# Manufacturing Engineering Technology Capstone Sequence

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Abstract

A hallmark of engineering technology education is the "hands on" learning style integrated with close industrial involvement. In following with that excellent tradition, the Manufacturing Engineering Technology program and Manufacturing Technology programs at Eastern Michigan University require a "hands on" capstone course sequence in cooperation with industrial sponsors.

"Hands on" learning and industrial integration are not new concepts. Most people agree that working with industry while in college provides students with a valuable educational experience. As with most things, it is easier said than done. The focus of this paper is not on the benefits of industrial/academic integration but rather how to successfully incorporate industrial involvement in capstone courses.

## Background

In 1993, prior to the implementation of engineering technology, the Manufacturing Technology program developed a capstone course sequence consisting of MFG 316 Design for Manufacture and Tooling, MFG 421 Manufacturing Engineering Analysis, and MFG 490 Manufacturing Enterprise Capstone. The sequence of courses emulates the product realization journey of small businesses. The first course in the sequence develops a product concept and the last course in the sequence produces and sells the product. Students in each class form a small business, select job functions, and perform the responsibilities of those respective job functions.

MFG 316 students generate original product concepts. The products developed must contain at least five discrete components. The class votes on the "best" concept and the remainder of the semester is spent developing a prototype, bill of materials, tooling, etc. The MFG 316 class forwards its concept to MFG 421 Manufacturing Engineering Analysis. MFG 421, further develops the product forwarded from the previous MFG 316 classes. Students in MFG 421 form a small business and select job functions such as design engineering, marketing, finance, sales, production planning, packaging, quality, and process engineering. They are responsible for building prototypes, tooling, and developing a bill of materials, production and sales schedule, and business plan.

In September 2003, MFG 421 accepted its first project from an industrial sponsor. The sponsor was an individual who owned a small machine shop and developed a rough prototype of his concept. He was very enthusiastic about his idea and wanted help refining the design into a product that was easier to manufacture. The sponsor was initially attracted to the Center for Product Research and Development housed within the Industrial Technology Department in the College of Technology. The Center for Product Research and Development (CPRD) was formed in 2002. It provides a vital link between University activities and manufacturing and construction industries through applied research and education. Sponsored projects in the CPRD are typically given to faculty however some projects are appropriate for student involvement. In this case the sponsor was enthusiastic about having students work on his project. A class project is typically less expensive for a sponsor than faculty research.

At the conclusion of MFG 421, the bill of materials, final prototype, business plan, final drawings, and tooling are transferred to MFG 490 the following semester. MFG 490 students produce and sell the products, both to students and to others outside the University. In the case of the sponsored project mentioned above, when the final design is agreed upon, the students will build several prototypes for testing. In this case the sponsor is unsure about pursuing a patent; however, he has requested a patent search be done to determine if there are any infringement issues.

Below is a photo of MFG 490 students manufacturing EMU’s trademark eagle. This product concept was developed in MFG 316 and further developed for production in MFG 421. Unfortunately, due to intellectual property concerns a photograph of the sponsored project discussed above is not included.

Conclusion

For all the benefits of the industrially integrated capstone sequence there are an equal number of challenges such as communication, intellectual property, and resource management. These barriers and challenges are many but not insurmountable.

Communication among the student team members, the supervising faculty member, and the sponsor(s) is extremely critical and often difficult. The benefits of good communication are not always obvious; however, the penalties of poor communication are typically very obvious and very painful.

Communication can be verbal and written in the form of emails, drawings, and documentation. In the capstone course the project manager and supervising faculty member communicate with the sponsor with the primary communication being between the project manager and the sponsor. The project manager should forward or copy their emails to the supervising faculty member. The great aspect of emails is that they can be saved easily, can transfer photographs readily, and are quick. Email is not always sufficient and verbal communication via phone calls or conference calls is necessary. Phone calls are difficult to arrange when the people involved have conflicting schedules.

The importance of complete and unambiguous drawings is often underestimated. Students gain an appreciation for accurate detailed drawings after they waste hours making the wrong part or a part that will not fit or work. They also realize that it is quicker in the end to work out the part problems during the design stage; rather than using trial and error methods by producing numerous prototypes. Additionally, students learn that arbitrarily assigning tight tolerances leads to a high scrap rate and many hours of process engineering.

Documentation, while tedious and not very glamorous to produce; is extremely important. Accurately and precisely recording what materials are needed and who the suppliers (address and phone) are prevents subsequent classes from reinventing the wheel.

Another important issue to be addressed is intellectual property. When students help develop a prototype do they have any rights connected to the product? Can students be inventors? Who owns the intellectual property? Are students required to keep their work confidential? When working with industrial sponsors those are all key questions. Some Universities have technology transfer centers to manage IP issues while other universities, such as Eastern Michigan, are developing IP policies.

When students are developing a new product or prototype with a sponsor the students must sign a confidentiality agreement. They are not permitted to disclose any information regarding their project outside the class. If the invention is patented or described in a printed publication in any country more than one year before the date the sponsor's U.S. patent application is filed or the invention was in public use or on sale in this country more than one year before the date the sponsor's U.S. patent application is filed the sponsor will be barred from getting a patent on his/her invention. Therefore it is important to the sponsor that information regarding their project is not disseminated.

Regarding inventorship, anyone contributing to what is claimed in the patent is considered to be an inventor and must therefore be listed in the patent application and patent as such. It is necessary to keep track of who contributed to the patent claims. This can be difficult especially if the project runs two semesters. The other issue is who owns the patent i.e. who is the assignee? The university and sponsor need to reach an agreement regarding ownership prior to starting the project. Students must also agree that while they may be listed as inventors the patent will be owned by someone else.

The final challenge to be discussed is resource management. Sponsors pay for materials however they may not be willing to pay for equipment. For example, a tubing bender may not be a common piece of equipment in most manufacturing labs. It could be tricky if the sponsor wants five prototypes made from half-inch diameter tubing. Outsourcing is a possibility however that drives up the cost for the sponsor. Often smaller sponsors give their projects to students to save money. Building a fixture for the project could work or sharing the equipment cost with the sponsor may work.

Also, regarding resource management, procuring materials in a timely fashion can be difficult. For sponsored projects, it is difficult to anticipate what materials will be needed prior to the beginning of the project. The requisition process, at least at Eastern Michigan, is extremely slow. A purchasing card and suppliers with online catalogs setup for credit card purchases can make the procurement process faster.

Future

In the future, the capstone courses will continue to work closely with industrial sponsors. In an effort to manage the projects the University is considering developing an Enterprise Center (EC) to be housed in the Industrial Technology Department. The EC will serve as an interface between capstone courses and industrial sponsors. The EC will also serve as an interface between capstone courses and the University.

The EC goals parallel many University strategic directions. The EC will provide undergraduate research opportunities and promote engagement and linkages with local businesses in addition to business within Michigan.

The EC will be managed by faculty and operated by students in the capstone courses. It will work with sponsors establishing expectations, work plans, costs, etc. The Center will have its own account within the University enabling the Center to deposit money from sponsors and distribute it to the capstone courses as required. In addition to resource management, the Center will also manage IP issues related to the sponsored projects.

Finally, Eastern Michigan University has made a commitment to the state funded SmartZone project. Michigan SmartZones are collaborations between universities, industry, research organizations, government, and other community institutions intended to stimulate the growth of technology-based businesses and jobs by aiding in the creation of recognized clusters of new and emerging businesses, those primarily focused on commercializing ideas, patents, and other opportunities surrounding corporate, university or private research institute R&D efforts. The Ann Arbor/Ypsilanti SmartZone envisions the entire community functioning as a virtual business incubator taking advantage of the region's rate of business formation, which is fourth in the nation.

The future of EMU’s capstone sequence includes further integration with industrial sponsors and the exploration of patents and licensing agreements. Additionally, the cross-disciplinary nature of the capstone sequence can be expanded by soliciting the participation of nonmajors (business majors, etc.). Finally, in the future, the capstone sequence can engage in real-time collaboration with capstone courses from other universities. The design, manufacturing, and business functions of many companies are geographically separated. There is no reason two or more universities could not emulate that.

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