Precalculus Mathematics. Successful completion of MATH 1285 qualifies students to take MATH 2554. A few of our students must begin their mathematics courses in MATH 1203 College Algebra (two semesters behind MATH 2554), and a very small number must begin in MATH 0003 Beginning and Intermediate Algebra (three semesters behind MATH 2554). Note that FEP students who are not calculus-ready are also not eligible to enroll in PHYS 2054. For FEP students who take MATH 1285 in the Fall Semester, the MATH 2554 and PHYS 2054 requirements shift to the Spring Semester, the Freshman Engineering Science Elective must be CHEM 1123/1121L, and the University Core Elective shifts to the Fall Semester. These students are then one MATH class behind at the end of the Spring Semester. Note also that some students who do not qualify for MATH 2554 based on their ACT score complete the prerequisite courses on their own before enrolling at the University of Arkansas.

Honors sections of MATH 2554, MATH 2564, CHEM 1123/1121L, PHYS 2054, PHYS 2074, ENGL 1013 and ENGL 1023 were available to qualified FEP students during the 2007-2008 and 2008-2009 academic years. During the 2008-2009 academic year, honors sections of GNEG 1111 and GNEG 1121 were created and offered for the first time. Enrollment in the Honors College at the University of Arkansas requires a composite ACT score of at least 28 and a high-school GPA of at least 3.5.

In implementing the FEAP, extensive interaction with the College of Arts and Sciences at the University of Arkansas is required. Most importantly, the FEP staff works closely with the College of Arts and Sciences to implement block scheduling for the Fall Semester. In the block scheduling system, each FEP student is assigned to a block consisting of approximately 22 students. All students in a given block have identical class schedules (except for electives).

The Freshman Engineering Student Services Program

The FESSP provides proactive support to FEP students through summer orientation, academic skills and personal wellness workshops, academic advising, peer mentoring, supplemental instruction and tutoring, an academic living-learning community, and extracurricular activities. The FESSP is housed in the 5500 sq ft Freshman Engineering Center. The Freshman

Engineering Center includes faculty and staff offices, a peer mentoring center, a tutoring room, a project room, a 60-seat computer lab, and a large study lounge. The peer mentoring program is staffed by approximately thirty CoE sophomores, juniors, and seniors. Participation in the peer mentoring program is required as part of GNEG 1111 and GNEG 1121. The supplemental instruction and tutoring activities are offered via the University of Arkansas Enhanced Learning Center (ELC). Because of the historical struggles of first-year CoE students at the University of Arkansas, ELC activities are primarily focused on MATH courses.

The Introduction to Engineering Course Sequence

A key element of both the FEAP and the FESSP is the Introduction to Engineering course sequence (GNEG 1111 and GNEG 1121). The goal of these courses is to prepare FEP students for their transition into a discipline-specific CoE undergraduate program. In both courses, a variety of engineering topics (statics, DC circuits, statistics, engineering economics, mass balance, etc.) are used to train the students on applying a disciplined approach to completing engineering homework assignments. These topics are also used to facilitate the development of FEP students' abilities in spreadsheet modeling (using Microsoft Excel) and computer programming (using Visual Basic for Applications behind Microsoft Excel). Throughout the courses, the primary emphasis relative to grading is placed on submitting complete, correct, and neat homework in a timely fashion. Most FEP students find that achieving a high grade in GNEG 1111 and GNEG 1121 is a result of beginning assignments in a timely fashion, diligently following directions, and taking advantage of resources available for assistance. As such, the FEP faculty and staff consider the grades in GNEG 1111 and GNEG 1121 to be accurate measures of the students' work ethic.

The Introduction to Engineering course sequence also provides a forum for many activities related to CoE major selection, career development (resumes, interview skills, job search strategies, coops and internships, etc.), academic skills development (note taking, test preparation strategies, etc.), and personal wellness. Relative to major selection, several GNEG 1111 and GNEG 1121 class meetings are dedicated to departmental information and recruiting sessions. These sessions culminate with Decision Day, a class meeting in March during which students announce their CoE major.

The Fall 2007 Freshman Engineering Program Cohort

The Fall 2007 FEP (FY07) cohort includes 343 students. Under our university's definition, the students in the FY07 cohort include all students who were new to the University of Arkansas in the Fall Semester of 2007, entered the University of Arkansas with 24 or fewer transfer semester credits, and were enrolled in the CoE on the 11th day of class in the Fall Semester of 2007. Cohorts of this type are used to track retention and graduation statistics at the University of Arkansas.

Cassady and Mulvenon¹ (2009) detail the academic performance of the students in the FY07 FEP cohort. The key points from that paper that are relevant to this paper are:

- 53% of students who attempted MATH 2554 in the Fall Semester of 2007 earned a passing grade. The students who attempted MATH 2554 in the Fall Semester of 2007

earned an average grade point in that course of 2.0. Note that a grade of C or better is required to advance to the next MATH course at the University of Arkansas.

- 33% of the students having an ACT mathematics scores of 28 or less who attempted MATH 2554 in the Fall Semester of 2007 earned a passing grade.
- 68% of students who attempted MATH 2554H Honors Calculus I in the Fall Semester of 2007 earned a passing grade. The students who attempted MATH 2554H in the Fall Semester of 2007 earned an average grade point in that course of 2.6.
 - 50% of the students having an ACT mathematics score of 29 or less who attempted MATH 2554H in the Fall Semester of 2007 earned a passing grade.
- 67% of students who attempted MATH 1285 in the Fall Semester of 2007 earned a passing grade. The students who attempted MATH 1285 in the Fall Semester of 2007 earned an average grade point in that course of 2.3.
- 80% of the students who earned a grade of A in GNEG 1111 (which we believe indicates a reasonable work ethic) and attempted a MATH class in the Fall Semester of 2007 earned a passing grade in that MATH class. 52% of the students who earned a grade of B in GNEG 1111 (which we believe indicates a mediocre work ethic) and attempted a MATH class in the Fall Semester of 2007 earned a passing grade in that MATH class. 22% of the students who earned a grade of C or worse in or withdrew from GNEG 1111 (which we believe indicates a poor work ethic) and attempted a MATH class in the Fall Semester of 2007 earned a passing grade in that MATH class.
- 75% of students who attempted CHEM 1103 in the Fall Semester of 2007 earned a passing grade. The students who attempted CHEM 1103 in the Fall Semester of 2007 earned an average grade point in that course of 2.3.
 - 54% of non-calculus-ready students who attempted CHEM 1103 in the Fall Semester of 2007 earned a passing grade.
 - 95% of the students who earned a grade of A in GNEG 1111 and attempted CHEM 1103 in the Fall Semester of 2007 earned a passing grade in CHEM 1103. 68% of the students who earned a grade of B in GNEG 1111 and attempted CHEM 1103 in the Fall Semester of 2007 earned a passing grade in CHEM 1103. 35% of the students who earned a grade of C or worse in or withdrew from GNEG 1111 and attempted CHEM 1103 in the Fall Semester of 2007 earned a passing grade in CHEM 1103.
- 53% of students who returned to the FEP for and attempted MATH 2554 in the Spring Semester of 2008 earned a passing grade in MATH 2554. These students earned an average grade point in MATH 2554 of 1.8.
- 65% of students who returned to the FEP for and attempted MATH 2564 in the Spring Semester of 2008 earned a passing grade in MATH 2564. These students earned an average grade point in MATH 2564 of 2.3.

Cassady and Mulvenon¹ also detail the second-year retention statistics of the students in the FY07 FEP cohort. The key points from that paper that are relevant to this paper are:

- 62% of students returned to the CoE for their second year, 81% returned to the University of Arkansas for their second year, and 19% did not return to the University of Arkansas for their second year.
 - More than 90% of the students who earned a grade of A in their Fall Semester 2007 MATH class returned to the CoE for their second year.

- More than 70% of the students who earned a grade of B or C in their Fall Semester 2007 MATH class returned to the CoE for their second year. More than 90% of these students returned to the University of Arkansas for their second year.
- Slightly less than 50% of the students who earned a grade of D in or withdrew from their Fall Semester 2007 MATH class returned to the CoE for their second year. More than two-thirds of these students returned to the University of Arkansas for their second year.
- 15% of the students who failed their Fall Semester 2007 MATH class returned to the CoE for their second year. 35% of these students returned to the University of Arkansas for their second year.

Based on our analysis of the academic performance and retention of the FY07 cohort, the FEP faculty and staff took several actions for subsequent academic years.

- Because of the apparent relationship between work ethic and grades in MATH and CHEM courses, more emphasis is being placed on developing a strong work ethic in the early weeks of GNEG 1111.
- Because of the performance of students in MATH 2554 who barely meet the ACT mathematics standard for entry into MATH 2554, the FEP supported the proposal of the Department of Mathematics to raise to 27 the ACT mathematics threshold for entry into MATH 2554.
- Because of the struggles of our students in MATH 2554H, the FEP faculty and staff are more cautious in advising students to enroll in MATH 2554H.
- Because of our students' struggles in MATH 2554 and the apparent relationship between MATH grades and retention, the MATH 2554 tutoring programs in the Freshman Engineering Center were significantly expanded.

The New MATH 2554 Tutoring Programs

Due to the need to improve student performance in MATH 2554, additional support was provided for FEP students through the University of Arkansas Enhanced Learning Center (ELC). The ELC is located within the Freshman Engineering Center and provides tutoring at no charge to students. The corresponding initiatives for the 2008-2009 academic year included:

- peer tutoring – Through a partnership with the Enhanced Learning Center, tutors skilled in MATH (through MATH 2574) were hired to provide weekly tutoring in the Freshman Engineering Center. FEP students were able to receive quality tutoring at no cost in a convenient location since the FEP center is located in the same building as their GNEG 1111/1121 courses.
- distraction-free study zone – In addition to the peer tutors, this program consisted of recruiting volunteer peer tutors from the CoE. These students were selected on the basis of their performance in MATH 2554 and MATH 2564. Many of these students were also actively involved in the CoE in a number of engineering student organizations, including honors organizations. Because of their involvement, these same students had friends who were also qualified to participate as tutors. Prior to the midterm and final exam period, a week-long series of tutoring sessions were held, utilizing these student volunteers. Student volunteers worked anywhere from thirty minutes to two hours tutoring FEP

students during those weeks. FEP students were able to take advantage of free tutoring in preparation for their exams. Student volunteer tutors were offered movie tickets as incentives to participate in the program. Additionally, many of the FEP peer mentors were recruited to participate in the tutoring program, and this was successful as well since many of the FEP students were already familiar with the peer mentors.

- textbook program – The FEP purchased a number of textbooks for FEP student use. These included the textbooks used by CHEM 1103, MATH 1285, MATH 2554 and PHYS 2054. The textbooks were provided free for students to check-out while they studied in the FEP center. According to a number FEP students, a major benefit of the textbook program meant they could leave their personal textbooks in their residence halls and did not have to carry heavy textbooks across campus during the day.
- testing materials – Free testing materials (such as bluebooks, scantrons, #2 pencils) were provided for students during the semester and during finals. Many students took advantage of this program heavily during finals.
- review sessions – Because the FEP faculty and staff work so closely with key departments on campus, faculty in those departments are willing to provide additional support for FEP students. For example, the professor who writes the mid-term and final exams for MATH 2554 conducted review sessions for FEP students prior to the mid-term and final exams. These review sessions were heavily attended by FEP and non-FEP students taking MATH 2554.

The Fall 2008 Freshman Engineering Program Cohort

The Fall 2008 FEP (FY08) cohort includes 420 students. Table 1 includes summary statistics regarding the students in the FY08 cohort who entered the University of Arkansas with verified ACT scores. Table 2 contains summary statistics regarding the students in the FY08 cohort who entered the University of Arkansas with a verified high-school GPA. Table 3 contains summary statistics on the AP credit obtained by students in the FY08 cohort for courses that are required in the FEAP. These statistics reported in Tables 1-3 are consistent with those from the FY07 cohort and what was typical for first-year students in the CoE during the decade prior to implementation of the FEP.

	ACT Composite	ACT English	ACT Mathematics	ACT Reading	ACT Scientific Reasoning
average	26.9	27.0	27.9	27.4	27.1
median	27	27	28	28	27
% scoring 30 or more	30%	34%	36%	39%	30%

Table 1. ACT Score Statistics of the FY08 Cohort

average	3.79
median	3.84
% of students scoring at least 4	35%

Table 2. High-School GPA Statistics for the FY08 Cohort

Course	% of students having AP credit
MATH 2554	25%
MATH 2564	5%
CHEM 1103	4%
PHYS 2054	2%
ENGL 1013	5%
ENGL 1023	4%

Table 3. AP Credit Statistics for the FY08 Cohort

Fall Semester Academic Performance of the FY08 Cohort

Table 4 includes the Fall Semester 2008 distribution of grades (including withdrawals) received by students in the FY08 cohort in a set of key courses that are closely monitored by FEP faculty and staff. Because of the observed differences between MATH 2554H Honors Calculus I and MATH 2554, MATH 2554H is separated from MATH 2554 in Table 4. The grades from every other honors course are included with the grades from the non-honors course having the same number. Table 4 also includes the percentage of students who passed each course, and the average grade point achieved in each course.

	A	B	C	D	F	W	Total	% Passing	Average Grade Point
GNEG 1111	268	53	38	11	17	18	405	91%	3.4
MATH 1203	2	8	2	3	5	0	20	60%	2.0
MATH 1285	4	12	19	8	14	16	73	48%	1.7
MATH 2554	35	54	44	15	20	34	202	66%	2.4
MATH 2554H	12	9	6	1	1	1	30	90%	3.0
MATH 2564	14	24	12	2	4	0	56	89%	2.8
MATH 2574	5	7	3	2	0	2	19	79%	2.9
CHEM 1103	75	93	40	22	37	55	322	71%	2.6
PHYS 2054	105	79	21	6	4	10	225	94%	3.3

Table 4. Fall Semester 2008 Academic Performance of the FY08 Cohort

Our attempts to emphasize work ethic in GNEG 1111 appear to have been successful: 66% of students from the FY08 cohort who attempted GNEG 1111 during their first semester earned a grade of A. The corresponding statistic for the FY07 cohort was 58%.

Our attempts to improve our students' performance in MATH 2554 appear to have been very successful: 66% of students (up from 53% for the FY07 cohort) who attempted MATH 2554

during their first semester earned a passing grade. The students who attempted MATH 2554 during their first semester earned an average grade point in that course of 2.4 (up from 2.0 for the FY07 cohort). This improvement in performance is not a result of prohibiting students having an ACT mathematics score of 26 from enrolling in MATH 2554. Table 5 breaks down by ACT mathematics score the first-semester MATH 2554 pass rates for both the FY07 and FY08 cohorts. Note that in all but one of the categories, the pass rate increased (substantially in some cases) from FY07 to FY08. This improvement in performance continued into the spring semester: 76% of students from the FY08 cohort (up from 65% for the FY07 cohort) who returned to the FEP for and attempted MATH 2564 in the Spring Semester of 2009 earned a passing grade in MATH 2564.

ACT Math. Score	First-Semester MATH 2554 Pass Rate	
	FY07	FY08
26 or less	27%	45%
27	30%	62%
28	50%	63%
29	65%	64%
30	60%	71%
31 or more	83%	85%

Table 5. First-Semester MATH 2554 Pass Rates by ACT Mathematics Score

Our attempts to be more cautious in advising students regarding MATH 2554H appear to have been very successful: 90% of students (up from 68% for the FY07 cohort) who attempted MATH 2554H during their first semester earned a passing grade. The students who attempted MATH 2554H during their first semester earned an average grade point in that course of 3.0 (up from 2.6 for the FY07 cohort).

The academic performance of non-calculus-ready students continues to be a major area of concern for the FEP faculty and staff: 48% of students (down from 67% for the FY07 cohort) who attempted MATH 1285 during their first semester earned a passing grade. The students who attempted MATH 1285 during their first semester earned an average grade point in that course of 1.7 (down from 2.3 for the FY07 cohort). Furthermore, 33% of non-calculus-ready students (down from 54% for the FY07 cohort) who attempted CHEM 1103 during their first-semester earned a passing grade.

Second-Year Retention of the FY08 Cohort

In the Fall Semester of 2009, 69% of the FY08 cohort (up from 62% for the FY07 cohort) returned to the CoE, and 85% of the FY08 cohort (up from 81% for the FY07 cohort) returned to the University of Arkansas. These second-year retention statistics are the best observed in the CoE over the time period 1998-2009.

Statistics continue to support the relationship between first-semester MATH grades and retention: 90% of students in the FY08 cohort who earned a grade of A or B in their first-semester MATH class returned to the CoE for their second year; 75% of students in the FY08

cohort who earned a grade of C in their first-semester MATH class returned to the CoE for their second year; 38% of students in the FY08 cohort who did not pass their first-semester MATH class returned to the CoE for their second year.

Moving Forward

Based on our analysis of academic performance and retention of the FY07 and FY08 cohorts, the FEP faculty and staff took several actions for subsequent academic years.

- MATH 2554 tutoring programs were expanded beyond what was done for the 2008-2009 academic year.
- MATH 1285 tutoring programs were created and added to the programs in place for MATH 2554.
- A new CHEM 1103 tutoring program was created.

Bibliography

1. Cassady, C.R. and S.W. Mulvenon (2009). "Initial Analysis of Freshman-to-Sophomore Retention in a New First-Year Engineering Program", *Proceedings of the 2009 ASEE Annual Conference & Exhibition*.