DECLARING AN ENGINEERING MAJOR:

BY CHOICE OR BY CHANCE?

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Abstract

While registrar data indicates that 85% of entering students selected a major upon admission, only 21% of entering students indicated that they were sure of their decision. A review of individual motivations revealed a very haphazard decision making process, with 34% of students staying in the same major, 34% switching to a different engineering major, 15% leaving engineering, and the remainder uncommitted. High interest levels in a major were found to strongly correlate with performance in the introductory engineering course. Analysis indicates that the average course grade among respondents stating no commitment to a major was 63%, far below the average course grade of 81% for respondents stating confidence in their major. Interestingly, little correlation was found between course performance and student evaluation of teaching in this course.

These results indicate that many of the incoming students do not understand engineering as a discipline, the various engineering majors, or the importance of selecting a major. Accordingly, recommendations include the elimination of major declaration from the admissions process and ensuring a common first year by only allowing declaration of a major after fulfillment of a minimal set of course requirements in the second semester. Furthermore, outreach and counseling programs should be provided as the norm to improve awareness of engineering,

inform prospective and current students of specific disciplines, and thereby facilitate student motivation and achievement.

Introduction

Engineering education seems to have come under increased criticism lately, with many companies and students arguing that engineering curricula are too abstract and disconnected [1, 2]. It is interesting to reflect upon similar concerns of Henderson [3] and Grinter [4] dating back to 1983 and even 1955. These studies consistently indicate that engineering education should have the following properties:

1. Relevance to the lives and careers of students, preparing them for a broad range of careers, as well as for lifelong learning involving both formal programs and hands-on experience;
2. Attractiveness so that the excitement and intellectual content of engineering will attract highly talented students with a wider variety of backgrounds and career interests — particularly women, underrepresented minorities and the disabled — and will empower them to succeed; and
3. Connectedness to the needs and issues of the broader community through integrated activities with other parts of the educational system, industry and government.

Aware of these issues and also the intent of the College of Engineering to provide a common first year for freshman, a first semester Introduction to Engineering course was developed and taught to approximately 250 incoming students and 10 seniors at a nearby public high school. The intent of the course design was to ensure competence in basic skills such as unit conversion while providing exposure to common business and human concerns such as product developments, ethics, and career development. While the course strived to avoid major-specific content due to accessibility and redundancy concerns, the example of wire design for minimal

power dissipation was utilized to provide “fair warning” of typical material in subsequent engineering courses. To provide grounding of discussed engineering concepts, three design-build-test hardware projects were also developed. It was hoped that the course would increase student’s interest in engineering and thereby improve their likelihood of academic and career success as argued elsewhere [5, 6].

Declaration of Major

There can be little doubt that committing to a major is an important, life changing milestone that in most cases sets a person on a career path [7]. Selection of an inappropriate major can require students to undertake additional course work with considerable time and expense. To provide information about the different majors, the College of Engineering hosts a series of Open Houses in which prospective students may tour facilities and speak with faculty and enrolled students. Many of the prospective students do visit one or more departments to gain some perspective. Yet, these visits are usually less than an hour (and often only a few minutes) in duration. Furthermore, all departments provide the most encouraging and interesting displays possible in an effort to maintain and increase enrollments.

On the first day of class, a survey indicated that the vast majority of students had already selected their major. Indeed, a review of registrar data confirmed that 85% of the entering students had already selected a major, even though they had been provided little objective data for decision support. While there is no requirement for incoming students to select a major before their first semester, the students understand that it is generally advantageous to determine a major prior to registration for their second semester since each department teaches its own version of the second semester introductory engineering class. Accordingly, it is a possibility that the structure of the admissions process and course requirements may unnecessarily hasten the

declaration of major. Without reasonable data, the declaration of a major is only a random event without a rational basis, and students will have little confidence in their decisions.

One goal of the course is assist and assure student's declaration of major, even if it is outside of engineering. Approximately 25% of the course content is thereby directed to informing students of the various disciplines and career development strategies. In these sessions, the head of each department visited with course to provide information to undeclared or indecisive students. Most presentations provided an overview of the required courses, examples of their discipline via academic and industry projects, and also a discussion of career opportunities for their graduates. Most departments also had alumni share their personal experiences.

Approximately mid-semester, just prior to the pre-registration period for the second semester, the homework shown in Table 1 was assigned. The homework was graded 40% upon completion and 60% upon quality of composition.

Table 1: Homework Assignment on Declaring a Major

Part A. Please answer the following questions.

1. My interest in engineering is:
    a. Gone. I must get out of the college.
    b. Shaky. I'm not sure I want to be here.
    c. Sound. I think I'm in the right place.
    d. Absolute. This is the place for me.
2. My interest in a specific major is:
    a. Huh? I've no interest in a specific major at this time.
    b. Uncertain. I'm trying to pick between a couple alternatives.
    c. OK. I think I've got a targeted major.
    d. Absolute. I know the exact major for me.

Part B. Reflecting on Part A, discuss what factors you considered, and what additional information might be useful in reaching or validating your decision.

Part C. List the courses you plan to take next semester.

Question A.2 was intended to document each student's confidence level while Part B was intended to gain insight into each student's bases for declaring their major. The results of this query are provided in Figure 1, which indicates that only 21% of the students were "sure" of their selected major. This classification required the student to have answered (d) to question A.2 and also remain in the major he/she chose upon admission. While this proportion of students is low, there is nothing inherently inappropriate with the result since "undeclared" and "unsure" students may subsequently declare a different and more appropriate major.

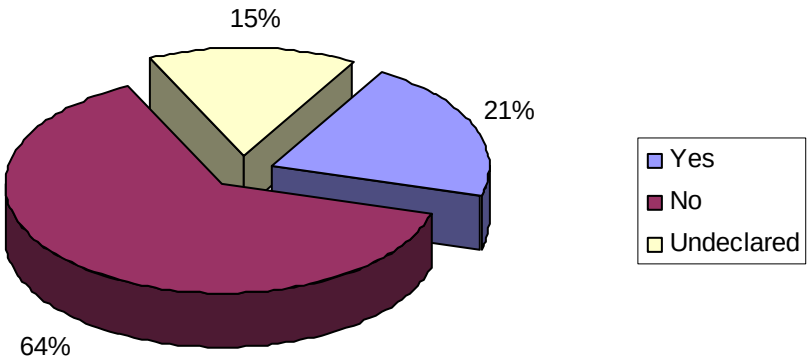

Figure 1: Proportion of Students "Sure" of Their Declared Major

Previous research suggests that the process of choice consists of two main aspects, an appraisal of the elements of choice one by one, and their comparison resulting in the choice being made [8]. In reviewing the responses to Part B, many of the students indicated a rational basis for the selection of their major, such as:

- *I studied electronics for 3.5 years in high school, and found I really liked it.*
- *During high school, I built four robots, 3 for the F.I.R.S.T. and one for the MIT state competition; I fell in love with Mechanical Engineering when I was on these robotics teams and joined ASME.*
- *After the presentation by the department head, I felt more comfortable about my major.*

These responses suggest a familiarity with the field and its subject matter, and an informed declaration of their major. However, many of the responses to Part B indicated that many of the students who were "sure" of their major might not have valid bases for their decision:

- *Chemical engineers are at the top of the engineering ladder, have the highest salaries, and dabble in everything.*
- *I learned in my EE Intro class that EE was the highest paid major.*
- *My cousin graduated from RPI in computer engineering and has yet to find a job; I'm going to be an electrical engineer because the country has become very dependent on electricity.*
- *My father and his father were both Mechanical Engineers.*

Approximately 50% of those "sure" of their major stated bases solely on expected salary or familial history. In indicating that they had an absolute interest in a specific major, these students must have believed that their assumptions and reasoning were sound. While financial returns may or may not be a valid basis for declaring a major, most students do not have access to truly objective data nor an understanding of the relationship between salary and a love for one's work. Similarly, decisions based solely on familial history may not be valid, since they neglect the potential opportunity cost of not investigating or pursuing other majors.

Next, consider the 64% of the declared students who were not sure of their major. It would be expected that many of these "unsure" students might reconsider and declare a different major. By comparing the responses to Parts B and C with registrar enrollment data, it was possible to document the actions of these students. The results, shown in Figure 2, indicate that 34% of the "unsure" students remained in the same major, 34% switched to a different major, 17% remained uncommitted, and 15% dropped engineering. It is interesting to note that 34% of these students

maintained the status quo, even if they had no basis for declaring a major upon admission to the University and were still unsure of their major at the time of pre-registration for the second semester. As the semesters pass and the sunk costs grow, it can be expected that many of these students will remain in their same major that was selected without any rational basis.

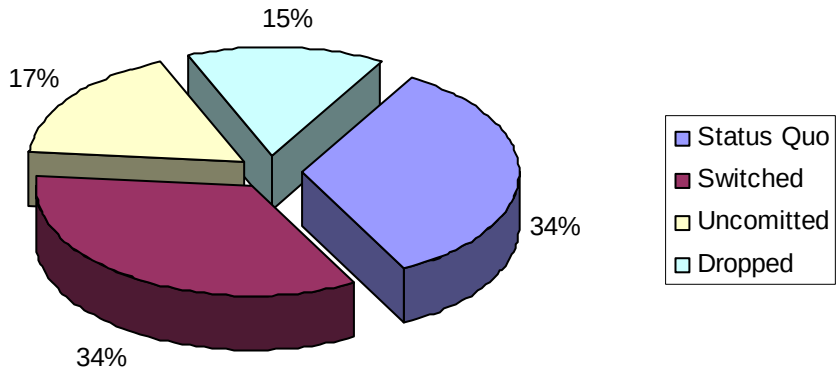

Figure 2: Action of Students "Unsure" of Their Declared Major

The University permits admission into the College without declaration of a specific major. It might be interesting to compare the actions of those "unsure" of their declared major with the actions of those who are "undeclared." The actions of the undeclared students are shown in Figure 3, and indicate that 64% intended to declare a specific major while 18% remained uncommitted and 18% dropped engineering. A comparison of Figure 2 and 3 indicates that there is no significant difference in the final decisions of "unsure" and "undeclared" students. Specifically, in both populations approximately two-thirds of the students had declared a major, one-sixth remained uncommitted, and one-sixth dropped engineering by the pre-registration period for their second semester. These are interesting results, since they imply that choosing to enter as an undeclared student and waiting to declare a major very likely will provide a more informed decision.

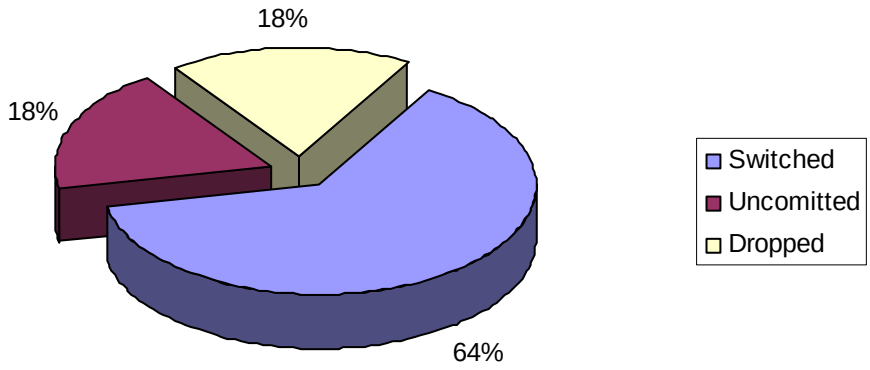

Figure 3: Action of Students with Undeclared Major

A review of Part B for the "unsure" and "undeclared" students indicated very similar responses to those "sure" of their major, though they often provided additional information regarding their decision making process:

- *I've done internships & camps related to engineering; the more I find out about EE, the more I want to be one.*
- *I believe choosing ME was a safe bet since it encompasses broad opportunities in the field that interest me.*
- *After a long debate about the optimal speed for gas mileage, I realized ME was the major for me..*
- *Too much chemistry in this major, I have a real interest in Civil.*
- *I'm still not decided – I am pursuing further input from older students to help me decide.*

However, many of the responses were disheartening, especially among those who indicated a decision to drop engineering. Some of the comments from these students included:

- *I took engineering because architecture was not offered.*
- *I had wanted to be an engineer as my father and grandfather. I'm only 18 and don't know what I want to do with the rest of my life.*
- *I was not prepared for this and need to rethink my life.*

- *I've realized that engineering is not right for me because I can't picture myself having a job as an engineer. I'm not having fun. Listening to engineers talk about their majors and jobs has not caught my attention.*
- *The engineering program was not what I expected; engineering is a huge commitment that I don't feel ready to make.*
- *My preoccupation with the state of the world has not allowed me to focus on my studies.*
- *I used to have a love of math and science but have lost it. I've had a change of heart rather than a change of mind.*
- *I didn't realize the science requirements were so deep; my math is non-existent, and I'm not sure I can do this.*

These responses indicate that many incoming students were not well informed about engineering, had chosen engineering for negative reasons, or were not well enough prepared to undertake a course of study. In such cases, students may lack the motivation to succeed, especially when poorly prepared academically.

Interest Level and Performance

Fisher and Ghidini [9] indicate that motivation may rationally be related to ability, belief, and confidence. It could then be expected that a student's interest level in their declared major may be related to their level of motivation and academic performance. To investigate the possibility of a linkage, the course average of each group of respondents by level of confidence in engineering and their major were calculated and are provided in Figure 4 and Figure 5, respectively.

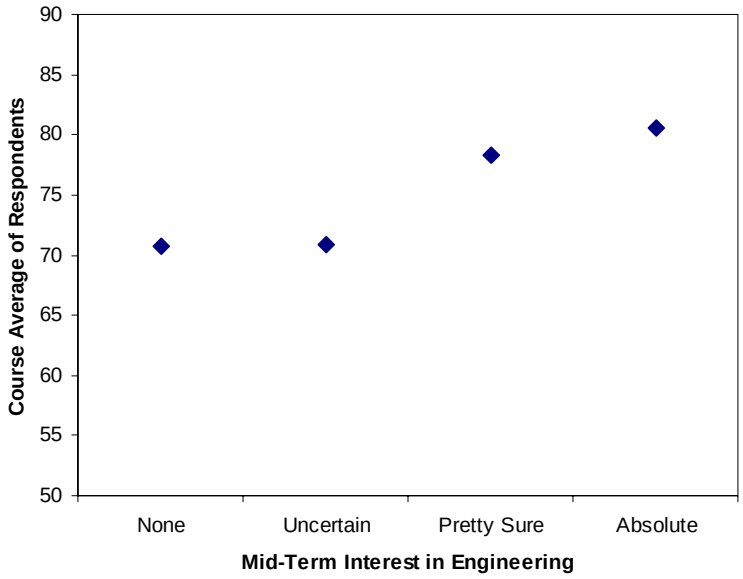

Figure 4: Course Average of Respondents According to Mid-Term Interest in Engineering

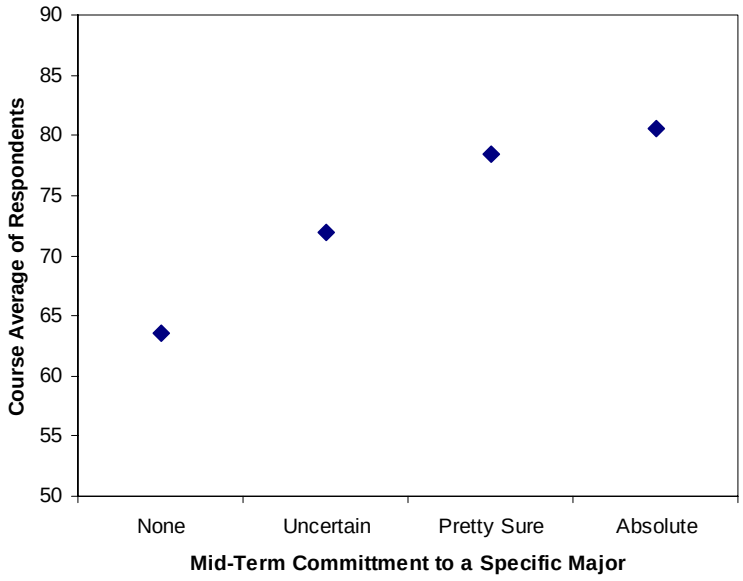

Figure 5: Course Average of Respondents According to Mid-Term Commitment to a Specific Major

As can be observed by the data in Figure 4, there is a strong correlation between the level of general interest in engineering and the performance in the course. Those who have no or low interest in engineering averaged 71% while those with moderate and high level of interest had an average of 80%. The relation between interest in a specific major and course performance was

even stronger as shown in Figure 5, with the spread monotonically increasing from 63% for those without interest in a specific major to 81% for those “sure” of a specific major. These results likely indicate that student’s interest level in their declared major is related to their level of motivation and academic performance in this introductory course.

Naturally, an alternative hypothesis for this relationship is that the students’ perceived performance in the course is determining their interest levels in engineering and specific majors. There are three arguments that counter this hypothesis. First, the students had been informed on multiple occasions that this course was not intended to “weed out” weak students. The homework utilized as the basis of this inquiry was assigned mid-way through the semester when only a small fraction of the grading had become available. Accordingly, students had not (as yet) indicated significant concerns about course grades.

Second, course performance at the end of the semester was calculated for different groups of respondents according to their action. The results, shown in Figure 6, are not as straightforward as those of the previous two figures. Those students who remained in their major had a high course grade average of 81.0%, which was higher than the 73.7% course grade average for those students who switched majors. However, the uncommitted students who were not sure of their majors had the highest course grade average of 81.5%, which counters the hypothesis that students’ interest levels are reduced with poor academic performance. Finally, those students who dropped had course grade average of 76.1%, higher than those who switched majors and equal to the average of all students in the course. This last result indicates that many of the students dropped engineering due to lack of interest, and not academic performance.

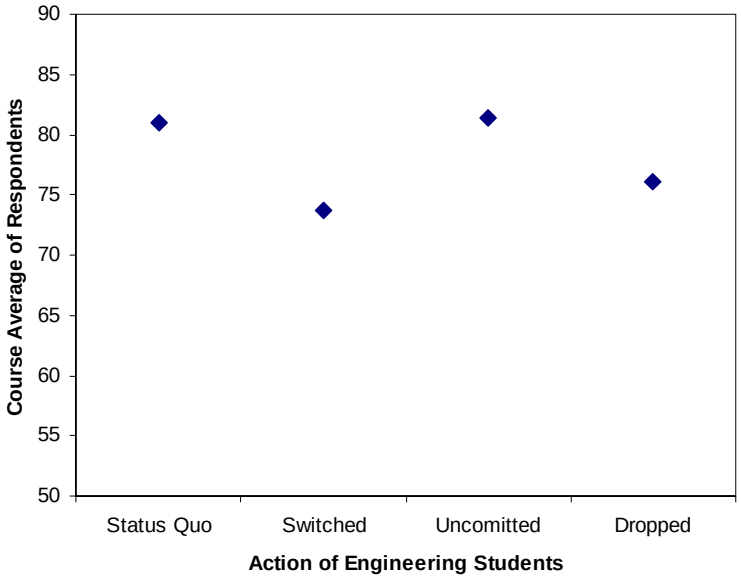

Figure 6: Course Average of Respondents According to Student Action

Third, a mid-semester teaching evaluation was conducted to provide possible course improvements. Students were asked the question "Compared to other courses, the quality of this course is: very poor, poor, average, good, or very good." After the conclusion of the course, the course performance was calculated for different groups of respondents according to their evaluation of teaching. The results are provided in Figure 7. Surprisingly, there is very little correlation between the course teaching evaluation and the course average of the respondents, with the exceptions of a few students who indicated the course was very poor and should be "dumbed down", "slowed down", and require "less work." This data indicates either that there is little correlation between teaching evaluation and course grading, or that students were largely unaware of their course performance.

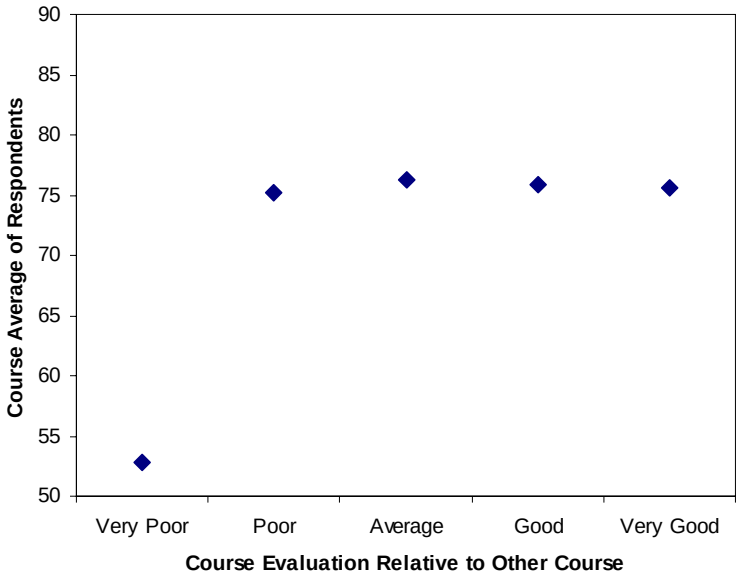

Figure 7: Course Average of Respondents According to Student Evaluation of Teaching

For all these reasons, it is believed that students' motivation and academic performance increase with interest level in the major, and not vice-versa. As such, it is important to provide students with information and guidance to objectively and confidently declare an appropriate major.

Recommendations

To improve the process of declaring a major, it is recommended that the admissions process not only not require, but actually prohibit, freshman from declaring their major on the application; sophomore and junior transfer students would of course indicate the major to which they've committed. If implemented, it is expected that undeclared students would experience less time pressure to choose a major and become better informed to thereby rationally declare their major. The concept of a common first year was explored at various public engineering colleges in New England between 1996-1998 [10]. While this objective was temporarily fulfilled by mandate of College deans, the majority of departments that participated quickly reverted to

offering and requiring major-specific courses in the second semester of the freshmen year, with some departments at some campuses making such requirements in the first semester. For instance, it is quite common for departments to provide instruction for CAD, Matlab, or other foundation tools in the freshman year which place later incoming students at a disadvantage. Such early course requirements prohibit the exploration of multiple majors, and thereby require students to make uninformed and truly random declarations prior to college admission.

A small percentage of the incoming students, approximately 10%, had participated in some college outreach programs or otherwise gained experience relating to specific engineering majors. For instance, some incoming students went to “design camp(s)” in which they undertook exercises, design competitions, and discussions related to engineering [11]. Other students indicated that they had participated in design competitions in high school, ranging from egg drop to bridge building to robots. Other students had experience working as an intern or technician in areas directly related to specific engineering disciplines. The results of this study indicate that these students were more likely to have developed a sincere and informed interest in a specific major and perform better academically. Accordingly, it is recommended that high schools, colleges, and professional societies continue to provide outreach programs that better motivate students to pursue specific majors and careers.

However, many (if not the majority of) students will not have the opportunity to participate in such life-changing outreach programs. Significant barriers exist for these students to access appropriate information to make informed decisions [12]. It is vital that appropriate information and counseling services be accessible and integral to the student’s experience prior to declaring a major. Interest inventories (such as those validated by Crockett [13]), one on one counseling sessions (e.g. [14]), student to student mentoring (e.g. [15]), alumni seminars, job fairs,

government employment reports, and decision making worksheets [16] are all tools that could and should be utilized in a structured approach to support the student's declaration of an appropriate major.

Conclusions

As engineering educators, faculty assume that enrolled students are committed to their major. However, this inquiry indicates that few students are sure of their declared major upon enrollment, and that a lack of confidence in their decision may correspond to low motivation and performance. Indeed, a conflict of interest may arise between those educators who desire to maintain and increase enrollments in their department by requiring students to enroll at the earliest possible date, and those students who are unsure of their decision and are willing to relinquish their decision to a distinguished authority. This conflict is further exacerbated by the continued need to cram more content into the engineering curricula, thereby forcing major-specific content to the freshman year.

The primary recommendation of this inquiry is that the declaration of major be removed from admissions forms to thereby ensure at least a common first semester prior to declaration of major. The results of this inquiry suggest that students will make more informed decisions regarding their choice of majors, have greater confidence levels in their declared majors, and subsequently have higher levels of motivation and performance. The recent emphasis on increasing engineering outreach will certainly provide engineering schools with increased opportunities to improve their curricula through significant federal dollars. As such, the future for engineering education is extremely bright should the community choose to provide a vision and plan.

Dedication

This paper is dedicated to Dr. Philip Barkan. Phil was considered a pioneer in engineering education and the Design for Manufacture field. Phil was a caring mentor, insightful researcher, and a good friend who fundamentally changed my life. My memories of him continue to inspire me.

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Biographical Sketch

David O. Kazmer, P.E., is a graduate of Cornell University (B.S., 1989) and Stanford University (Ph.D., 1995). He has previously been an engineer at General Electric (1988-1992), a faculty member at the University of Massachusetts Amherst, Director of Research & Development at Dynisco. He is currently an Associate Professor with the Department of Plastics Engineering at the University of Massachusetts Lowell, where he conducts design and manufacturing research pertaining to net shaped products, and plastics in particular. His research and teaching spans design of products, production machinery, instrumentation, and control systems through start-up and performance measurement.

Dr. Kazmer received the 1998 National Science Foundation CAREER Award, 1999 Lilly Teaching Fellowship, 1999 Young Investigator Award from the Office of Naval Research, and the 2000 University of Massachusetts Outstanding Engineering Junior Faculty Award. He currently serves as Chair of the ASME Technical Committee for Design for Manufacturing. Dr. Kazmer has an active interest in engineering education and professional practice, for which he teaches the introductory engineering course to all incoming students on the Lowell campus.