Project-based Learning: An Integration of Real World Project in a 3D Design Class

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Abstract

With the explosion of new practices in teaching pedagogies to prepare students to be better skilled in technical fields, it is essential to conduct a course to keep pace with the flood of innovations. In some circumstances and practiced traditionally, students learn from reading a textbook and working through its examples to conceptualize a subject domain. However; it is important to bring real-world projects into a classroom and allow students to experience a true problem-solving task. This paper will present a real-world project that was implemented in a 3D Computer-Aided Design (CAD) product design class where students solved a problem given from a company. This active project-based learning experience and curriculum design allows students to see beyond textbook examples and permits them to build a strong foundation in communication skills, engineering design, project implementation, project analysis and assessment. It enables students to not only apply theories but also interact with actual technology and enables them to learn from hands on experiences.

Introduction

Project based learning has always been a popular teaching pedagogy in curriculum design because it enables students to analyze and problem solve an authentic industrial task. Students also learn from each other while learning valuable communication and teamwork skills. In the class TECH 2231 Product Design and Analysis offered at Ohio Northern University (ONU) Department of Technological Studies (DTS), the class was given such an opportunity to work on a real-world situation. A company had approached the department with a situation that they needed assistance to solve. The given project task was to be completed as if the entire class was a group of competing “companies” pitching their ideas to the company that is looking for a feasible solution to the problem. Students were divided into groups as competitors and formed several fictitious companies where they were requested to submit proposals to solve the given task. The following described the completed proposal of the team project which included Problem Statement, Background Research, Scheduling - Gantt charts, Design Analysis, Cost Analysis, Computer Aided Design (CAD) sketch and assembly and prototyping development. The learning outcomes expected from this exercise was to work well in a group, how to prototype, research materials, and how to pitch a new product. For the purpose of this paper there will be only one team’s project.

Problem Statement

Students were charged to design a reusable set plate that could be placed and removed without breaking in a manner that will be more cost effective than making new set plates each time they were to be used. The set plates that are currently being used must be painstakingly made for each steel set location and are used only once. At the current design, after the concrete is cured, each set plate is broken out by hand via use of hammer and brute force, unable to be reused. The requirement of the completed design, keep the same functionality as the current design of keeping the anchor points in place, does not emphasize on the visual aesthetics as much as the functionality of the end product. There are no limitations of color or luster of the set plate as the company is looking for the functionality over visual representation. The set plates that are to be designed must be light weight and simplistic enough that it requires very little training on how to use it. The project teams consist of 3 or 4 class members and each member had a separate role based on the needs of the team, CEO, designer, researcher, etc.

Background Research

Team chose to make the product out of Aluminum Alloy 6069 as it fits the reusability objective as well as other objective that the team set for themselves and in turn was cost effective over time. The team were required to scour the internet or do their own testing in the department's labs to find the best possible material. The team went with their top 5 materials that passed the material properties guidelines and conducted a cost analysis, looking up what the price per unit of material and using formulas (some units were in feet or volume) to do a total cost. For this aspect the requirement was to make it as cost effective as possible while still meeting or exceeding the materials properties guidelines. Having to do this aspect of the project helped to prepare the group for the real-world as it is more than likely that student's future employers will require that the students also do the same sort of material/cost research.

Along with the materials research, the team groups were also required to do competitive products research. Through searching the US Patent office website, the students were able to find similar products to that of their own, but not so similar to the team's design that they would be infringing on others patented products. Below as shown in figures one, two and three are a few of the products that we had found which are similar to the team's set plate design. [2] [3] [4] Although they do not function the same as the set plates it was a good learning experience for when the students have to do patent research in the future.

Figure 1

Figure 2

Figure 3

Scheduling

As part of the requirements for the Set Plate project, the teams also needed to keep track of their schedule, workload distribution, define resources and more. Gantt chart allows the students to layout all aspects of the need in regarding to scheduling. The teams had a tight schedule to complete the task and as such the teams were also required to make a Gantt chart that follows the dates and times at which each part of the team's project was due including the team's mini presentation days, as well as the team's final presentation. The Gantt chart listed in figure 4 is what one team group used to keep on task.

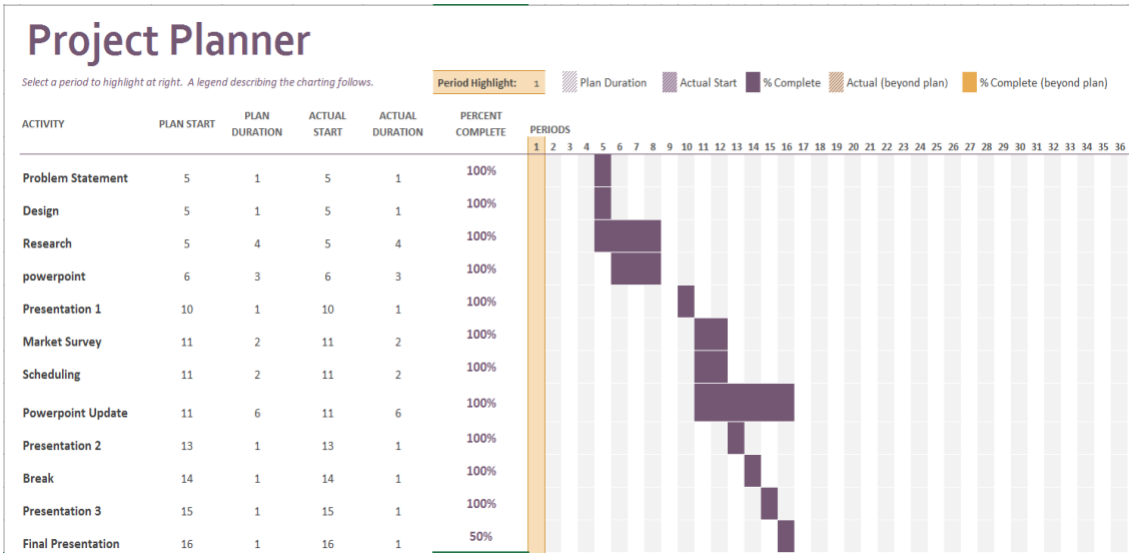

Figure 4

Design Analysis

Once the teams completed their prototype (as pictured by one team under **Prototyping Development, figure 8),** the teams needed to test whether or not their design will really work as how the customer company wanted. To test the prototype, the team scaled the set plates down to about one tenth the size to save on testing materials. The team also used small wooden dowel rods in place of the metal anchors that the customer company would use as well as bent paperclips in place of the u-bolts that hold the pieces together. The team decided to do this as it was scaled down, the team had to do a make shift testing with cheap materials. It was not a requirement (nor possible for teams to go to a worksite) to do prototype testing at full scale so the substitute scaled down models were acceptable for the project. At the completion of the team's testing, all components of the team's prototypes held up to the customer company's expectations. The prototypes showed signs of easy use once it is demonstrated to the users. The design was also simple enough that the pieces could be interchanged with other set plates.

Cost Analysis

A well-designed component, without an acceptable cost to produce, will not be feasible for a company to manufacture. The team analyzed the cost as part of the project's requirements and created the Bill Of Materials (BOM) which includes all material parts either the raw material costs or the costs to purchase. As shown in the table below, the BOM that the team came up with after taking the volume of each piece as well as the cost of aluminum 6069 described under the Design Research section of this article. [4]

Product	**Units**	**Unit Price**	**Total Price**
Outside Pieces (figure 6)	2	$10	$20
Inside Pieces (figure 5)	2	$10	$20
Middle Piece (figure 7)	1	$15	$15
Connectors (6 pack)	1	$5	$5
Total Price Per Set Plate			$60

Computer Aided Design (CAD) sketch and assembly

CAD drafting is essential as part of the design project. Several 3D drawing files were designed and created in order to get a visual representation of the components as well as to be able to 3D print them. The drawing files (.idw, .ipt) were converted to 3D printing file format (.stl) and later brought into the 3D printer to convert them into G-code which the DTS 3D printers would recognize in order to print out the class's prototypes. The following images are the CAD drawings that one of the teams sketched up for the set plate design. The component as shown in Figure 5 required only one unit in production while the components as shown in figure 6 and 7 required two units in production.

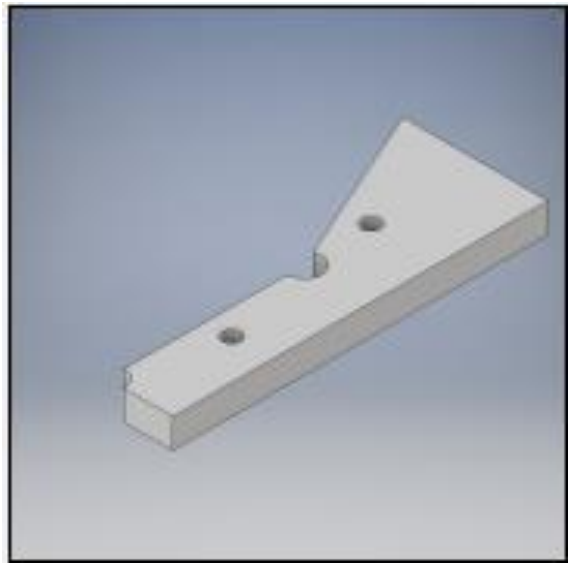

Figure 5

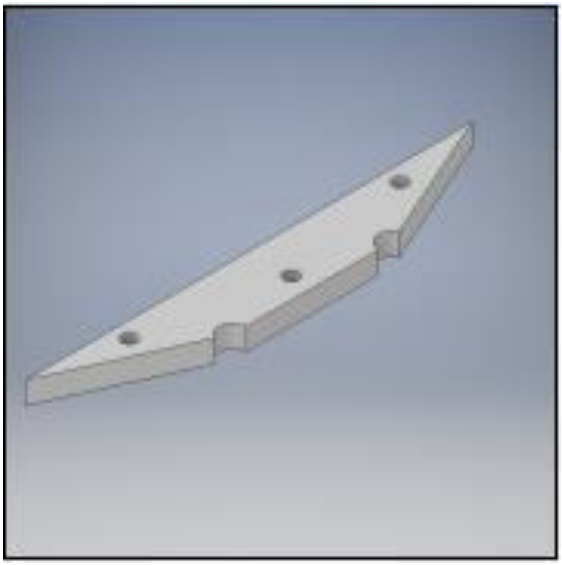

Figure 6

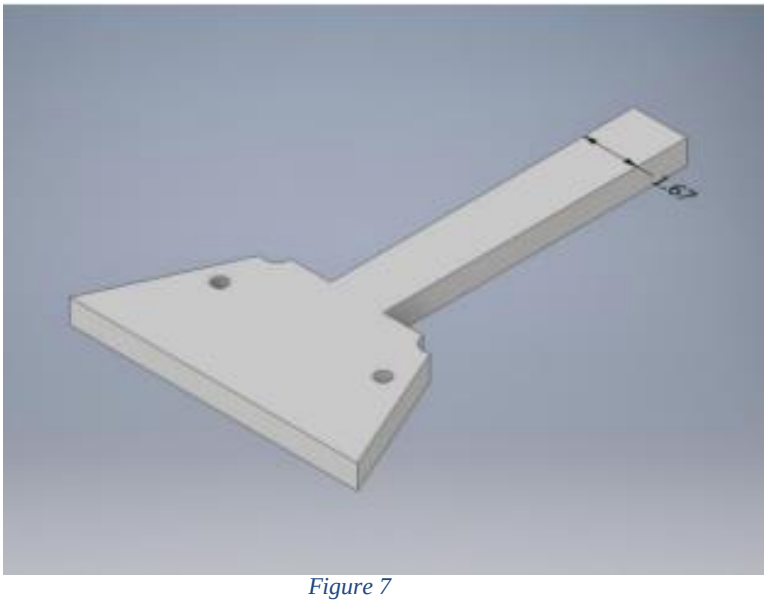

Figure 7

Prototyping Development.

Once as the 3D CAD drawings were made, the team was finally able to print them. During the printing process, the class as a whole encountered some complications with the 3D printer. One team was able to print out the first four pieces without any problem; however, when it came to the fifth and final piece, the team experienced 3D printer mechanical malfunction issue. There was a part within the printer itself that began to wear out and caused some imperfections as seen below in Figure 8. The imperfections in the middle piece (Figure 8) were determined to be minor and would not compromise the intent of the prototype. Due to the number of parts that are required to be printed for the entire class, with the worn-out piece in the 3D printer, it finally stopped working after another project group had tried to print out their design which left the teams with no other choice but to use what the team had.

Figure 8

Conclusion

This project was by far the best classroom learning experience that I as one of the students in the class have ever had to date. Throughout my academic career, I have always had a difficult time learning through the traditional way of teaching such as lecturing, reading from a textbook and doing in class worksheets. This new Real-Life learning experience has helped me learn in a way that is easier for me to comprehend. In doing a physical assignment I was able to learn by doing rather than by being told about how to design and pitch a product. Learning about designing, product research, prototyping, and presenting the final product has been the best learning experience that I have ever gotten from any of my academic adventures. Project based learning is a great alternative to the traditional teaching methods that we all know. This teaching methodology given beyond textbook learning opportunities to students and had really pushed the student groups to do their best as the real-world company was going to take their design and implement it into a real-life situation. Throughout the course of this real-world project, students learned outside of the box thinking which exceeds beyond the textbook instructions. In addition, they also learned how to delegate the work between themselves and other group members as well as what it would be like to compete for a company contract.

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