

# A Pre-Engineering Class to Help Transition Students Into an Engineering Major

*Donna S. Reese,<sup>1</sup> Robert Green<sup>2</sup>, and Martha Smith<sup>3</sup>*

**Abstract** – This paper discusses an introductory class at Mississippi State University targeted at students who declared an interest in engineering but who were not qualified for admission into an engineering major. These students are admitted to a pre-engineering major until they complete Calculus I, Chemistry I, and English I with C's or better. Analysis of the success of these students in moving into engineering majors led to the creation of this class in 2006. The lecture content of the class along with the assignments used for assessment in the class are presented. Analysis of data on the success of students (with and without the class) was done to determine the efficacy of the class in helping students to transition to engineering majors. No statistical difference was found in transfer rates for students who took the class versus those who did not. In addition, GPA's and retention at MSU were not statistically different. However, data did reveal that transfer students taking the class were particularly unsuccessful and this will allow us to provide better guidance to this group of students.

**Keywords:** Retention, introductory classes.

## BACKGROUND

Mississippi State is a public, land-grant, doctoral, research university classified as Doctoral/Research-Extensive by the Carnegie Foundation. Enrollment is approximately 17,000 students. The Bagley College of Engineering enrolls approximately 2,500 students, 2,000 of which are undergraduates. The College awards approximately 370 B.S. degrees per year through ten engineering programs (aerospace, biological, chemical, civil, computer, electrical, industrial, mechanical, software, and computer science). Demographically, approximately 12 percent of the Bagley College of Engineering undergraduates are African-American and 18 percent are female. Also, the Bagley College of Engineering ranks in the top 10 percent among U.S. colleges of engineering in research expenditures (~\$71M).

In the fall of 2001, the Bagley College of Engineering at Mississippi State University (MSU) instituted admissions criteria into the college above those required for the university. Prior to fall 2001 any student admitted to the university who expressed a desire to major in engineering was admitted directly to the college. Since this time, students who are admitted into the university expressing an interest in engineering who do not meet these criteria are admitted as undecided majors with a pre-engineering concentration. These admissions criteria were established by studying the graduation rates of students entering the college. The admissions criteria are a combination of high school GPA and ACT scores. Currently the criteria for admission to the college are: 23 or higher composite ACT score; or ACT of 20, 21 or 22 with a high school core GPA of 3.0 or better; or a high school core GPA of 3.5 regardless of ACT score as long as the student meets the university criteria for admission. Students who take the SAT rather than the ACT have their SAT score converted to an equivalent ACT and the same criteria apply. These students are admitted to engineering upon successful completion of 30 semester hours with a 2.0 or better GPA and grades of C or better in English Composition I, Calculus I, and Fundamentals of Chemistry. Transfer students who

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<sup>1</sup> Mississippi State University, Bagley College of Engineering, PO Box 9544, MSU, MS 39762, dreese@bagley.msstate.edu

<sup>2</sup> Mississippi State University, Bagley College of Engineering, PO Box 9544, MSU, MS 39762, green@bagley.msstate.edu

<sup>3</sup> Mississippi State University, PO Box 2839, MSU, MS 39762, mis16@msstate.edu

would not have been eligible for admission as new freshmen are also given this designation unless they have satisfied the requirements above with their transfer course work. Approximately 100 students annually are admitted with this designation.

Students in this designation are advised by a special advisor in the university's academic advising center. This center is tasked with advising all undecided students at the university but personnel in the Bagley College of Engineering work closely with the special advisor in the advisement of the pre-engineering students. Bagley College of Engineering personnel actually advise these students during Mississippi State's summer orientation sessions. The college of engineering has also published an advising guide which covers the initial set of courses that students in the pre-engineering designation should take based on the particular engineering major they wish to pursue and their math and English ACT sub-scores which determine placement in early math and English classes. Students in this designation are usually deficient in their math backgrounds and are advised to enroll in the appropriate math class each semester until they satisfy the math requirements of their intended engineering major.

From 2001-2005 a total of 546 students were studied to determine the rate at which they matriculated into engineering from this pre-engineering designation. This study determined that only 8% of these students moved to an engineering major one-year following admission and a mere 12% had moved to an engineering major after two years. While some of these students had unrealistic expectations about what their chosen engineering discipline actually involved and some did not have sufficient mathematics and reasoning skills to be successful in engineering, some of these students could be successful if they made up deficiencies in their backgrounds. More troubling to the college was the disproportionate number of minority students who were represented in this group.

### **PRE-ENGINEERING CLASS**

In the spring of 2006 the college instituted a one-hour Introduction to Engineering class for the students in the pre-engineering designation. This class has enrolled 65-85 students in each of five offerings since this time (spring 2006 and each fall 2006-2009). This course is taught in one large lecture section. This course was established with several goals in mind. First, the course was designed to give these students an overview of the typical post-graduation opportunities in each of the engineering disciplines. The course was designed to provide students with more information about what types of opportunities are available in each of our ten engineering majors so these students make earlier decisions about the appropriateness of their major choice. Secondly the course attempts to help students realize the magnitude of the academic challenge they were undertaking. About 1/3 of these students start in our pre-college intermediate algebra class upon entry to Mississippi State. These students have three semesters of mathematics that must be completed before they can even begin the calculus sequence required of engineering majors. Although the intent is not to discourage these students, they do need to have realistic expectations about the implications of starting at this level in mathematics on their expected graduation date. During the initial study of the students in the pre-engineering designation it was discovered that not only were many students not successful in moving into an engineering discipline, but that by the time they decided that they needed to pursue alternative majors, their GPA's were such that they were not eligible for admission into other majors on campus. This course would be considered successful if it helped those students who were capable of succeeding in engineering to make the transition and those that need to seek other majors to make the transition before they got into academic difficulty.

When this course was designed, similar classes at other institutions was considered as models. Hagenberger, Engerer and Tougaw [4] provide a survey of the common philosophies behind current Introduction to Engineering classes at other institutions. Although the MSU class is closely aligned with the category that they identify as providing the basic survival skills for college students, the MSU course also covers engineering specific topics as well. A conscious decision was made not to develop a project-oriented course (e.g., Elzey [1]; Lo, Lohani and Griffin [7]) due to the significant investment of faculty resources for such a course. Typically students in these types of courses have been admitted into engineering and the goal of such courses is to develop their design skills and pique their interest in engineering. The faculty have a vested interest in putting the required effort into these courses in order to retain these students in engineering majors. However, many of the students in the MSU class, approximately 90%, will decide not to major in engineering. While this is a beneficial outcome for the students involved, it limits the amount of faculty effort that the college is able to invest in this course. Other pre-engineering courses (e.g., Howard and Musto [5]; Pazos, Drane, Light, and Munkeby [8]) use peer team projects or software that

students will use in follow-on engineering classes to motivate students to continue in engineering. The typical student in MSU's pre-engineering designation is not mature enough to successfully navigate this type of project. In addition, the one-hour format of the course limits the types of in-class projects that can be undertaken and the amount of time students are willing to commit outside of class. Further, students in this class often cite that they wish to major in engineering because they like to build things or are good with their hands—we wish to stress to them that the major obstacle between them and an engineering degree is academic preparation, not hands-on courses. The end result is that our class is a combination of several different types of classes at other institutions.

### Course Content

MSU's class, Introduction to Engineering for Pre-Engineers (GE 1011), is a one-hour, lecture format course. The one-hour format was chosen so that the course would not interfere with the academic courses that students needed to take to gain admission into the engineering major of their choice. The course is graded (rather than pass/fail) to help make sure that students take the assignments in the class seriously enough to benefit from completing them correctly. The assignments in the class are designed to be beneficial to the students without requiring significant time investments that would detract from other courses. This class generally does not apply towards graduation for any of our engineering majors although some majors will count it in place of their one hour introductory course.

The lecture material in the course can be divided into two basic categories (see Table 1). The first part of the course deals with general college success strategies applicable to any major. Lectures are presented on study skills, learning styles, communication skills and time management. In addition, students are required to examine the required courses in their intended engineering major and develop a semester-by-semester schedule indicating which courses they will take until they can graduate. The students are required to pay particular attention to course pre-requisites and consider the pre-requisites in planning their course of study. This schedule is used during an in-class advising session to help students plan their following semester of coursework.

**Table 1 – Weekly Schedule of Class Topics and Assignments**

| <b>Date</b> | <b>Topic</b>                                                    | <b>Assignment Due</b>                            |
|-------------|-----------------------------------------------------------------|--------------------------------------------------|
| Week 1      | Course Introduction, Syllabus review, Preliminary questionnaire |                                                  |
| Week 2      | Study Skills                                                    |                                                  |
| Week 3      | Time Management                                                 | Initial one- to two-page paper on intended major |
| Week 4      | Communication Skills                                            |                                                  |
| Week 5      | Communication Skills                                            | Learning Styles Assessment                       |
| Week 6      | Learning Styles                                                 |                                                  |
| Week 7      | Engineering video                                               | Time Management Assignment                       |
| Week 8      | Engineering video                                               |                                                  |
| Week 9      | Pre-registration advising                                       | Plan of coursework to complete degree            |
| Week 10     | Engineering video                                               |                                                  |
| Week 11     | Engineering video                                               |                                                  |
| Week 12     | Guest speaker from industry                                     |                                                  |
| Week 13     | Alternative majors related to engineering                       |                                                  |
| Week 14     | Wrap-up; Evaluations                                            | Three-page paper on major                        |

The second category of class lecture deals with introducing the different engineering majors. Originally, department heads and/or undergraduate coordinators for each department were invited to come and share with students information about their particular degree program(s). These were generally 20 minute lectures by the department head but some departments also had students talk about their experiences in the cooperative education program.

Approximately 25 minutes per academic major was allocated and speakers are encouraged to focus on the types of things that students will do with that major after they graduate. Guest speakers were asked not to talk about the degree requirements but instead to focus on the types of experiences students will have in the work force following graduation. In the fall 2009 semester we replaced these lectures with videos showing engineers at work in the various professions. With the videos we were able to make sure that career information was presented as well as to show the integration of the different engineering majors on projects. In addition, we had a guest speaker from a local industry (Paccar) talk about the new facility they are locating to our area and the types of engineers that are involved in their operation.

A representative from the Career Services Center presents a lecture in the course after all engineering majors have been discussed. This speaker gives students information on majors which are related to engineering as well as providing information on career services programs designed to help students find appropriate majors. This information has proven to be timely for the students in the class who decide not to pursue engineering majors but do not know how to go about finding another major which is appropriate for them.

The course grade is based on the assignments that the students submit as well as class attendance (see Table 2). Class attendance is weighted fairly heavily (25%) so that students are encouraged to be in attendance to hear about all of the engineering programs and not just the one that they think they are interested in. It was felt that many students would attend only the overview of their chosen major without this requirement. Since many of these students have misconceptions about what their chosen major entails, this requirement helps to make sure they had been exposed to all fields in case they decided their initial major choice was not appropriate for them.

The final three-page paper that the students write is also worth 25% of the course grade. By this time in the semester students have had two lectures on communication skills, including the appropriate way to cite references, and have had more exposure to what their chosen major entails. This paper requires students to discuss the particular type of job they wish to have upon completing their degree and requires them to research the professional society in their chosen field. Students who have decided not to major in engineering write this paper on whatever major they are considering at that point in the semester.

**Table 2 – Grading**

| <b>Assignment</b>                            | <b>Weight</b> |
|----------------------------------------------|---------------|
| Initial paper on intended major              | 15%           |
| Learning styles assessment                   | 10%           |
| Time Management Assignment                   | 15%           |
| Plan of coursework to complete chosen degree | 10%           |
| Final three-page paper on chosen major       | 25%           |
| Attendance                                   | 25%           |

Several textbooks (Gomez [3], Landis [6], and Schiavone [9]) were considered for use in this class. Each of these books provides an overview of different engineering disciplines as well as general college success strategies. In the end, Gomez was not selected due to a concern that the students would be turned off by the fact that the textbook indicates it is for upper elementary and lower-level high school students. The Landis book covered all of the material that was needed but also had extraneous material. The Schiavone text has been used for the last two course offerings. However, comments from the students indicate that they are not making use of the text. Beginning with the fall 2008 offering the textbook was listed only as an optional reference. Students are given several websites, including the Bureau of Labor Statistics site, as reference material for researching their chosen major.

During the last three class offering (fall 2007-09) the class also made use of Mississippi State's university standard audience response system from eInstruction ([www.einstruction.com](http://www.einstruction.com)). Each student was required to buy and register a transmitter that they brought to class each day. These were used to take attendance in the class as well as to provide opportunities for student feedback during the lectures on the general college success skills. Although there were issues initially with students getting their transmitters, in general this system did provide greater interaction with the students during those sessions. This system is also used in other required courses for engineering students such as freshman chemistry.

## Student Evaluation Feedback

Student feedback on course evaluations has been uniformly positive. Comments such as “Every engineering student should take this class” and “[the class] Reinforced my decision to pursue my major” are quite common on the evaluation forms. The aspect that students said they enjoyed most was the lectures by the different department representatives on their majors. A good number of students indicate that the course has either confirmed their choice of engineering major or introduced them to another engineering major which was more interesting to them. Even the students who decide not to major in engineering value the course for helping them to make that decision. One student wrote on his evaluation form “I learned a great deal about the major I chose. And I also learned that I didn’t want to do engineering but am thankful that you helped me make up my mind.” The most common comment from students on what improvements could be made to the class were suggestions dealing with having hands-on projects, segregating the class at times to focus on particular majors, and having actual visits to the departments to see facilities and laboratories rather than having the departmental representative come and make a presentation in class. The engineering videos presented in the last offering were a reaction to this suggestion. It was not feasible to do visits to each department so the videos provided a “visual” way for students to see the major. Other suggestions will be incorporated into future class offerings.

## ASSESSMENT DATA

During the fall 2009 semester we undertook a study of all of the pre-engineering students who had entered MSU from fall 2001 through fall 2009. We collected information about these students’ ACT scores and GPA’s upon entry to MSU as well as their academic performance and majors at MSU during the first three years, including whether or not they remained enrolled. If the students had graduated in any major from MSU we also captured that information. In order to be able to judge any effects that taking the class had on these students we also collected information about when they took the introductory class and what grade they made in the class. We used a T-test to determine any significant differences in these variables between the students who took the class and those who did not.

The first variable that we examined was whether or not students who were designated as pre-engineering were more (or less) likely to be enrolled in engineering than the students who did not take the class. After the first year, there are actually more of the pre-engineering students enrolled in engineering who did not take the class (10%) than those that did (6%). However, when looking at the students three years after their initial entry, there was a positive impact from taking the class even though it is not statistically significant (13% of the students who took the class were enrolled in engineering versus 9% of those who did not). We hypothesize that students who may lack very little to fulfill the requirements to enter engineering are content to not take the course but that others who do take the course are more motivated to pursue the necessary prerequisites and finally do gain entry into engineering. We also looked at the students who took the class and separated them into two groups: those who made C’s or better in the class and those who made D’s and F’s. Students who passed the class (with a C or better) were statistically more likely to enter engineering than those who did not pass the class. We hypothesize that students who take the class seriously (and therefore pass) are also taking their other classes seriously and are therefore much more likely to complete the requirements to enter an engineering major. Students who fail the class are also statistically more likely to not be enrolled at MSU one, two or three years after admission. This seems to represent a group of students who are not ready for college at all, much less an engineering major.

A disappointing finding of this study is that students who took the class had a significantly **lower** GPA (after 1 year, 2 years and 3 years at MSU). We are at a complete loss on how to explain this phenomenon. It could be that we are sufficiently poor instructors that we are actually causing these students to develop poorer communication, time management and study skills. We would like to believe this is not the case! We hypothesize that this could be due to the fact that students who take the class have more perceived attachment to engineering and therefore persist longer (even when faced with poor grades) than those who did not take the class and are therefore less attached to engineering and more willing to change to other majors where they can perform better academically. Further studies are needed to determine the root cause of this effect.

This phenomenon did cause us to examine the population of students taking this class to see if there were any differences between the students who entered pre-engineering as freshman versus those who transferred to MSU and were still not eligible to be admitted to an engineering major. The GPA’s of freshmen who took the class versus

those that did not were not statistically different. However, the GPA's of transfer students did differ significantly (although the number of transfer students who took the class is fairly small). This may, in part, explain the overall difference in GPA. Approximately 36% of the pre-engineering students are transfer students. It has been our practice in advising these students that if they are close to admission (having the 30 hours with a 2.0 or greater but lacking one of the three required courses) that we let them take the intro course in their major rather than the pre-engineering intro course. We hypothesize that students who transfer to MSU after a significant time at a community college who still do not have the prerequisites to enter engineering are not likely to gain admission. However, the numbers of students who we can follow through three years who are in this category is too small to be able to make valid comparisons. This bears watching in the future.

In conclusion, the analysis of this data indicates that the class, at best, may be leading to a slightly higher attrition rate into engineering majors. This analysis does indicate that we should advise transfer students to complete the requirements for admission to engineering prior to transferring to MSU. Failure of this class is a good indicator that students will not be successful in transitioning to engineering. The University Academic Advising Center personnel will use this information to better advise these students on other career choices.

## **FUTURE WORK**

Current plans are to continue to offer this course and gather further data to increase the sample size. We also plan to look further into the correlation of math and English ACT subscores and success in engineering. As stated above, some students have a significant hurdle to jump in preparing for calculus. These students may be the ones who are leaving engineering and, if that is the case, then it would not be unexpected. We can also hypothesize that math and English ACT subscores may be better measures of high school preparation than the composite ACT score. If this proves to be the case then we can revise the admission criteria to reflect this and deny admission to those not meeting the criteria. Those students denied admission would still be able to transfer to engineering if they met the requirements for transfer students of successfully completing 30 semester hours, and earning Cs or better in English, chemistry, and calculus.

We also think this course is a good vehicle for providing strategies for success in college. The concern is that perhaps the university rather than the Bagley College of Engineering should be providing it and that it should be required of all undecided majors and not just the pre-engineering majors. If the data continue to indicate that the majority of students who take this course do not ultimately enroll in engineering then we will work with the university to make necessary modifications to the course content and assist in offering it to the whole university community.

## **REFERENCES**

- [1] Elzey, Dana, "Teaching Intro to Engineering in Context – UVA Engineering's New Cornerstone," Proceedings of the 2006 ASEE Annual Conference & Exposition, June 18-21, Chicago, IL. (semester-long hands on project).
- [2] Felder, R.M. and R. Brent, "Understanding Student Differences." J. Engr. Education, 94(1), 57-72 (2005).
- [3] Gomez, A., W. Oakes, & L. Leone, Survey of Engineering: An Introduction to Engineering & Technology for Middle School and Lower High School Grades," Great Lakes Press, St. Louis, MO, 2007.
- [4] Hagenberger, M., B. Engerer, & D. Tougaw, "Revision of a First-Semester Course to Focus on Fundamentals of Engineering," Proceedings of the 2006 ASEE Annual Conference & Exposition, June 18-21, Chicago, IL.
- [5] Howard, W., & J. Musto, "Solid Modeling as the Cornerstone of an Introduction to Engineering Course," Proceedings of the 2006 ASEE Annual Conference & Exposition, June 18-21, Chicago, IL.
- [6] Landis, R., *Studying Engineering: A Road Map to a Rewarding Career*, 2e, Discovery Press, Los Angeles, CA, 2000.
- [7] Lo, J., Lohani, V., & Griffin, O., "Full Implementation of a New Format for Freshman Engineering Course at Virginia Tech," Proceedings of the 2006 ASEE Annual Conference & Exposition, June 18-21, Chicago, IL. (hands on project, OO problem solving).

- [8] Pazos, P., Drane, D., Light, G., & Munkeby, A., "A Peer-led Team Learning Program for Freshmen Engineering Students: Impact on Retention," Proceedings of the 2007 ASEE Annual Conference & Exposition, June, Honolulu, HI. (Peer team projects to improve retention)
- [9] Schiavone, P., *Engineering Success, 3e*, Pearson Prentice Hall, Upper Saddle River, NJ, 2007.

**Donna S. Reese**

Donna Reese is a professor of Computer Science & Engineering and Associate Dean for Academics and Administration in the Bagley College of Engineering at Mississippi State University (MSU). She has been at MSU for 20 years. Her current research interests are in recruitment and retention of students in engineering, particularly from underrepresented groups.

**Robert Green**

Robert Green is the undergraduate coordinator for the Bagley College of Engineering. He has been at MSU for 25 years where he has also worked as a research engineer. His research and teaching interests are in engineering and public policy and engineering ethics.

**Martha Smith**

Martha (Missie) Smith is a senior majoring in industrial engineering at Mississippi State University. She will graduate in December 2010 and plans to pursue graduate studies in IE focusing on human factors.