Implementation of an Experiential Learning Strategy Based on a Classroom/Industry Partnership

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abstract

The classroom/industry connection is an often-underutilized tool, which could prove to be invaluable in an educational setting. The experience of working with an outside company in order to complete a class project not only emphasizes the importance of organization and teamwork, it also enhances the students' education through experiential learning by illustrating the processes that companies often employ. A Product Design class in the Mechanical Engineering Technology major at Rochester Institute of Technology utilizes this educational practice to supply students with real-world experience. Through this experimental process, multiple benefits are discovered, along with several pitfalls, which will serve to educate students who may encounter similar experiences as they progress through their engineering education. This report addresses these benefits and pitfalls as well as proposes methods with which to combat such problems encountered throughout the process.

introduction

The product design curriculum in the Mechanical Engineering Technology major is comprised of a series of three classes that are intended to walk the students through the entire process from the initial problem to a completed project. The three courses in the series are *Product Ideation and Concept Selection*, *Development and Design of New Products*, and *Product Realization*. Through these courses, students are expected to continually develop a product with the notion that it will be able to be released to market upon completion of the sequence.

In the first class, *Product Ideation and Concept Selection*, the focus is mainly on the problem and brainstorming phases of the product design process. First, students develop a problem statement with which to brainstorm possible solutions. From this, students are expected to create customer surveys and develop a customer requirements document. The culmination of this course involves an investigation of intellectual property for the specific product the team develops as well as a final product requirements document.

The focus of the second course, *The Development and Design of New Products*, is to provide students an experience of what it is like to develop their idea into a conceptual product before manufacturing. This consists of formulating a product specifications document and a statement

of work, along with a manufacturing and assembly feasibility study. Through this course, students complete various deliverables such as a human factors study, which analyzes any ethical concerns throughout the design. In addition, students formulate a preliminary manufacturing cost, as well as the total cost for assembly. When these steps are completed, students must create a detailed and releasable set of design drawings in CAD.

In the third and final class in the series, *Product Realization*, students are expected to follow through with their design into the manufacturing stages. This consists of creating prototypes of their design that can then be used to perform tests in order to ensure the product specifications document is met. Upon completion of this course, students have the knowledge of exactly how a deficiency in a product or process can be used to develop an effective and marketable solution.

Along with learning the correct process to develop a product, students sometimes have the opportunity to work with a company to design and develop a product that supports current technology in industry. Working with a company results in a far greater learning experience for students as many of the intangibles associated with industry are experienced. One such experience began in December 2006 in the second of the three courses at Rochester Institute of Technology. A small company in Fort Meyers, Florida, named *Dawning Technologies, Inc.* asked a professor in the Mechanical Engineering Technology department for help to create an enclosure for their medical interface unit. *Dawning Technologies* produces equipment, which is used mostly in the medical industry, to "integrate analytical devices and information systems, including improved control over system-to-system connections."[1] As a small company who specializes in the software engineering field, they do not employ the resources of a mechanical engineer. Therefore, they turned to the product design class to create the enclosure to hold the necessary circuits and equipment.

For this project, *Dawning Technologies* presented students with their product requirements document, the required dimensions and tolerances for all electrical aspects, and the intended deadlines for all stages of the product design phase. From this information, students were required to create a Statement of Work and then proceed through the entire product design process beginning with brainstorming ideas and ending with the release of CAD drawings to a manufacturer of the company's choice, based on suggestions of the students.

discussion and analysis

The lack of industry experience has been a chronic problem, which limits many graduating students looking for a positive start to their careers. Not only does the process of working with industry serve as a learning strategy, it also assists students in finding higher-level jobs as they graduate college. Because of this, many students express interest in the series of courses.

The first advantage of a classroom/industry partnership is the learning that takes place through teamwork. In traditional class projects, students learn how best to communicate and interact with other students and faculty only. When an industry is involved, this presents a third connection with which students must become familiar. The ability to effectively speak and work with representatives, who ultimately release the product, is most important. Through this

collaboration, students learn how to work effectively with people outside of their own organization.

This concept of effective communication is important from the beginning of the process. Because of the company's lack of knowledge of the mechanical engineering discipline, they were not aware of what information was needed for students to successfully design an enclosure for their system. This led to multiple misunderstandings between the two parties such as sizes and tolerances of the desired enclosure as well as the overall size of the internal circuit boards. This communication problem continued throughout the entire project and even into the manufacturing stage. From this, students realized the importance of effective communication and the necessity of ensuring all parties agree on every topic.

One lesson taught early in the process is the importance of project planning. Through typical class projects, students are shown how to do this; however, they rarely follow the plan. This is because students are used to working with less rigid restraints than what industry demands. When working for a company, students are forced to create a project plan and follow it to the letter in order to ensure all deadlines are met. Project planning is extremely important to master in order to successfully complete nearly all engineering courses as well as all projects throughout a student's future career.

An important benefit, which comes from working with industry, is the troubleshooting experience that students gain. In academic-based product design projects, students work in small teams to produce a minor part, only used to illustrate the process. While this is an effective way to follow the process and gain exposure to some of the troubles that are encountered, working with industry serves to show students the process and implications on a much larger scale.[2] This serves as a solid backbone for graduating students who are faced with industry-caliber projects in their first job. One example of this lesson surfaced when it came time to release the drawings to an injection molder. At this point in the project, the partner company had approved all drawings and multiple rapid prototypes had been produced to check for tolerances and clearances. Upon sending the drawings, students were immediately faced with the problem that it could not be manufactured, mainly due to draft angles and undercuts. Before this, they were unaware of the requirements for injection molding and had only paid attention to the prototypes. The drawings were redesigned in CAD (Figure 1) and sent back to the molder. In a normal class setting, while it may be discussed, there is no need to go through the entire process of making all aspects correct if the part is not going to be produced. Therefore, the need to actually have the product manufactured served as a learning experience which otherwise would not have occurred.

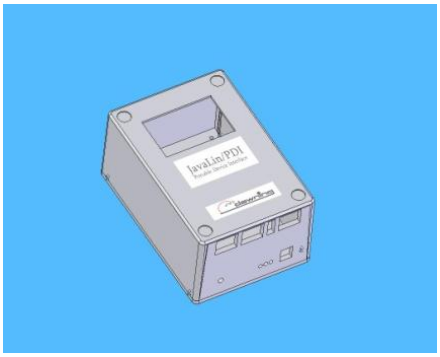

Figure 1 – Final CAD Drawings

Perhaps not normally viewed as a result, but just as important, is the sense of pride the students gain upon completion of a similar project. They are proud of their work when it is successful and they can actually see it go into production and out into businesses. In a typical product design project at RIT, students submit the final design or prototype to a professor for a grade and it does not continue any further. When working for a company, students create designs or prototypes and pass them off to the manufacturing phase followed by the sales phase. These extra phases illustrate the later stages of the design process and serve as a reward for students who see their product sold in the real world. This sense of pride results in the students caring more about the project than a typical classroom assignment. The company also benefits by receiving a design or product that is at the highest quality possible.

The last major advantage for students in this type of academic/industry collaboration is the ability to include this experience in their professional resume. An assignment like this shows potential employers that the student has experience beyond simple classwork and has knowledge required to complete major projects. With a steadily growing number of engineering graduates, students require something that will set them apart from their peers. Due to this experience, students have familiarity in a topic that is in constant need in the engineering field. Therefore, depending on the collaborating company, students may be invited to work for them immediately upon completion of the project. In addition, students are able to bring a rapid prototyped sample unit (Figure 2) to interviews to highlight an example of their achievements.

Figure 2 – Completed Prototype of Enclosure

Although there are many advantages for the students, college, and company involved, there are also some pitfalls. Some of these cannot be foreseen and must be dealt with as they arise; however, with good planning many can be prevented. These difficulties range from communication struggles to deadlines to organizational practices.

The most apparent difficulty that was encountered was the inability to communicate effectively with *Dawning Industries*. As mentioned earlier, employees were unaware how to share necessary information to students. In addition, students had not yet learned how to convey their needs effectively to industry. This difficulty of interaction between the two parties led to many misunderstandings and last-minute revisions. In addition, since the company could not devote multiple employees to a single project, students were required to talk to a sole engineer regarding all matters. This made it difficult at times to move forward in the process, as the engineer was not always available. One example of this communication breakdown occurred near the end of

the project, just before the drawings were needed at the injection molder. As the device required a touch-screen LCD panel, a writing stylus (Figure 3) was necessary to operate the unit. For ease of use, *Dawning* requested a compartment be made in the sidewall of the unit to hold the stylus. However, because of this late addition, drawings had to be extensively re-drawn. When the new drawings were sent to the molder, it was found this small addition would cost nearly $10,000 more than the initial quote. The compartment was subsequently removed and the drawing reverted to the original. With better communication, this addition and resulting problem could have been discussed at an earlier time. Students would not have been forced into scrambling at the last minute, nor would the company have lost valuable time.

Figure 3 – Writing Stylus

For this project, two RIT-owned and operated RP machines were utilized very heavily in order to provide a model of various designs to *Dawning*. The ability of the company to hold a design in their hands and visualize the final part made it much easier for them than a CAD drawing would have. Though this capability was a great advantage in the project, it also brought attention to a major disadvantage as the final deadlines approached. Students were regularly sending prototyped models to the company, and employees did not realize the work that goes into creating a CAD model, which can then be prototyped. Therefore, the phenomenon known as "feature creep" became a major problem for students to overcome. During the last three weeks of the project, *Dawning* frequently requested new features be added to the design to serve additional purposes, which had not been initially discussed. While this was not a problem for the first few occurrences, the design changes became more in depth. This became a much more troublesome issue, forcing continued attempts to balance new features with manufacturability. One example of "feature creep" in this project can be seen in Figure 4. The sidepiece of the unit initially had four, square cutouts. *Dawning* asked that five cutouts be added to the bottom half after the initial drawings had been sent to the injection molder. While these additions are minor in comparison to other changes, the steps required to make this modification required an extra week of work to ensure proper dimensions and placements. These late additions caused many problems in the maintenance of scheduled deadlines for both the students and molder.

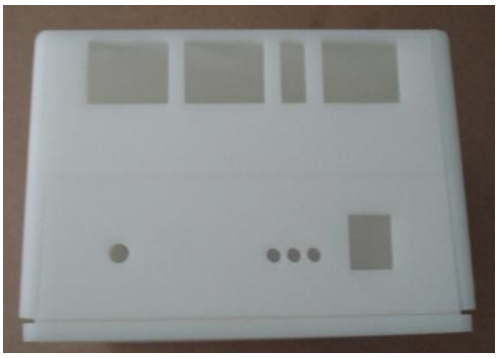

Figure 4 – Feature Creep of Lower Cutouts

Another problem, which will often arise when performing a similar project at any college, is scheduling time to complete the necessary steps. While the company is focused solely on their one product, students involved in the project often have a minimum of three other classes and the workload that is associated with them. This makes it very difficult for inexperienced students to organize, and set aside, enough time to perform assigned tasks to their fullest potential. This performance decline not only affects the company, but also the students involved. The company, of course, cannot get the best possible product, and the student does not have the time to learn from the experience because they have limited time to work. This becomes even more of a problem as deadlines approach. *Dawning* would often attempt to contact a student during the day to either update a design or check in on progress. Throughout the day, students were in classes and could not answer calls. This led to the poor communication discussed earlier.

In order to complete a project like this, awareness of how to avoid or work around these setbacks is critical. Upon successful completion of a classroom/industry partnership, students and faculty learn many ways to make future projects run more smoothly. As stated previously, communication is perhaps the most disruptive issue. Due to this, the need for accurate and concise communication should be stressed to students involved in a similar project. While it may be a difficult lesson to teach without having this type of experience, it is critical that students gain a background in sharing ideas with industry representatives. They will find it is very different from speaking with professors and peers. A great way to increase communication is to schedule a weekly conference call with the company. This forces students to have a dialogue with the company and it keeps the company informed of progress and troubles.

The utilization of the rapid prototyping machines proved invaluable in transferring ideas into physical parts for *Dawning* to hold. However, with this technology comes the problem of "feature creep". It is critical to know when to tell the company that the project is completed and students are no longer held responsible for any design changes. Many companies are able to see how beneficial RP machines are, but are unfamiliar with problems that arise from continually using them. For this problem, the professor needs to set limits and criteria that designate the time to end the project and part ways with the company.

Students are responsible for projects in multiple courses per quarter, thus cannot devote all their time to any one in particular. It is important, for this reason, that students learn effective time management, including project planning. With a plan, students can compare where they are in the process to the scheduled timeframe.

conclusion

Through a classroom/industry partnership, students learn in a different, more effective manner, mainly through experience. Working with a company not only serves to better a student's education, it also increases the likelihood of finding a successful career upon graduation. In this project, disadvantages were encountered; however, the advantages far outweigh these. In addition, by using some of the techniques discussed in this paper, many of the major difficulties associated with a collaboration effort can be lessened or avoided. If all students in the Engineering or Engineering Technology disciplines are involved in similar experiences in the future, graduating engineers will be better equipped to handle all projects and the unforeseen issues that will arise throughout their professional career.

acknowledgements

Special thanks to Greg Schallert et.al. from *Dawning Industries Inc*. for helping students to gain industry experience.

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