Unexpected Consequences of Thoughtful and Innovative Engineering Education Curricular Reform: Identifying Competing Orientations and Sources of Pressure

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Abstract – Engineering professionals committed to thoughtful and innovative engineering education curricular reform consistent with ABET are acutely aware of the struggles associated with interdisciplinary collaboration. Within the context of accreditation requirements, ideally administrators and faculty work together with input from alumni, advisory boards, employers and students to continuously improve their academic program. But in reality various stakeholders end up being sources of pressure for change, and hence form the basis of a potentially unhealthy competition. This manuscript seeks to identify concerns, provide narrative examples, and detail several *un*expected outcomes (anxieties, execution, assessments, etc.) that can result from the collision of competing philosophical, disciplinary and pragmatic orientations to the scholarship of teaching and learning in engineering. Specific supporting documentation comes from a civil engineering senior design capstone course, a course where faculty, industry, clients and an advisory board are directly involved in varying degree.

Keywords: ABET, curriculum.

INTRODUCTION

Since the introduction of ABET 2000 criteria, engineering programs have been strongly encouraged to justify current practices and/or reform curriculum in order to demonstrate that their students attain specific program outcomes. While the accreditation requirements have remained relatively stable over the past decade, anticipated revisions to program outcomes will require programs to demonstrate that graduates can explain key concepts and problem-solving processes in management, business, public policy, public administration, and leadership. Furthermore, the 2008-2009 revisions to the ABET Criteria for Accrediting Engineering Programs includes new recommendations about curriculum requirements (Criterion 5: Curriculum) for the professional component that detail the amount and type of mathematics and basic sciences as well as integration with the core engineering content in order to achieve accreditation. ABET serves as an important catalyst for engineering curricular reform whether engineering programs embrace these changes or not.

For the past decade, engineering professionals have been preoccupied with designing and assessing courses to satisfy ABET engineering criteria [1]. The purpose of the current manuscript, however, is to identify concerns, provide narrative examples, and detail several *un*expected outcomes (anxieties, execution, assessments, etc.) that can result from the collision of competing philosophical, disciplinary and pragmatic orientations to the scholarship of teaching and learning in engineering. In order to achieve the purpose we will identify the concerns and pressures typically related to undergraduate engineering curricular reform, provide narratives as exemplars of each pressure, and enumerate the unexpected outcomes in order to provide recommendations for thoughtful and innovative future reform.

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CONCERNS AND PRESSURES

The prominent stakeholders to consider when implementing curricular changes are the faculty, administrators, and students most affected by the changes. Understanding the nature, force, and impact of potential pressures will ultimately help to facilitate intentional curriculum implementation. A graphical representation of the prominent stakeholders and potential pressures are illustrated in Figure 1 where the authors have attempted to quantify the interactions between the various components in a typical undergraduate engineering education program. The strength of each pressure is portrayed by the weight and size of each line. Additionally, the overall importance of any specific component is represented by the size of the corresponding circle. It is important to note that it is beyond the scope of the current manuscript to include pressures inherent in industry and within the educational system that are not directly relevant to curricular reform. Hence, extraneous facets of the academic community (e.g., student life, extracurricular activities, research, work schedules, publications, service, personnel issues, budget reports, etc.) are not considered in this discussion.

For engineering faculty, the most apparent source of outside pressure emanates directly from ABET. However, the source of pressure for changes to ABET criteria stems from professional societies (e.g, ASCE, ASEE, ASME, IEEE, etc.) Therefore, ABET is presented *near* the top of the model because their requirements exert the most direct and powerful outside influence on curriculum, but the link between ABET and professional societies should not be ignored. The link is especially important because it is influenced by the perception(s) of an "ideal engineer." The concept of "ideal engineer" originates from several sources (e.g., professional societies, administrators, faculty, industry, etc.). It is the perception of the "ideal engineer" that originates from professional societies which is then translated into ABET requirements that influences specific engineering criteria and graduate qualifications. These criteria and qualifications are then directly integrated into engineering curriculum. To realize the actual influence of ABET, we need only to reflect on the changes that were made in engineering programs and procedures across the nation as part of ABET2000. Programs were either compelled to make curricular and procedural changes or face the consequences of probation loss of ABET accreditation. Recently, an engineering department of a prominent university made the decision to formally change their program/degree name (and related curriculum) in order to reduce the demands imposed by ABET accreditation reviews.

Another source of pressure on ABET originates from Industry/Employers and other advisory boards. Though their influence is minor compared to professional societies, they must also be considered. Industry/Employers also impact the curriculum directly, though not with the same force as ABET and typically through advisory committees, as well as alumni. It is critical that programs faced with curricular reform understand that no curricular changes will take place without faculty approval and commitment. One extreme (but valid) argument is that the only curricular changes that are possible occur because of faculty influence. From this perspective, the faculty will indirectly encounter the same pressures as those exerted on the curriculum.

Of course there are other influences/pressures that are present in engineering programs. The curriculum is implemented one class at a time, so this top down pressure manifests itself through general program requirements (GPA, credit hours, etc) in specific courses. The faculty member responsible for a particular class has his/her own ideas and standards which will be implemented through the course content and requirements. Whether realized or not, students also have limited influence on courses which is manifest through their choices to enroll in different courses, schedule a course based on instructor assignments, or transfer to another program, as well as their in-class collective abilities. This same type of student pressure, albeit minor, can be placed on faculty through similar mechanisms, as well as through course evaluations.

Faculty feel equal pressure from administrators, curriculum, individual course requirements and, to a lesser degree, from students (+7). The curriculum creates pressure as the faculty must present the offered courses as part of their work effort and understand how the various classes interact to support the curriculum (prerequisite expectations, student advising, elective and required courses). Furthermore teaching responsibilities can be assigned or faculty can volunteer. The course requirements, while set by the instructor, create pressure through normal course administration (grading, assignment creation, etc) and content coverage. Faculty pressure will only increase as ABET requirements expand to include business, management, public policy, and leadership requirements. Administrators also exert influence on faculty with expectations for quality teaching evaluations, negotiated work distribution, course assignments and support resources. Of course this influence/pressure has the potential to diminish over time—especially after faculty earn tenure.

Administrators feel pressure from various sources (+8), but none as great as the pressure to receive and maintain

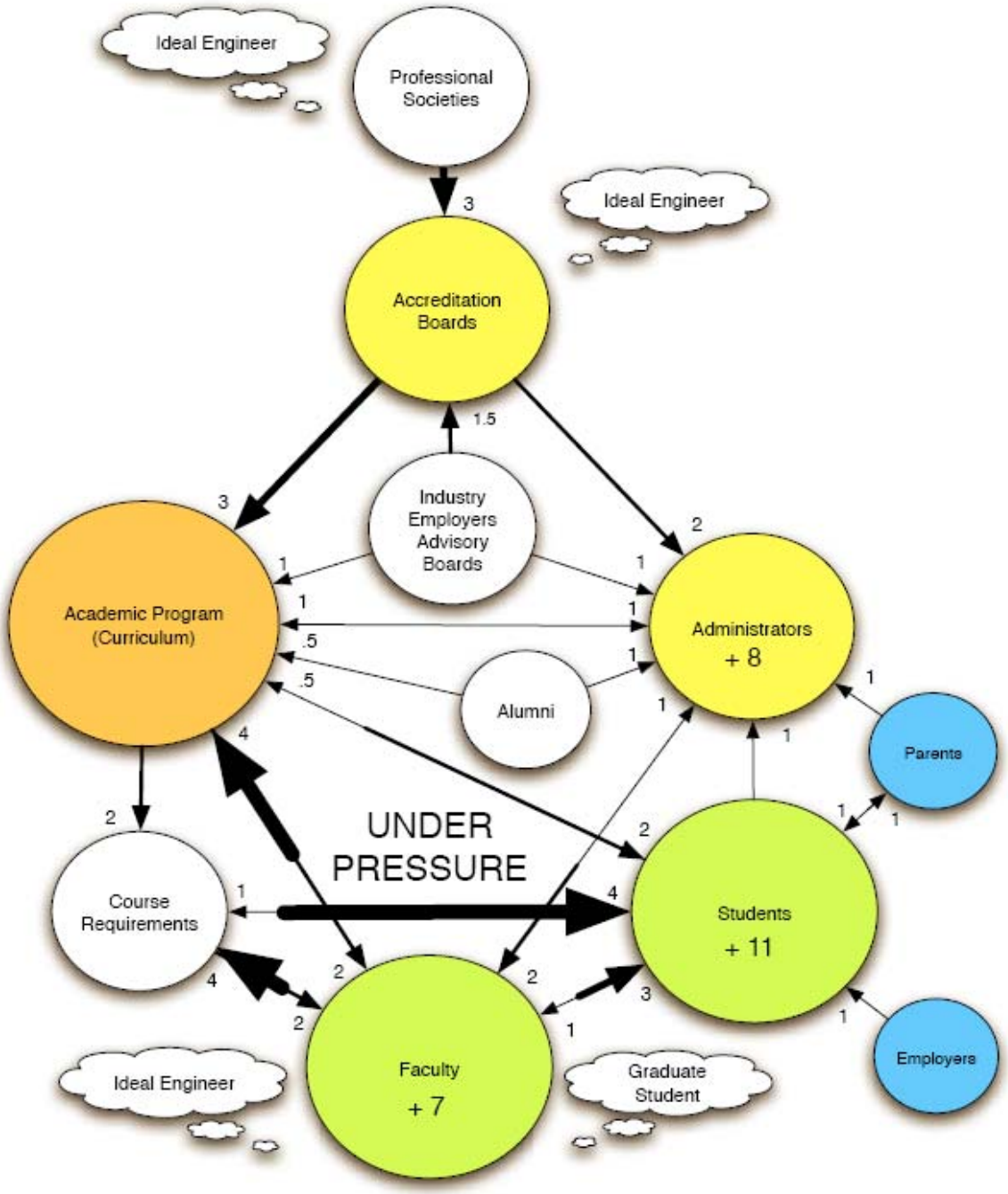

Figure 1. Prominent stakeholders and potential pressures of curricular reform.

program accreditation. There is some pressure exerted by the faculty, mainly associated with resource allocations and to some extent teaching assignments, as well as alumni (donations and associated expectations), industry advisory boards (number and quality of graduates), parents (educational cost and timeframe) and students (overall student experience).

Finally there are strong pressures felt by students (+11). Students receive the greatest pressure from the course requirements. After all, if they want to graduate and call themselves an engineer, they have to perform well in each class. But students also feel strong pressure from faculty who must evaluate student work, present course material and administer the class. Furthermore there are real and limited pressures on students from parents (time and cost) and employers (grades, personality, job qualifications, etc).

In Figure 1, the authors attempt to quantify the amount of pressure experienced by any particular stakeholder. The quantitative significance is based on the relative magnitude, rather than the number itself. There are two points of contention. First, some faculty might be inclined to dispute the assertion by the model that students (+11) are under greater pressure than faculty (+7). However, because the pressures illustrated in the model relate only to curricular issues, these relative pressures are accurate. Other pressures on faculty—outside curricular issues—include conducting research and publishing, providing service, directing graduate students, etc., are not included in the model or the current discussion. The second point of contention is that administrators (+8) —as individuals who have no direct connection with curriculum or delivery do not experience greater pressure than the faculty (+7). However, there are several additional sources of administrator pressure not experienced directly by the faculty (i.e., alumni, parents, etc). In sum, while no one source contributes a significant amount of influence on conducting curricular reform, many sources contribute to the overall pressure.

COMPETING ORIENTATIONS

As one could image with all these interactions, or pressures, there are ample opportunity for conflicts, or competing orientations. For instance administrators want more students for more resources, but more students mean bigger class sizes and hence greater effort in administering a class and/or great need for resources to handle the larger number of students. Moreover, students want less coursework and better/clearer explanations of the material. Faculty spending the time to address different learning styles coupled with the underlying pressure of content coverage leads to direct conflicts.

Philosophical conflicts are also apparent between faculty and accreditation boards about the ideal outcome of an undergraduate engineering curriculum. Many faculty are concerned that ABET accreditation seems to focus on applied skills required of ideal engineers while minimizing the impact of undergraduate engineering curriculum to prepare students for graduate education.

Other pragmatic conflicts arise as faculty attempt to reform and sequence an already packed curriculum with content that seems to extend beyond the limits of faculty pedagogical expertise (e.g., management, leadership, communication, etc.). When taken to the extreme, faculty resent the unrealistic demands being placed upon them by professional societies, accreditation boards and industry advisory boards.

Perhaps the most volatile competing orientations occur between students, faculty, and accreditation boards during the actual execution of curricular reform. Students perceive the inclusion of teamwork and communication training as time-consuming, unimportant, and fluff while faculty feel unprepared to teach and assess performance skills. Pressure on faculty can result in the omission of many ABET requirements from course requirements as a strategy to appease students and ease student pressure.

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NARRATIVES AS EXEMPLARS OF PRESSURE

Perhaps the best illustrations of the nature, force, and impact of curricular pressures can be found by examining the narratives which are provided during graduating senior exit interviews and surveys. Students are acutely aware of

their deficiencies as they approach assignments in capstone design courses and are faced with increasing pressure from both faculty and the course requirements. For example, ABET requires that all graduating students complete an interdisciplinary "capstone" design course. The course requires students to work extensively in teams, draw on all previously learned content, and translate their work in written documents, graphical summaries, and oral presentations.

As is illustrated in the model, students feel the most significant pressure from course requirements and from faculty. Several narratives serve as exemplars of this pressure. For example, students frequently express concern about the lack of specific guidance and the resulting pressure. "*I wish we were given what a professional report (for each deliverable) would consist of and look like before we began each task*" or "*often times it felt like we were thrown into an assignment without having the vision and basic knowledge of what was to been done."* Another source of student pressure comes from the interdisciplinary nature of the projects. *"The senior design project should be discipline-specific. Structures, transportation, construction, water, and geotechnical should all have independent senior design courses to provide a more in-depth project for a student's particular area of interest."* Perhaps the most dominant of student pressures originates from the amount of time and effort that was required to complete the course. "*The curriculum did not include enough technical content to complete our project*" or "*the course should be taught over two semesters."* The primary source of pressure on students from faculty is expressed by students concerning the nature of grades. "*Due to the subjective nature of our deliverables, grading was very frustrating for our group since grading variability was of greater significance than in previous classes because there was no one correct solution."* For some students, the pressure is seen as overwhelming and unmanageable. *"Let students take the course the semester before their graduating semester. In our last semester, we are completely burnt out on school."*

Narratives from faculty illustrate shared and increasing pressure from students, the overall academic program (curriculum), course requirements, and administrators. Engineering faculty are frequently confronted with student concerns about the amount or type of course requirements. Statements such as, *"do you really want us to include ALL of these components in our written report"* or *"we need you to tell us where to find the information we need to solve the problem and how you want us to present it."* Additionally, the overall academic program curriculum puts pressure on faculty to remove technical engineering content from the curriculum in order to accommodate ABET and the "soft side" of engineering. These pressures are apparent in several faculty narratives including, "*the level of technical contents can be higher,"* or "*I would prefer to see students get a little bit more technical on the subject,"* and *"unfortunately, it seems that the style and presentation are the emphases."* With respect to course requirements faculty typically confront pressures when faced with evaluating non-engineering assignments (e.g., oral presentations, team productivity, leadership) and will state, *"I don't feel prepared to objectively assess inherently subjective performances like oral presentations."* Finally, faculty feel pressure from administrators when they hear, *"students are complaining that your class is too difficult—you should back off on the workload."*

There is a recent trend in capstone design courses to involve outside professionals to provide technical assistance and feedback. The addition of outside consultants and their accompanying narratives provide a stark contrast to student narratives. For example, engineering professionals who are not academics frequently respond favorably to their experiences with narratives such as "*Quite simply put, I feel the class offered a real world perspective of the trials, tribulations, and duties of an engineer"* or *"students were reminded that civil projects are for the people and that their concerns, which are not derived from a formula, must be addressed and accommodated."* Some of their comments, however echo concerns and increase faculty pressure. For example, *"sure, the class was a great deal of work but my love for working with students probably caused me to spend more time than I should have. Protect your volunteers from themselves***"** or "*the students didn't even scratch the surface of the amount of work that actually goes into a complete design project.*" Likewise, outside consultants suggest that "*there is a lot of material covered in a short period of time—was it too much?"*

Taken together, these narrative exemplars illustrate the some of the most frequent pressures and conflicting demands on all of the significant stakeholders when attempting thoughtful and innovative engineering education curricular reform.

LESSONS LEARNED

Several unexpected consequences are apparent when considering the prominent stakeholders and potential pressures of curricular reform. The most salient is that curriculum developers need to be aware of, and take into consideration, how the pressures interact to improve or diminish the outcomes of the "ideal engineer." Another

lesson learned is that curriculum developers must balance concerns that curriculum not be overly applied to the detriment of theory and other scholarly pursuits (e.g., graduate school). One potential consequence of internal and external pressures is that faculty may reduce rigor in order to enhance student satisfaction. When confronted with pressure from students to make changes, faculty (with encouragement from administrators) might be tempted to oversimplify the courses that are typically used to assess ABET outcomes. When modifications are attempted, the resulting curriculum is perceived by some students as less rigorous. Furthermore, if major changes occur, ABET assessment and the resulting documentation is made more challenging. Finally, if the pressures are not managed, there is a risk that engineering programs may choose non-compliance as a strategy for dealing with ABET pressures. This may be especially true as ABET 2010 continues to broaden the interdisciplinary focus (e.g., business, communication, public policy) that many engineering faculty perceive as going beyond their scope of influence.

CONCLUSION

The current manuscript has attempted to provide a comprehensive model to identify curricular pressures and sources of concern, provide narrative examples, and detail several *un*expected outcomes related to curricular reform. Based on the model, and considering only the prominent stake holders (faculty, administrators, and students), the students feel the most pressure. The underlying significance of the model is that pressure can attenuate the impact of any individual change. In other words, when changes are made—either in the curriculum or class, or based upon faculty requirements (no matter what the source or motivation)—a greater impact will be experienced by students than by any other group. Hence, when faculty consider making curricular changes, they need to be aware of, and consider all of the pressures in order to create thoughtful and innovative programs.

REFERENCES

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Biographical Information

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