Multiple Avenues for Industry Input

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Abstract

Engineering programs have many types of industry connections. Examples include industry advisory boards, alumni, capstone projects working with local industry, guest speakers, field trips, customized training for local industry, and professional organizations such as the Society of Manufacturing Engineers.

All of these connections can be leveraged to inform curriculum. This paper describes how these opportunities have all been used to make changes to our program curriculum.

Introduction

As an applied field, engineering education has long understood the importance of relevance in our programs. The strength of an industry appears highly correlated to the strength of the science and engineering knowledge in that industry [1]. So a strong link between our educational programs and the industries we serve must be nurtured. We must first understand industry needs before we can develop the knowledge, skills, attitudes, and values our students require to be successful. Without this understanding, the likely result is a skills gap which can cause junior engineers to struggle when attempting to secure their first job. This gap has implications for how industry, faculty, applicants, and the general public perceive the relevance and readiness of engineering graduates to meet current needs [2].

This has become ever more challenging as technology continues to advance at a faster and faster pace. Broadbent and McCann [3] have identified some major challenges to maintaining a close connection with industry. These include motivation, appropriate skills, capacity and funding, cultural differences between academia and industry, and logistics issues. For example, academia and industry account for their time differently. Faculty often have more flexibility as long as their teaching and research objectives are met. Company personnel, however, typically account for their time on an hourly basis. Academic timetables are fixed, whereas industry often does not know what they will need to be working on too far in advance. Perhaps the most major challenge is the lack of time for both partners.

It is helpful, therefore, to maximize all opportunities to interact with regional and local industry. This paper outlines the numerous types of contact our program has with local industry and how we have attempted to use every morsel of input we can gain to inform our curriculum.

Industry Advisory Board

Like most engineering technology programs, we have an advisory board comprised of 10-12 representatives from local industry. In addition to periodic review of the program objectives and outcomes, we use our Industry Advisory Board (IAB) to gather input on specific courses. Course content has changed as a result.

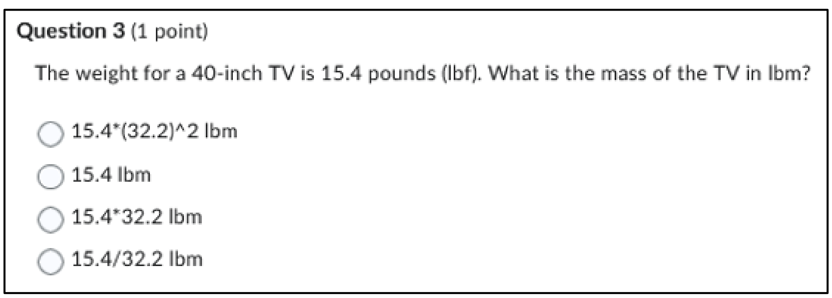
The board was asked for feedback at a recent meeting on two courses: MFET 241 (Applied Statics and Dynamics) and MFET 440 (Production Systems Control). Typically, 2 questions are prepared for each course to start the discussion.

MFET 241: Applied Statics and Dynamics

The two questions asked were:

1) What units are typically used in your company, U.S. customary units or metric units or both?
2) Is there any content related to "dynamics" that would be particularly useful for students to know, e.g. moments, energy, momentum?

The board indicated both measurement systems are used. This is typically dictated by the customer. This input was used to intentionally prepare students to use both systems and to comfortably switch from one system to another. Figure 1 shows a sample quiz question.



Question 3 (1 point)

The weight for a 40-inch TV is 15.4 pounds (lbf). What is the mass of the TV in lbm?

- 15.4*(32.2)^2 lbm
- 15.4 lbm
- 15.4*32.2 lbm
- 15.4/32.2 lbm

Fig. 1. Sample quiz question applying advisory board input.

The second question produced several suggestions including addressing any dynamics that are related to automation. Several companies in the region have been moving to automation in the last several years because they cannot find enough workers. We are currently exploring options for enhancing the automation component in our curriculum to address this suggestion.

MFET 440: Production Systems Control

The questions asked for this course were:

1) Any one report format that students should be learning before graduating?
2) What topics related to production systems would be beneficial?

The result of the first question generated a long list of suggestions related to ERP systems. Currently, we are looking for affordable options to incorporate some type of ERP training into the course project.

Input from the Board is not necessarily incorporated into the course discussed. Sometimes it is more appropriate to adapt elsewhere in the program. Regardless, the input is deemed valuable and still used. For example, the second question for this course resulted in the suggestion to train students to *do* training. Have them actually create training modules and write procedures so the technician can understand them. Students need to be able to write procedures not for another engineer, but for the lay person. Specifically, the Board said, “so a 3-year-old can understand them.”

Even though the program already emphasizes the importance of engineering communication, it would be very beneficial to incorporate this experience into the program. Although this has not been added to the course in question, it has been incorporated into 3 other courses.

Course 1: MFET 343 (Computer Integrated Manufacturing) asks students to practice creating instructions with clear communication. An example is in Figure 2.

> 5. Please create an instruction of how to set up z = 0 (*Part zero, tool number: 2*). Assume that readers don’t know how to set up.

Fig. 2. Instructions for lab assignment applying advisory board.

Course 2: MFET 345 (Production Processes) already had students create a procedure sheet for creating a center punch on the lathe. See Figure 3. The goal was for students to learn how to think through the order of operations. However, this is a prime opportunity to incorporate the Board’s suggestion. Expectations were modified so that students are now graded on the appropriate order of operations *and* the clarity of the instructions in the procedure sheet. See Figure 4.

<u>Materials:</u> One piece of ½" diameter 1144 "stress proof" steel

<u>Procedure</u>:

1. Write up a procedure sheet for turning your punch as per print.
   Have it approved by the instructor ***before*** cutting your stock. This is graded!!
   Note: You must include the length at which the round stock is to be cut and the angle at which the taper needs to be set.
   [*Expect at least 2 days for it to be graded, approved, and returned.*]

2. Do **NOT** cut your metal without instructor approval. Then machine as per print.

3. Use the center grinder to polish the tip surface before heat treating.

4. Heat treat the punch as per the class demonstration.

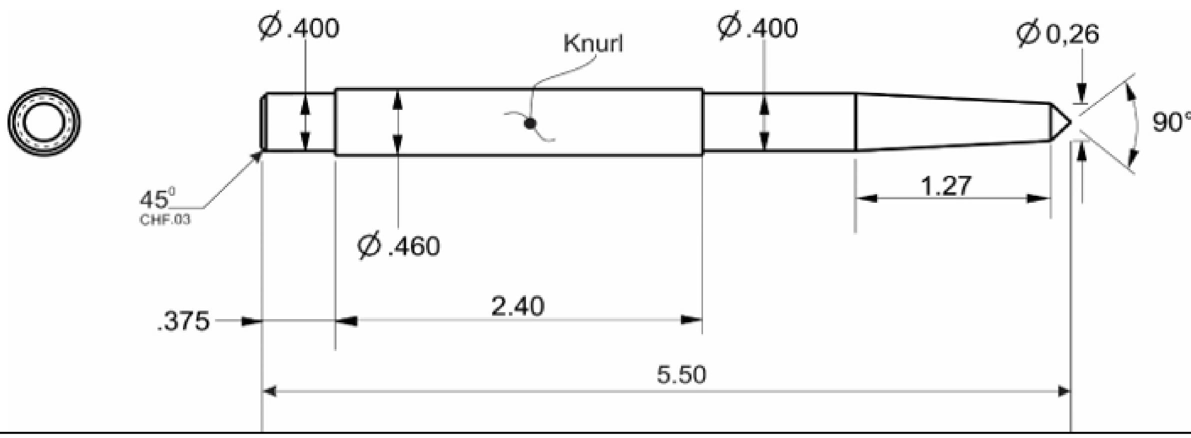


Fig. 3. Original lab instructions for the center punch.

<u>Procedure</u>:

1. Write up a procedure sheet for turning your punch as per print.
   - Type the instructions to ensure they are legible.
   - Be sure to include *every* step.
   - Write the instructions so that a technician will know exactly what to do.
   - Use terminology that someone without manufacturing experience can understand.
   - You will be graded on the order of operations AND the clarity of the instructions.
   -

   Have it approved by the instructor ***before*** cutting your stock. This is graded!!
   Note: You must include the length at which the round stock is to be cut and the angle at which the taper needs to be set.
   [*Expect at least 2 days for it to be graded, approved, and returned.*]

Fig. 4. Altered lab instruction for the center punch.

Course 3: MFET 446 (Manufacturing Concepts) explores the management side of the profession. Included is a unit on safety. A new homework assignment was developed. See Figure 5.

1. Read the scenario below describing a task that must be done. Write a set of instructions on exactly how to complete this task, being sure to train workers on how to do each step safely.
    a. Go to the Metals Lab. Carefully walk through the entire procedure so you understand every detail.
        - Take note of any possibilities of performing any step incorrectly.
        - Note any safety concerns, including possible MSD's.
    b. Create an instruction sheet for completing the task.
        - Use pictures and/or diagrams.
        - Write clear instructions so that anyone, even someone without manufacturing experience, will be able to understand them. (Do not write for another engineer!)
    c. Partner with another student to create an instructional video to use with the instruction sheet. Both the video and the instruction sheet should be able to stand alone (each provides sufficient instruction without the other).

Fig. 5. New assignment for safe task instructions.

We have several practices that promote valuable input.

- First, each meeting begins with a quick summary of all the changes made to the program as a response to input from the previous meeting. This ensures continued input from our IAB because they can see we are listening and are effectively using their input to make changes.
- We distribute the agenda a few days before the meeting so members are more prepared to respond.
- We do little talking in the meetings. After giving the quick summary of changes and a very brief update on the program, we switch to asking questions and listening carefully to their responses.
- We document the results and discuss at a faculty meeting where the suggestions can be implemented. It is best if the ideas are written down along with an expected date for implementation.
- We engage with board members in other ways throughout the year when possible. For example, we sometimes connect with board members at other community events, take students to their facilities for tours, discuss needs of the program with a board member who is knowledgeable in that area, etc.

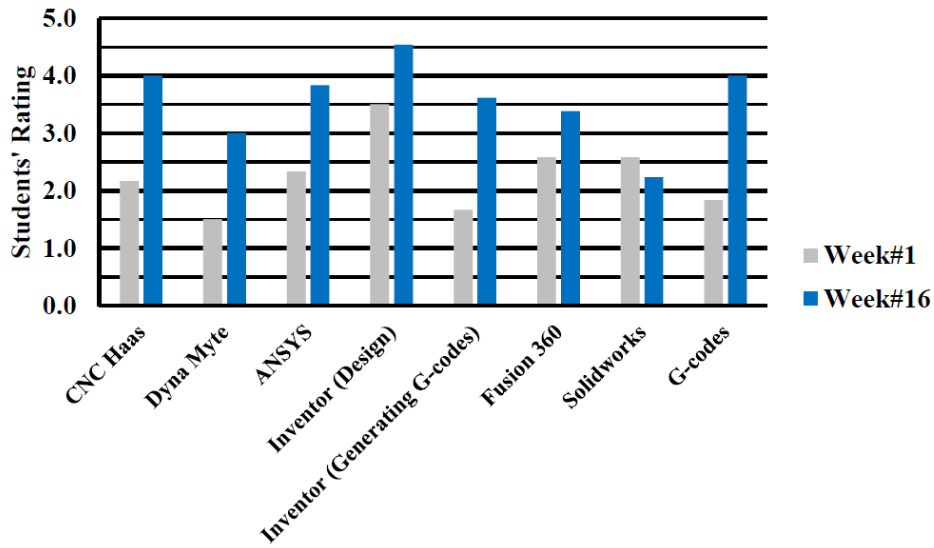
Alumni

Alumni of the program often stay connected to the faculty. Several have indicated the value of having learned different software packages while in the program. This has provided motivation to continue looking for opportunities to incorporate other software such as ANSYS and Fusion

360. This was reinforced at an Industry Advisory Board meeting when the members indicated familiarity with various software would be valuable.

MFET 343 (Computer Integrated Manufacturing) intentionally introduces students to several software packages. The instructor surveyed the students. Results are in Figure 6.

Survey questions: Please evaluate your experience. For numerical data, 1 = Never used before, 5 = lots of experience on this.



** Solidworks was not covered in ETS343. It was used as a control group in the surveys.*

Fig. 6. MFET 343 survey result – Week #1 and Week #16 – Fall 2020.

There is much literature on how to engage with alumni in general. For the purposes of curriculum improvement we have found the following tactics helpful.

- Develop a good relationship with as many students as possible while they are in the program. This makes it natural to stay connected for some time after graduation. These alumni readily offer insight into their professional lives the first few years in the field. This can provide many suggestions for improvement, especially if there is a consistent theme that emerges. For example, a number of our graduates are hired specifically because of their deep knowledge of lean manufacturing. This encourages us to maintain that focus. When several alumni mention the same lack, we can move to mend that gap.
- Use the alumni to connect with the company as well. For example, two recent graduates are now working for a local company. The company has discovered these graduates are a very good fit for some of their needs. They have started reaching out to us to offer tours, guest speakers, etc. to develop a relationship with us. Thus, the alumni have provided an avenue for yet more industry input.
- Many programs have some alumni on their industry advisory board and we have found this useful too. They are in an excellent position to give input into the program since they are intimately acquainted with it.

Capstone Project

Our program has students complete a two-semester capstone project that tackles a real problem from a real company. Weekly meetings with each student team allows us to identify any content or skills the students lack. While every project will naturally require additional learning in some areas, if a pattern emerges, this common lack can be identified and then incorporated into the curriculum.

A common issue that was observed throughout the first couple years of capstone projects was the lack of professionalism in the email communication between the students and the company. Since a course outcome is to "consistently interact in a professional manner," this had to be addressed. The course now includes some training on how to write a proper email. Figures 7a-d show some selected questions from two new assignments based on readings from "Wait, How Do I Write This Email?" [4]

1. Rewrite this email remembering to make your point at the beginning. (Note: In a later book, Rubin calls this the BLUF method for **B**ottom **L**ine **U**p **F**ront.)

   Clarence,

   I am the operations manager of the Centerville facility working with a development team in the New Products Division. You and I met last year at the company-wide quality training event. My project team has been stumped regarding the need to improve the quality of the XF-8 product line. We have determined the issue is likely in the underlying chemistry of the polymer. However, none on the team have the experience to determine if our alternative choices will react better with the injection molding process. We need to talk to an expert on polymers. We would like to run these suggested alternatives by you and get your expert opinion on them. Do you have a time when you can meet with our team to discuss this?

   Sincerely,
   Esmerelda

   Sample Solution:

   Clarence,

   We met last year at the company-wide quality training event. My current project requires an expert on polymers. Would you be able to meet with my team? We need to improve the quality of the XF-8 product line. We believe the issue is likely in the underlying chemistry of the polymer, but we do not have the experience to determine if our alternative choices will react better with the injection molding process.

   Sincerely,
   Esmerelda

Fig. 7a. Selected question from new assignment on proper email construction.

3. Correct this email according to advice from the book.

    Peter,

    Good morning!

    I am really relieved to tell you we were able to complete repairs on the CNC machine on Line 2! Believe it or not, the exact part we needed was in stock at the hardware store down the road!! We can move forward and complete this order ahead of schedule!

    Just wanted to give you the good news!

    Raj

    Sample Solution (remove all exclamation points):

    Peter,

    Good morning. We were able to obtain the needed part and repair the CNC machine on Line 1. We will be able to complete this order ahead of schedule.

    Have a great day,
    Raj

Fig. 7b. Selected question from new assignment on proper email construction.

14. Craft an appropriate email signature. The key is to be sure your preferred method of contact is prominent and there is not a lot of excess.

    Solution: look for name, contact info, little else

Fig. 7c. Selected question from new assignment on proper email construction.

10. All 4 sentences below contain the same information. Which one do you prefer to read? (Hint: Do you even need to actually *read* them? If YOU prefer to read the shortest sentence, don't you think your reader does too?)
    a) The most appropriate method for this project would be to use a MIG welding process because the wire-feed aspect of this process can be automated without a lot of undue complications that could be problematic.
    b) The method the team has decided to recommend is the MIG welding process since it has been shown that MIG welding can be automated without too much difficulty.
    c) The method of choice would obviously be MIG welding since it is relatively easy to fully automate this process.
    d) The best method would be MIG welding since it can be fully automated. *(solution)*

Fig. 7d. Selected question from new assignment on proper email construction.

The needs of the capstone students also prompted a proposed change in the degree map for the program. Projects most often have required knowledge of facility layout and ergonomics. These topics are currently included in two courses taught in the senior year. The proposal is to modify these courses and move them to the junior year. Two junior-level courses will also be modified and moved to the senior year in their place.

To find areas of improvement through this connection, we find the following strategies helpful:

- Insist students act as professionals and train them in this skill. Companies are more likely to continue a relationship with us when they have a positive experience. This leads to more opportunities for input.
- For the same reason, set expectations on communication between the students and the company. All communication, including email, should be professional.
- Make expectations very clear to all. We work with the students to create a document detailing the deliverables and timeline so that the company knows exactly what they will receive from the arrangement. Again, this promotes a positive relationship which helps maintain the connection.

Fall of 2020, during the height of covid, the expectation was that we would need to find alternative projects for the students. But even before deciding whether or not to send out a request for projects, companies approached us. Before the fall semester started we already have more than enough projects offered to allow all students to continue working on company-sponsored projects. Insisting on professionalism was likely a main factor driving this response from the companies.

Guest Speaker

Industry professionals are sometimes invited to speak to a class. Careful observation of their presentation has sometimes led to small curriculum changes.

A local manufacturing engineer was invited to speak to a class on the topic of leadership. Several aspects of his talk were later incorporated into this class, e.g. the effects of poor leadership, and discussions on which style of leadership is best under different circumstances.

A course in safety invited a safety expert to speak. He had over 30 years of experience in the field, was a dynamic speaker, and had intriguing examples of cases he had dealt with. He emphasized several important points, such as what to expect in the field (you will see blood, you will be on call 24/7) and how critical it is to have owner buy-in and support. A main point was that safety and productivity must balance. Without a productive workplace there will be no need for safety because the business will likely fail. The goal of the workplace is to have a high level of efficiency/productivity with a low level of loss/injury. The course content was modified to ensure this important point was addressed in future classes. Figures 8a-c show a newly developed class discussion prompt, follow-up quiz questions, and an exam question that all address this concept.

<u>The Goal</u>

a) What is the basic goal of any manufacturing company (really, of any business)?
Produce a profit – the bottom line!
Without a profit the organization will not be viable, it will fail

b) To accomplish this need, what is the goal for all of production?
A high level of efficiency/productivity

c) How does safety enter into the equation?
Modifies the goal: Have a high level of efficiency/productivity, but with a low level of loss/injury

d) "Safety first." Is this true?
Actually, no. Safety and productivity MUST balance.

Fig. 8a. New class discussion prompt.

2. According to class discussion, is this statement true or false? "Safety first."
FALSE

3. Safety must balance with
    a. production. *(solution)*
    b. claims reporting.
    c. personal issues.
    d. environmental protection.

Fig. 8b. Quiz questions.

4. What is wrong with this statement? "Safety first!"
    a) Words are not enough. There must be a tangible reward or workers will not take safety seriously.
    b) Safety actually comes second after ensuring the workers needs are met (as in Maslow's Hierarchy of Needs).
    c) Safety must be balanced with production because without production there will be no need for safety. *(solution)*
    d) It is not emphatic enough to convince the workers that safety must be their primary concern.

Fig. 8c. Exam question.

It is important to take notes during the presentation to highlight what the expert believes is important enough to share with the next generation of professionals. It is also helpful to note which topics elicit student engagement. Compare these points with the course content. Perhaps a few changes to the course would better align with current trends in the field.

Field Trip

Field trips are another avenue for securing industry influence on curriculum. We arrange for a field trip to a local manufacturing facility for nearly every junior and senior class. The goal is to provide students with the opportunity to see a variety of types of facilities before graduation (small, large, modern, traditional, plastics, metal, food, etc.) This alone is a valuable way to connect industry to the curriculum. But the field trips occasionally prompt deeper changes.

For instance, students in ETS 448 (Applications of Composite Materials) have a facility tour to Carfair Composites. Composite manufacturing processes, such as Resin Transfer Molding, are addressed in the class before and after the tour. In addition, new labs related to carbon fiber and fiber glass were developed after the first tour to this facility. Students now have a unique opportunity to see actual products, such as carbon fiber and fiberglass, in several labs. These labs use 36 different carbon fiber and 24 different fiberglass samples. See Figure 9. A lab involving hardness testing was also developed from the composite material samples provided by the composite materials company.

Lab 2: Carbon Fiber Lab

Names: ____

Please look at carbon fiber samples (36 different carbon fiber samples) and answer the questions below.

PART A (Page 1-3): (In HH215 – use samples)
PART B (Page 4): (in HH212 – search info using a computer)

Part A. Carbon Fiber – Weave Types Drawings (in HH215 Classroom)

1. Please find these weave types from the samples and i) draw the pattern: (don't need to be very accurate, but need to clearly show the difference between each type.) You can simply draw the pattern as shown the figure on the right. Also, ii) write model number (e.g. F-835) of the sample that you select to draw.
   ** EPI: End per Inch*
   ** PPI: Pick per Inch*

Plain

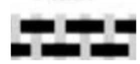


Fig. 9. New ETS 448 Carbon Fiber Lab.

To get the most out of a field trip, it should be aligned with the curriculum. As seen above, the purpose in touring the composites factory was to observe current trends in the field and see if the course needed to be adjusted. We have found that when we let the company know what the students are learning, the company will tailor the tour to address that content. For example, a recent tour to Quanex cabinet door facility focused on production flow because that was a main student learning outcome in the course. Students (and the instructor) saw some emerging trends that can now be incorporated.

Customized Training

The professors in this program occasionally conduct customized training for local industry. The company will typically specify what they need their employees to know. This provides us with an opportunity to see current needs for local industry. This sometimes prompts small curriculum changes. One example is in the MFET 340 Continuous Improvement course. After developing the training for a local company, 8D root cause problem solving was added to the unit on root cause. In Figure 10, the last part of the question (part c) was added.

Consider the scenario below.

a) Develop a Fishbone Diagram for possible causes of a defect.
- You should have 3-5 main categories.
- You should have *at least* three levels represented in the diagram.
- You may do a hand-sketch but it must be readable. Or you can use JMP to create the diagram.

b) Using the most likely causes identified in part a, create an interrelationship digraph.
- It would likely be overwhelming to create an interrelationship digraph with too many causes. Select what you consider the most likely 7-9 causes.
- The digraph can be hand-drawn, but must be neat enough I can read it without an interpreter.

c) Use the 8D root cause approach with the scenario. (Respond to each o bullet.)
- Discipline 0: Problem Realized
  - How can the problem be isolated until a solution is found?
- Discipline 1: Team Creation
  - Who would be needed on the team to solve this problem? The production manager? The sales manager? The machine operator? The custodian? Etc.
  - Will the team need training? What type of access will they need?
- Discipline 2: Problem Information
  - Write a concise problem statement for this issue. Be sure a possible solution is NOT part of the statement.
  - Is the problem identified in the statement measurable?
- Discipline 3: Containment
  - Revisit the response to Discipline 0 – would this be a viable long-term solution? Why or why not?
- Discipline 4: Root Cause
  - Refer to your answer to part a with the fishbone. Which cause do you suspect is most likely? Why?
- Discipline 5: Corrective Action
  - Assume that cause was indeed the problem. What type of corrective action(s) could be taken?
- Discipline 6: Verification
  - How could you verify you solution is effective? How would you test it?
- Discipline 7: Prevention
  - Assume your solution has been verified. What action could be taken to prevent this cause from occurring again?
- Discipline 8: Recognition
  - How will you recognize the team that solved this problem?

Fig. 10. Added question (part c) based on industry training.

A good practice is to incorporate a problem the company is currently addressing into the training. This obviously makes the training more relevant to the employees. But it also gives us an opportunity to see what types of issues are being seen in regional industry. We can adjust the curriculum to better prepare students to tackle those issues.

Professional Society

The Society of Manufacturing Engineers (SME) has published a Book of Knowledge (BoK) outlining necessary knowledge and skills for a graduate in manufacturing engineering technology [5]. The BoK was created by and is endorsed by SME which represents a large population of working professionals from all industries involved in manufacturing.

The original curriculum was mapped directly to this list. While not every topic can be covered in 4 short years, all main topics and nearly all other topics were mapped to specific courses to ensure the program prepared students with the knowledge and skills the industry professionals have identified as necessary. See Figure 11 for an excerpt from this mapping (the complete map is large).

RUBRIC			DESCRIPTION	Course(s)
1			**MATHEMATICS, APPLIED and ENGINEERING SCIENCES, MATERIALS**	
	1.1		Mathematics	
		1.1.1	Algebra	MATH 112
		1.1.2	Trigonometry	345
		1.1.3	Analytical Geometry	
		1.1.4	Calculus (*CMfgE only*)	MATH 211
		1.1.5	Statistics	STAT 239
	1.2		Applied and Engineering Sciences	
		1.2.1	Metrication (SI) System	115, 240, 345
		1.2.2	Physics	PHYS 231
		1.2.3	Chemistry	CHEM 210
		1.2.4	Statics	241
		1.2.5	Dynamics	241
		1.2.6	Fluid Mechanics	242
		1.2.7	Thermodynamics/Heat Transfer	242
		1.2.8	Electrical Circuits/Electronics	270
	1.3		Materials Application	
		1.3.1	Metals (Properties, Applications)	243, 345
		1.3.2	Plastics/Polymers (Properties, Applications)	348
		1.3.3	Composites (Properties, Applications)	448
		1.3.4	Ceramics (Properties, Applications)	448
		1.3.5	Fluids (Properties, Applications)	242
2			**PRODUCT/PROCESS DESIGN and**	

Fig. 11. Excerpts from course mapping to SME Body of Knowledge.

Many professional societies have developed a similar body of knowledge for professionals in their field. Many also recommend books, workshops, webinars, etc. These are the people working in the area so noting what they are stressing is valuable input into what we should be teaching.

Conclusion

While not every source and every piece of feedback will prompt large changes, even small changes can improve a program. The Japanese word kaizen in the lean manufacturing philosophy is used to describe a cultural mindset of making constant small improvements. This can be applied to the educational process as well. We have learned to use every ounce of feedback we can glean. The sources are numerous: the industry advisory board, alumni, capstone projects sponsored by local industry, guest speakers, field trips, customized training for regional companies, and professional organizations which are predominately comprised of professionals working in the field. Each source is valuable for maintaining a relevant curriculum.

It is not just a matter of providing fully prepared graduates to the region. A strong connection between an industry and scientists/engineers will strengthen that industry [1]. This paper has detailed several examples of how we have used all connections to improve our program. The process is not complicated, but must be intentional. Any program can tap into these same sources and many likely do for at least some of them.

Most engineering technology programs have numerous connections to industry. A key to success is leveraging every one of them to improve curriculum.

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Biographies

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