

## **Aiming for a System that Provides Closer to 100% of a Student's Needs**

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Over the years of thinking about what we offer to students in engineering, it is plain to see that there is a necessity to provide future engineers with the tools needed to function productively in society. When looking at how we prepare mechanical engineers it is fairly easy to see the needs of the customer. Whether it be mathematics, fluids, controls, vibrations, heat transfer, or design, the educational systems across the country and for the most part the world prepare students for their entrance into their careers. There is no argument in that, but as one looks at the whole body and not just the technical composition of our students, there is a need to continue to explore how we can provide closer to 100% of their needs and not just those of the technical body. Over the past twenty years or so, we have tried in the Department of Mechanical Engineering at Michigan State University (MSU) to delve into areas that are normally not on the radar of the mechanical engineering student. Those areas are “extras” in the teaching of students and if we take the time to question our students on what they have been asked to do outside of the technical pursuits, I believe that we will find that their perceptions of life in the real world will far exceed fluids and controls. The purpose of this paper is to look at all the things that have been experimented with over the years at MSU and in future papers prepare documentation that reflects the reactions of the students to these “extras.”

Within this paper will be a description of the attempts made to expand the horizon of our students, anecdotal remarks from students throughout the years, and a plan to gather information that, hopefully, will show that those “extras” are not really that. They are important elements in the education of the technical student, an education that must include a myriad of other topics to ensure that we have fully rounded students entering the workforce. With multiple descriptions provided, the reader should be able to see a variety of activities that could easily be incorporated at other institutions.

### **Introduction**

The focus here is not to tell people how the effort needs to be done. It is more relating things that should be explored in the education of our engineers. Yes, they need the required courses to prepare them for the life that they will lead in the outside world, but there are other things that we need to address and remind them of on their education.

As one looks at one's engineering curriculum, one notices similarities with multitudes of other programs across the country and the globe. Engineering prep courses merge with statics and dynamics; Calc 1 flows into Calc 2 and 3 and 4; Students learn design, controls, vibrations, heat transfer, and fluids. They finish their courses and they graduate as competent mechanical Engineers. This is all well and good, but the obligations of living in the real world tend to draw our students into other pursuits that require additional foundations in their education. In the year 2000 we saw ABET focusing more attention on issues that branched away from those normal paths listed above. They include communication, ethics, lifelong learning, and contemporary issues. All programs in order to become accredited had to address those ABET standards. Programs have gone through a number of 6-year evaluations and there are still issues that need to

be addressed. With this in mind, the Department of Mechanical Engineering at MSU began to investigate what needs a student might have in the real world and how the department could provide a certain amount of preparation for those needs, including ABET requirements but also focusing on additional student needs.

### **A Department's View**

Over the past years, the department focused on one critical issue in a student's education, that of communication. Long before ABET made it a point that had to be addressed, instruction in writing and oral production were included in multiple courses. Students practiced their written skills in fluids, controls, vibrations, design, heat transfer, and capstone courses. Communication was not an add on to all these courses it was an integral part of the curriculum. Short written assignments culminating in formal reports allowed students to experience a path that they would follow in their careers. The important element was making sure that this writing experience was happening on a regular basis throughout the curriculum, not as a one-time affair and quickly forgotten. Over the years, students showed that continuous practice of their writing skills did produce better writing and an attitude that communication was important in the life of an engineer. Conversation with students who graduated reflected on their understanding that to be able to communicate was truly an important part of their careers.

While communication was being instituted in the various courses, faculty started to provide their own elements to the process. Faculty carried on conversations that went beyond equations and laws. Talk before classes involved plays that had been attended, programs watched on television, and books that were being read. Suddenly faculty were not only preparing students for careers in engineering but also in the art of being able to talk about issues. If this conversation was both interesting and useful to faculty, then it became a learning experience for the students. These early talks were an asset to the program and a true broadening of the educational system.

As ABET provided suggestions for improved curricular pursuits, oral presentations became the next item to be both improved and expanded. Presentations that happened in most cases in the senior year only started to appear in courses across the engineering curriculum. Now the written elements were combined with the oral productions, thus helping to increase the importance of being able to communicate engineering not just learn it.

Then with the advent of the ABET 2000 requirements, further investigation started, focusing upon what other elements might be useful in a student's education, moving well beyond the regular path of fluids, controls and the like. The first conversation focused on a need to start putting ethics into the curriculum to a much greater extent. Within the plan for ethics, an immediate movement began to not only plan for more ethics instruction, but planning to expand into other areas that were felt to be valuable for the students' futures.

As the ethics conversation continued, it was decided that a new required course be added to the curriculum that could address many needs that were not being met in the curriculum. It was also felt that the course would be taught in the junior year in order to provide these students with materials that in most cases they had not spent any time investigating. Interestingly the topics focused on were actually in many cases those that should have been stressed in lower level

courses. But with the restraints on time and the ability to convince people to look at these topics, it fell to the junior level course to do as much as possible to literally open the eyes of the students to information that they had in some cases never heard.

As we began to talk about ethics, we discovered that many students felt that they knew everything there was to know about ethics. They knew right from wrong and that shooting somebody or robbing a bank was wrong or bad or unethical, so what else is there. As conversations continued, the world of ethics and behavior in the workplace and all the elements that no one seems to care about suddenly blossomed. One quickly realizes that ethical behavior should begin at a very early age and progress through one's entire education. Inserting the discussion of Ethics into all classes is important and at least we started the conversation.

### **ME 300 Professional Issues in Engineering**

With the focus on ethics, we immediately moved into a realm that seemed to be similar to the lowest levels of the oceans, unexplored and unknown. This area was all that is handled by the Ombuds at the university and eventually Ombuds in the real world. The current Ombuds came with plenty of ammunition and incidentally treats. She regaled the students with insights into their rights and responsibilities on campus and in life. It was truly interesting to watch the shocked looks on the faces of the students when they heard (probably for the first time) that they actually had rights. Rights that encompassed everything from being heard when they had concerns to being protected from unscrupulous teachers. By combining rights with responsibilities, this brought to the assembly the realization that this was a two-way street. You get but you also have to give.

From the Ombuds, the conversation went to what is the real world, not just a place for jobs and money, but how to approach those jobs and plan for the long future ahead. Speakers talked about the importance of planning for retirement from day one on the job. How money can be saved and how it can be squandered. They also reflected on the loss of jobs and how to make the best of the loss of employment by being ready for it and preparing long before it happens. Again, students had not been acquainted with unemployment. They were only told that they would all have jobs waiting for them. Students never seem to be told the whole story. They are deluged with the wonderful aspects of the life of an engineer when the more unpleasant aspects are left to later times when they will have little education on how to deal with them.

This quickly led to dealing with critical thinking. Thinking is obviously taught in every course in curriculum. Students think about equations. They put numbers in and they take numbers out and they get answers that correspond to the answer book. Do they spend a lot of time thinking about the ramifications of those answers and equations? In many cases – No. With all the work that is being done in other courses in looking at problem definition and trying to work out solutions, the element of critical thinking needed to be investigated. Students quickly discussed not just one answer but the necessity to spend serious time investigating as many solutions as one can find and eventually discovering the one solution to follow, then seeing if that answer really works or needs to be modified. A simple question like, "How do you get to the airport if you have a flat tire?" creates a much longer discussion than one might expect.

The idea that there are a variety of answers that have to be discussed leads to a discussion of the creativity that exists in everyone. Many engineers find it extremely difficult to realize that they are actually very creative individuals. Exercises aimed at making students create in ways that they might not have before allows for that creativity to be uncovered. Activities aimed at drawing and writing poetry help the student realize that he or she has a talent that they might not have experienced before. Sending engineers to a local art museum forces them to view artwork and evaluated their feelings about it.

Along with the creative elements, students were encouraged to look beyond what they were learning in technical classes. Writing to professors and graduate students makes one think that that is the audience of their future. When told to write, investigate, and evaluate what is written to a wide range of audiences makes a student think about the language used, the persuasive methods attempted, and how well the writing will be received. Stories were told and the students were required to analyze varieties of text that took the same story but changed the audience, the language, and the tone of the text. This provided the students with insights into how they would be shifting their text across many audiences in their futures.

And now because the future has been mentioned, one element of the student's future that should be spoken of much earlier in their education is graduate school. Many of our undergraduates hear little or nothing about graduate school until the closing days of their undergraduate years. There is complaint about students not flocking to graduate school, even when we fail to speak of it early enough to capture their attention and literally lure them away from quick jobs in industry. At least by talking to them in their junior year, we can in many ways convince them that graduate school has a place in their plans. Contact with faculty who talk about how graduate school worked for them along with emphasizing research that might catch the students' attention was a good element of the course.

One of the last things discussed was the infamous recommendation letter. Many faculty dread that horrible experience where John or Mary walk in and say, "Could you write me a letter?" The student has not seen the professor for three years and wasn't especially memorable in the course that the professor taught. At least now, the professor knows the student's first name. Much discussion goes on about cultivating individuals who might write letters of recommendation. Have they seen the student before? Do they remember that student? Did the student make an effort to go to office hours? Students fail to realize that it takes real effort to put together a well written letter. One of the exercises done was for students to write letters about a fellow student and recommend them for a job or institution. The students are then given the task of writing their own letters with the idea that when going to ask someone for a recommendation you should bring along a draft for the individual to at least have as a guide.

With all the above, the response has been extremely good for a variety of reasons. One focuses on students feeling that the content is aimed at elements within their education that have been passed over because so many other things are felt to be more important. In many respects, they need to hear items for which they will benefit in the future. Whether it be rights or ideas of preparing for retirement when you are 22, the student focus is the important element. They have felt that they are the center of the course. They are not just learning about what is required to be a

successful engineer, they are finding out what will make the life of engineer all that more exciting and valuable to them. In the following table we look at some of the topics that were presented, the assignments given for them, and the reactions to the topics.

Table 1. Topics in ME 300, types of Assignments, and Reactions

Item in Class	Assignment example	Reaction
Ethics	Research current examples of unethical behavior	The consensus was, “Why haven’t we talked about this earlier?”
Rights and Responsibilities	Lecture by Ombuds	Eyes opened to rights not thought of before “Why didn’t we know this as Freshmen”
Poetry	Write poetry of any form	Never done but willing to try
Art Museum	Visit and Comment Now virtually	Many said that now they could say it was alright to go there, not just sneak in
The Future	Lectures by individuals who have experienced work in industry, government, and academia	Discussion opened to what life is really like in the working world, especially when compared to various job areas.
Economics	The world of Supply Chain	“Nobody has talked about this before”
Communication	Written and oral activities	“Good to know that it is important in engineering.”
Life in Business	Industry speakers and reflections	
Critical Thinking	Problem solving tasks and discussion	

## Conclusions

As the pandemic comes to a close, we will spend more time surveying the students on the elements they truly feel are valuable and future items that can be included to improve the current and future lives of beginning engineers. As to the pandemic, the comments about the class have been insightful. Because the topics are things that have not been broached before, the class becomes unique and many students comment on how relaxing many of the assignments are. The

variety/out of the box nature of the assignments let students heavily involved with technical engineering find a moment to simply relax. The lack of pressure provides a little light in the long days of being trapped in one location. This one focus will be another aspect to investigate further. Investigating how the students need courses that allow relaxation in our curriculum will be appropriate study to follow.

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