AC 2010-2118: COLLABORATIVE LABORATORY FOR MULTIDISCIPLINARY STUDY - CASE STUDY SPRING 2009

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Abstract

For the past couple of years, a disconcerting and repeated criticism by the engineering industry of recent college engineering graduates is the inability to creatively solve problems coupled with ineffective communication with workers in other disciplines or trades. Additionally, a lack of discipline has also been noted. Typically, these criticisms are voiced in meetings of college industrial advisory boards, industry partners and alumni established in their discipline. In an effort to address this, the Mechanical Engineering Technology (MET) Department of Youngstown State University initiated a joint pedagogical experiment with the Department of Fine and Performing Arts (F&PA) at Youngstown State University. The goal of the experiment was two-fold – to expose the engineer to an ‘out-of-the-box’ thinking environment and to establish a means where effective communication with non-technical personnel was required. The experiment was jointly developed between the departments so that the students from both departments would work towards their own pedagogical objectives. The goal of this paper is to detail investments and benefits of this type of collaborative experience for the student as well as the requirements for implementation, assessment and success of the work.

Assessment of the student’s progress throughout the project and the student’s scholastic improvement overall were tracked by both MET and F&PA faculty. The results of the experiment have provided enough confidence to conduct further experiments which are being planned for the Spring semester of 2010.

I. Introduction

The United States has long prided itself on the innovative capabilities of its industrial base. Henry Ford’s assembly line concept not only put the Ford Motor Company ahead of its competition when it was introduced, it also helped the United States out-produce the world during WWII. Innovation put us on the moon and fueled the computer and internet boom of the 1990’s. Studies going back as far as 1959 have identified engineering creativity as a vital contributor to industry competitiveness and the national welfare. [1] A preponderance of literature published in the past five years points to a lack of soft skills, including creative innovation, as factors in declining global competitiveness. [2,3,4,5] At the root of this problem is a deeply entrenched educational paradigm that does not encourage creative thinkers.

This innovation was possible because there were people that not only understood engineering principles; they also knew how to apply them in ways that satisfied a human need. These engineers were well-versed in their discipline and also understood the need itself. They could communicate effectively, listening to other’s needs and could speak to the users and colleagues to effectively and efficiently build an product that was accurately targeted to the actual need, not a perceived one.

II. Background

In recent years, there has been a steady increase in the occurrence of complaints from industry concerning the quality of recent graduates. These complaints usually start with a comment such as, “the newer students don’t know as much as the older ones.” After investigation, a few facts were discovered that have a large impact on the students’ retention of lessons and comprehension of the concepts.

Comparisons between the present curriculum and that of the past showed that while the courses had been updated, the content was essentially of the same quality as before. Overall, this can be considered a positive. As any discipline matures, the curriculum must reflect the advancements. The critical aspect here is that the updates were usually driven by the new editions of the text, instead of being initiated by the instructor. While it is unreasonable to expect that each and every class improvement is driven by an instructors direct experience in that particular area, it should be noted that almost none of the improvements were initiated by the instructor’s personal knowledge in that area. This highlights the point: presenting concepts out of a book from an instructor that has not had practical experience can turn into reading concepts out of a book. The discussion of the subject is much more superficial and important aspects of practice are not conveyed.

Comparisons between the present labs and that of the past showed that much of the lab equipment was the same equipment as was used years ago. Budgets of many schools have been cut during the recent decade. This has led to the extended use of older equipment. In many cases, this is not a problem, especially in the beginning classes. Fundamental principles can be illustrated on simpler equipment. The problem becomes acute in the more advanced classes where current technology is critical to the student’s understanding of current methods and equipment used in industry at the time.

It was noticed that a larger percentage of faculty had little or no industrial experience when compared to previous years. More faculty were hired directly out of university programs, and the ones that were from industry had less experience and far less responsible roles. This is particularly bad for a discipline that is primarily concerned with the application of the concepts taught in class.

Academia, as a whole, has shifted towards research oriented programs. Many believe that working on basic research will help bring about innovation. The issue here is that in the majority of the cases, the research revolves around many premises that are not practical or are too focused in one area, taking time from other work. Maybe a little more research time needs to be given to practicality.

General education requirements (GER) have failed in their mission to give students a ‘well-rounded’ education, especially in communication. This fact is demonstrated by the Writing and Oral Intensive curriculum components that are typically required in STEM curricula. Their purpose is to provide training in communications that are related to the discipline. What then, is the purpose of the original communications class? These components have been abandoned at Youngstown State University during the Spring 2010 semester because assessments have proven them to be largely ineffective. Even large colleges like Harvard have had difficulty in determining exactly what should be in a GER program.[6] Understanding relevant subjects of basic economics, human relations and history have been thrown into a pool of classes such as 'History of Rock and Roll' that provide little value to the discipline while taking up valuable resources in time and credit hours. Studies have shown that many GER programs are not meeting their own goals and the students and faculty are not gaining any value from taking them.[7]

III. Collaborative Laboratory Development

The principals of this paper each have more than 15 years in practicing the engineering discipline for before getting involved in academia. Having worked with some of these graduates that were discussed previously first hand, a premise was developed to address that following issues:

1. provide a setting for the students to use the skills they learn in class to solve problems in creative and innovative ways
2. increase students' ability to handle loosely defined and open ended questions
3. develop communications skills with non-technical colleagues
4. develop negotiation skills and the art of the compromise while still achieving the end goal
5. learn how to plan a project and develop the discipline to hold to it

A team of faculty at Youngstown State University is working to develop a collaborative laboratory (dubbed CoLab) that will serve as a unique learning environment for students in engineering and the sciences to work in multidisciplinary design teams with students who do not necessarily come from a technical background. The lab is a cooperative effort between faculty in the College of Science, Technology, Engineering and Mathematics (STEM) and the College of Fine and Performing Arts (FPA). The Arts were chosen for the pilot project because the sculpture class maintains a well-equipped lab that supports several industry standard processes such as investment casting, vacuum forming and metal work. They were interested in using our 3D computer modeling, rapid-prototyping and CNC machining capabilities. This synergistic relationship provided a win-win arrangement for both programs. The projects were setup with an Engineering Technology student and an Arts student.

The pedagogical goals for each program are slightly different for each program, but the project goals are the same. Each team is to create a product, produce a prototype and complete plans for production. Typically, the Art students provide a concept which they must work with the ET student to get into production. The projects are vetted by faculty from both departments, and the faculty is available for guidance. Both students must agree to the project – this is critical to get the 'buy in' from the students. It is important to note here that guidance must be kept to a minimum so that the students determine how to work together to maintain design intent while making adjustments for production. The teams are required to keep a record, including photographs, of their progress and conduct a presentation at the QUEST event in the spring. This entails good documentation and project planning to make the deadline. Their grade is based on not only meeting the design intent of the project, but also to conduct the presentation in a professional manner.

For the ET student, the pedagogical goals are to work on a problem that is not a prepared exercise with a defined 'best method'. The ET student needs to apply the tools that they have learned on their own. The ET student receives 2 semester hours credit for the successful completion of this course. When combined with an appropriate semester co-op, an ET elective can be replaced with these credits.

The Art student learns the logical approach to solving a technical problem that is very relevant to their careers: being able to efficiently make multiples of their work with standard manufacturing practices. The Arts student's credit for participation is determined by the Arts department and is typically equal to the ET student's credit.

IV. Project Profile

The first group that went through this program was initiated in November, 2008. The students met and they decided that they could work together. The Arts student present two proposals for consideration, and after deliberation, they picked a project to make a retro-styled cell phone. It was to be a practical size with a rotary dial and a flip lid. It was decided that it was reasonable to expect that the electronics would be supplied by a different team, so they concentrated on the body and external features and left room for electronics, but that would be out of the scope of the project. Part of the design intent was that the phone was not to be made of modern materials so that a retro style could be maintained. They decided to make it out of bronze. For the desired aesthetic, bronze is consistent with the retro technology style (called "steampunk"). From the engineering perspective, it is easily machinable and could be manufactured by commercially viable mass production casting processes. Since the goal of the project was to design and manufacture a product and the suitability to any particular purpose was of little value to the pedagogical goal of the project, the bronze material was allowed so long as they had a plan to use other materials if the chosen material proved to be unsuitable in use.

The project started at the beginning of the Spring semester and the presentation for the Quest event was to be during the second week of April. The students immediately worked out the basic concept based on constructing a prototype out of bronze that had all the features the phone body would have. Surprisingly, the students included the ability of the prototype to be directly used for a plastic vacuum form. This was a student driven decision based on a discussion that they had concerning the available equipment. While an injection molding machine was available, separate molds would need to be made for its use and they determined that the schedule did not allow for this. This was a very astute decision, especially considering that this happened at the beginning design stage.

Using their set of design requirements, an initial design sketch was produced (Figure 1) from which a three dimensional parametric model was made which showed all parts and the assembly process (Figure 2).

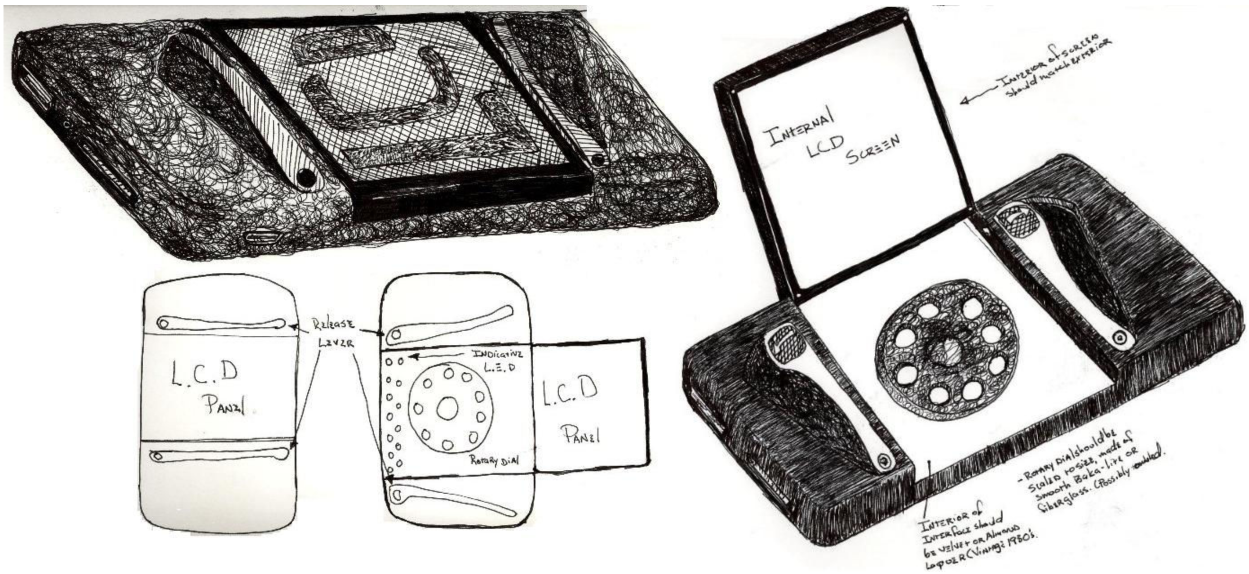

Figure 1

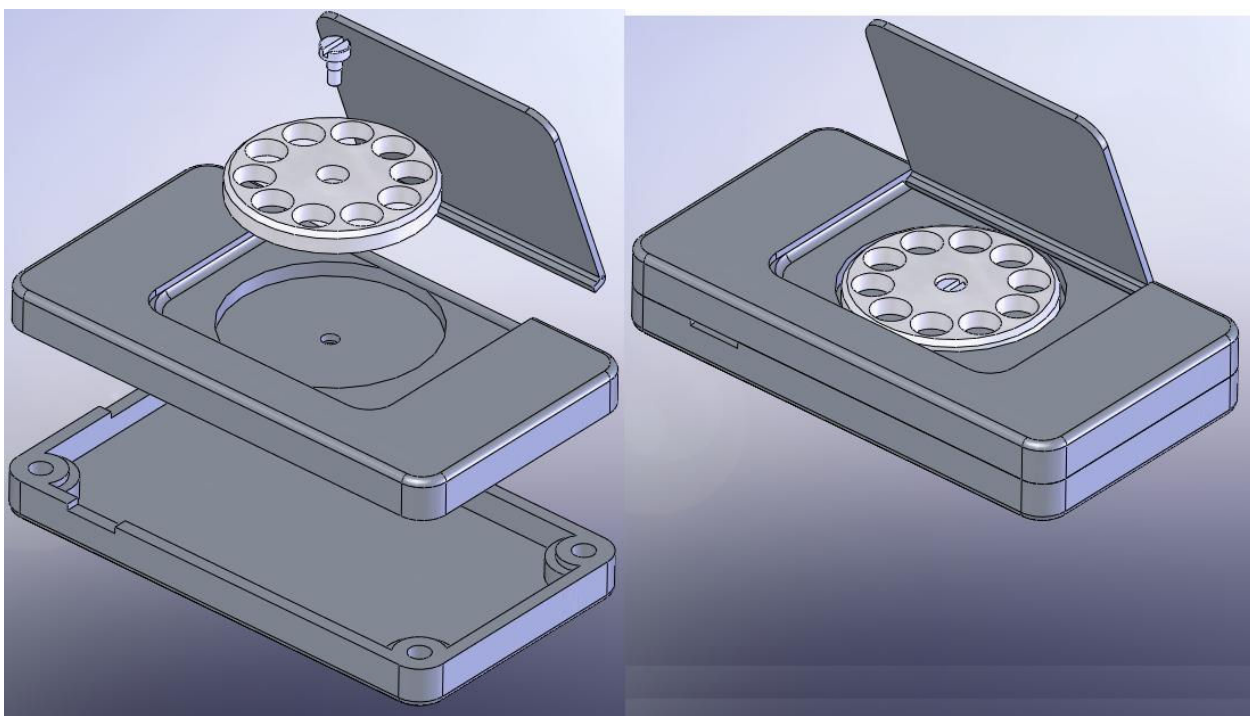

Figure 2

The design and production process plan was reviewed by the faculty and after approval, a wax prototype was run and the investment casting of the parts were scheduled. During the time that the wax was being shelled, the machining work was completed for the rotor and lid components. After the casting pour was completed, the machining was started. Since the investment cast had most of the details included, machining was kept to a minimum. A progress check was done by the faculty at this point (middle of February) and the quality of the work was a marked improvement over the previous work by either student. Notably, both students were in tune with exactly where the project was, what task was next and exactly how much time they had left.

They also made more than one prototype in case they had a production problem with any of the parts. Each part was machined with like parts so clamping setups were minimized. 90% of the machining was completed by the students with the ET student showing the Arts student how to use the shop equipment.

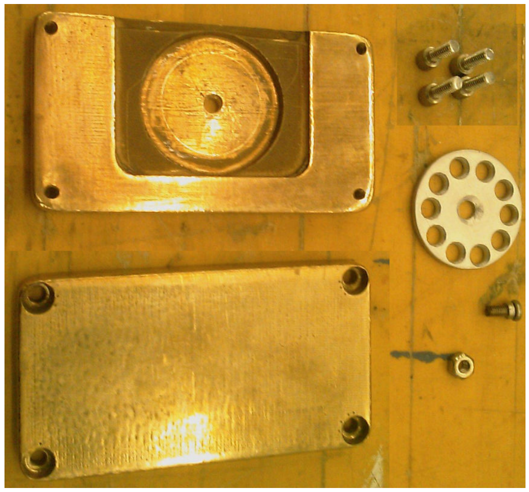

Figure 3

By the third week of March, the students had their prototype essentially complete (Figure 3). The Art student then used one of the prototypes for a vacuum form. The ET student was able to learn the vacuum molding process from the Arts student at this point. From a teamwork point of view, this is notable because quite frequently engineers have difficulty learning from non-technical people. This illustrated that the ET student had no issue with this aspect.

The records they kept during the project were very complete. This made the presentation content very comprehensive. Their presentation was selected for the QUEST event.

V. Project Assessment

Following the project, an assessment of the students' progress was made. Only the ET student will be discussed here.

The goals that were stated at the beginning of the project were achieved by the students. They created, performed, documented and presented a product and process of their own design that was practical and maintained the design intent of the product. Their teamwork was evident throughout the project. There was no part of the project where only one student was working and the other was not. A question could be asked of either student and both had the same answer. This was a good sign of the level of communication between the two. It should be noted that the channels of communication between the students at the very start of the project were very good. It is crucial that the ET student be able to listen to the Art student and understand what the design intent is to be. The ET student also needs to know that their job is to make the project producible, so their 'buy in' during the project selection phase cannot be underestimated.

The primary outcome for this project was to provide a setting for the student to use the material from his studies in creative and innovative ways. Evidence of this was shown in the decision to make the prototype in such a way as to make it useable for a vacuum form mold. The prototype was also designed to take advantage of the particular characteristics of each part of the manufacturing process. It is important to note here that for someone skilled and experienced in the art, some of this may seem trivial. For a student to make these decisions with little applicable experience or guidance from faculty shows that the students were making decisions on their own and basing these decisions on a sound factual basis that work to the advantage of the project. This is the type of creative and innovative problem solving that the project was to develop.

The ET student treated the Art student as an equal partner in the team. This is one of the critical aspects of the project outcomes concerning communication and teamwork. A common area of contention between engineers and non-technical personnel in the workplace is an attitude of intellectual superiority over less schooled coworkers. It seemed in this case that because both started the project on an equal footing, the relationship continued that way.

An interesting aspect of the ET student was that almost from the very beginning of the project, he was trying to put together the production process. This was self-directed as faculty guidance is used as sparingly as possible. This discipline was one of the outcomes listed discretely at the beginning of the project, and is a very necessary quality for the success of the project and highly desirable in industry.

As could be expected, the student showed an increased interest in the studies during the semester the project was conducted. While his grades for the semester went up a grade letter, the more important aspect was that his drive had shifted from just trying to pass the classes to taking a genuine interest in the material he was studying. This led to better understanding of the concepts as well as better retention. These improvements were evident on the ABET assessment of program outcomes.

Perhaps the best indication of success may be one that doesn't appear on many academic evaluations. The student had drafted his resume and was actively looking for work in the engineering field, whether as an intern or part-time. By the end of the semester, he was hired by a local food manufacturing company where he is still working and has been promoted. He expects to stay on as an engineer after graduation.

VI. Continuing Work

The project is running again this year with more students participating. The basic premise is to remain the same, although the specific problems will be different. The project reviewed here was fortunate that the pair of students worked well together. From the beginning, they seemed to have a compatible mode of operation which greatly affected the success of the project. This year, groups of students were put together based on the students' own choices. The contact between the students before the choice was kept to a minimum so that their decision of a partner was based largely on the proposed projects and not on the partner themselves. This more closely matches the inter-relationships in industry where there is little consideration for the personal compatibility between co-workers and is more in tune with the particular talents of each worker and how these talents relate to the needs of the project.

An important side effect of this project was the change in many of the student's evaluation of their own academic careers. Many have changed from a goal of just passing classes to wanting to excel and gain broader experience in their discipline through co-operative work-study, internships or jobs at local companies. This may be the biggest impact of the project. When the students are motivated and interested in success, they will usually achieve it.

VII. Repeating and Enhancing the Lab

The lab was setup at the university to work with existing equipment to minimize costs and shorten the implementation time. The selection of the Arts department was made because it had existing facilities that complimented the Engineering Technology facilities. There were also faculty in the Arts that were interested in collaborative efforts for their own pedagogical reasons. In this case, the Arts were an easy choice to make. Another alternative was Criminal Justice Forensics and Archeology, but they did not have sufficient laboratory facilities or compatible class time for an immediate fit. Discussions are ongoing with their faculty to develop these opportunities. In order for the opportunities to be beneficial to both departments, there has to be a complimentary nature to the skills both disciplines bring to the project.

The separate departments are free to determine for themselves how much credit each student should receive. The issue of credit is important to the student so that they get something for their time. In the discussed project, the credit was applied to an engineering technology elective that had content pertaining to the manufacturing aspects of the project. This evaluation should be made by faculty that have a good understanding of the content of both the project and the class it will partially replace. This particular elective is a three hour course. The remaining semester hour is usually fulfilled by a Professional Practice credit for an internship that has aspects of its performance that also pertain to the elective. The collaborative laboratory was scheduled as a Special Topics course which was already in the approved curriculum. This course is flexible in the credits awarded, so it can be tailored to the quality and quantity of work to be performed.

The lab is currently being conducted during the Spring 2010 semester. Three pairs of students were enrolled for this run. The faculty from the Engineering Technology and Arts chose three candidates from their programs and the students were allowed to choose their partners. One of the groups failed in short order. An assessment was made and it was determined that the Art student was too close to graduation and had too many time commitments to participate. His estimate of available time was off considerably, perhaps highlighting a needed skill he did not sufficiently develop. It is important to note here that no assistance was given to the group to 'help' them complete the work. Options were given to the student that was still engaged to modify the work so he could complete a project on his own, but he chose to drop out also. This is still considered a learning experience for the students.

The other two groups are doing well with challenging projects. It is too early to determine if they will complete successfully, but one group has their project well in hand and have made very good decisions to stay on track.

Recommendations for future labs would include the following:

- ensure that the participants accurately determine that they can devote an appropriate amount of time to the project.
- make sure that the groups develop timelines for the projects with milestones that can be reviewed during the work.
- schedule reviews based on the abilities of the individual groups. Some groups can work autonomously while others will need more guidance.
- review projects carefully to make sure that the students have a budget or available material to complete their project.
- state clearly at the beginning of the project what the deliverables are. In the case presented here, the Quest presentation was a deliverable as well as a workable production process.
- Accurately assess the student's desire and potential for this work. This can bring certain students 'out of their shell' while others will show no improvement in performance.

VIII. Future Plans for the Co-Lab

Currently, the Co-Lab is planned to continue for selected students for the next academic year. The goal is to make this a component of the Engineering Technology curriculum where all students would take part in this type of learning experience at some time during their academic career. The difficult judgment to make is when to have a student participate. Some are ready during their sophomore year, while others still have problems collaborating during their senior year. The current thinking is to require a permit for registration of the class. The permit would be provided by a faculty member that has knowledge of the student's capabilities. Participation in the Co-Lab would typically take place during the Sophomore or Junior year and it would be a prerequisite for the capstone class.

Other disciplines will be available for collaborations, provided that they can offer some meaningful Engineering Technology component in the collaborative work. It is hoped that at some point, this can be a part of a meaningful GER program that will incorporate genuine interdisciplinary collaboration, provide meaningful skills in communication, social interaction, the value of other points of view and first hand insight into other disciplines.

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