Enhancing Freshman Learning Experience in Computer Aided Drafting and Design (CADD) Through Applied Learning Experiences: Connecting the Dots

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Mechanical Engineering Technology

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Abstract

Engineering design is an integral part of the freshman learning experience in mechanical engineering and mechanical engineering technology programs. Not only it is important to teach students the concept of design, it is also important for them to be able to "connect the dots"; by being able to apply tools, skills, and knowledge they gained, in design projects as well as in other engineering courses. A great way to achieve this goal is through applied learning experiences. Applied learning is an instructional approach that includes various methods of teaching such as: project-based learning, hands-on learning, experience-based learning, service-learning, etc. In an effort to provide freshman engineering technology students an applied learning experience, two innovative approaches have been developed and implemented to the freshman level Computer Aided Drafting and Design (CADD) course. The first approach is the incorporation of hands-on exercises that follow Bloom's Revised Taxonomy. The second approach is the development of a learning community where it is built focusing on the Computer Aided Drafting and Design and Manufacturing Processes courses. This paper provides an overview of the two approaches including their objectives, exercises, projects, and future plans. The design and development of the exercises and projects will be discussed in detail.

Keywords

Applied learning, Bloom's Revised Taxonomy, Learning Communities, CADD

Introduction

First year of college is an important year to freshman students. The new high school graduates are required to learn college level course materials and the new college life that they have never experienced before. It is important for academic programs to provide the freshman students with great learning experience so that the students will not be confused when they start and more importantly the students can excel in the programs. A great way to enhance freshman student learning is to introduce applied learning in the academic programs. Applied learning is an instructional approach that includes various methods of teaching such as: project-based learning, hands-on learning, experience-based learning, service-learning, etc[1]. Accordingly, the four-year mechanical engineering technology (MET) program at a State College has introduced two new innovative applied learning experiences in its Computer Aided Drafting and Design course. The CADD course was chosen to enhance freshman learning experience because it is a freshman course and engineering design is an integral part of mechanical engineering and mechanical engineering technology programs[2].

The first approach is incorporation of eight hands-on exercises to the freshman level Computer Aided Drafting and Design course, where the order and the flow of the exercises are built based on Bloom's Revised Taxonomy[3]. The goal of these exercises is to provide students a continuous applied learning experience throughout the semester while following the Revised Bloom's Taxonomy[3] for each exercise. The exercises contain various types of questions to measure students' understanding of the subject matter along with different styles of learning assessment. These exercises are completed during the laboratory component of the course as an additional activity.

The second approach is the development of a learning community for freshman students. The learning community is built focusing on the freshman level Computer Aided Drafting and Design and Manufacturing Processes courses. As a part of the learning community, these courses have collaborative teaching and joint projects. The instructors of both courses coordinate the teaching materials so that students can always reference the teaching materials in both courses and are learning the materials in the right pace. A joint project is introduced between the courses to enhance the learning experience. The project requires students to create a 3D model of an assembly and manufacture the assembly. This paper provides an overview of the two approaches including their objectives, exercises, projects, and future plans.

Current Course Structure and Pedagogy of CADD

Computer Aided Drafting and Design (CADD) course is a freshman course offered in the Mechanical Engineering Technology Department at the State College. The course is required by the Mechanical Engineering Technology (MET) B.S, Manufacturing Engineering Technology (MFG) B.S and Facility Management Technology (FMT) B.S. Programs. It is a 3-credit and 4-contact hour course. The course consists of a lecture component and a laboratory component. In the lecture component, the instructor introduces the class materials to the students. The students will then practice their CADD skills in the laboratory component. During the first seven weeks of the semester, the course focuses on technical drawing and 2D AutoCAD. In the remaining eight weeks of the semester, the course focuses on 3D modeling using Autodesk Inventor. Two textbooks, Technical Drawing with AutoCAD[4] and 101 Autodesk Inventor 2017[5], are used in this course.

CADD Applied Learning Experience – Bloom's Revised Taxonomy

Project-based learning proved to be a great instructional methodology to teach engineering courses[6]. The objective of this study is to develop hands-on applied learning experiences to provide students in the CADD course an applied learning experience following the Revised Bloom's Taxonomy structure. The anticipated course outcomes are (i) to provide students a learning environment that supports academic success and continuous learning, (ii) to have a structured platform to provide hands-on exercises and (iii) to employ the use of Bloom's Revised Taxonomy approach to promote critical thinking to teach drafting and design. For the CADD class, a total of 8 Hands-on exercises in three different areas of the course have been developed. The three areas of the course are: hands-on drafting orthographic views, Learning drafting with AutoCAD and learning 3D Modeling with Inventor, respectively. Table 1 provides the list of the exercises.

Table 1: CADD Hands-on Exercises

Course Learning Area	Hands-on Exercise
Learning Orthographic Design by Hand Drafting	**Exercise 1.1 –** Introduction to Orthographic View Drawing **Exercise 1.2 –** Orthographic View Drawing and Dimensioning
Learning 2-Dimensional Design with AutoCAD software	**Exercise 2.1** – Introduction to 2-Dimensional Drawing with AutoCAD **Exercise 2.2** – Orthographic View Drawing with AutoCAD **Exercise 2.3** – Orthographic View Drawing and Dimensioning with AutoCAD
Learning 3-Dimensional Solid Modeling with Inventor Software	**Exercise 3.1 –** Introduction to 3-Dimensional Modeling with Inventor **Exercise 3.2 –** Introduction to Assembly Formation with Inventor **Exercise 3.3 –** Introduction to Creating Exploded Views for 3-Dimensional Assemblies in Inventor

The exercises developed following the same structure of Revised Bloom's Taxonomy. Step 1- Remember, Step 2 – Understand, Step 3 – Apply, Step 4 – Analyze, Step 5 – Evaluate and Step 6 – Create. All the exercises developed in a worksheet format, where students either can write their answers in the empty spaces provided by the question or they can draw and sketch in the grid spaces provided in the worksheets. As an example portion of the worksheets are shown in Figures 1 and 2. Figure 1 shows an example of the Step 2 – Understand from Exercise 1.1 Introduction to Orthographic View Drawing. In this step, students are provided with a technical drawing with mistakes and asked to review the drawing and identify the mistakes. These mistakes can be related to the placement of the views, distance between the views, closeness to the border, and missing dimensions. After completion of this step, the instructor and the students carry an in-class discussion on why these are mistakes, how could the technical drawing can be drawn correctly and review the rules. Figure 2 shows an example of the Step 3 – Apply from Exercise 3.2 Introduction to Assembly Formation with Inventor. In this step, students are provided with 2 parts before they are assembled and after they are assembled and asked to review the example to list what are the constraints that are used to create this assembly. Upon completion of this step, the instructor and the students carry an in-class discussion on how to fully constrain an assembly and review additional in-class examples.

STEP 2. UNDERSTAND

Clarify the mistakes in the following drawing:

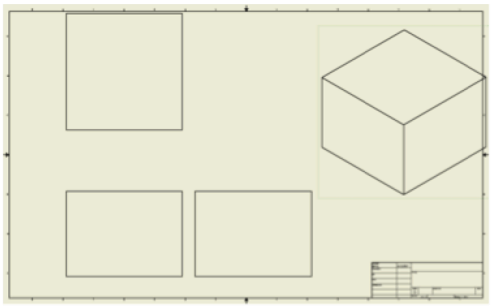

Figure 1: Exercise 1.1 Introduction to Orthographic View Drawing, Step 2 -Understand

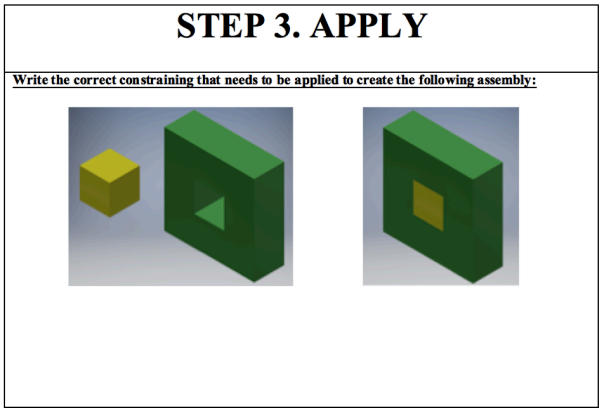

Figure 2: Exercise 3.2 Introduction to Assembly Formation with Inventor, Step 3-Apply

In an effort to assess the effectiveness of the implemented pedagogy and evaluation of the student gains two different assessment strategies will be employed. A formative assessment strategy will be employed throughout the semester where a set of questions assessing student learning will be provided after the completion of each in-class exercise. Upon completion of the semester, a summative assessment strategy (final exam and final project) will be used to measure students' learning of the course objectives.

CADD Applied Learning Experience – Learning Community

A learning community that consists of Computer Aided Drafting and Design (CADD) and Manufacturing Processes is developed. The learning community is introduced to the METBS and MFTBS programs for the first time in the Fall 2017 and is expected to be offered again in coming semesters. Doolen et al. [7] suggests that collaborative learning and learning communities may play a role in engineering student success. Therefore, the objective of this community is to create a cohort of freshman students in the programs and build a strong relationship between the students. The goal is to improve student's learning in both freshman courses as well as the remaining courses in the MET/MFG programs. The two proposed courses are the foundation courses in the MET department that prepare students for product development and manufacturing. Both courses consist of a lecture and a lab component and both are the prerequisite courses for many MET courses.

The skills taught in these two courses are interrelated. For example, students in Manufacturing Processes must know how to read technical drawings in order to work on their class projects, however the students will learn the details of technical drawings in CADD. Similarly, students in CADD must understand how products are made when they design their class projects, but the various methods to manufacture a product are mainly taught in Manufacturing Processes. Therefore, the authors believe that the learning community will certainly improve the student's learning in the proposed courses.

Two main activities involving collaborative teaching and joint projects are proposed in this community. First, demonstration models will be fabricated and used in both courses. Figure 3 shows an example of the demonstration models. The idea of the models is to show students how

a physical 3D object can be presented in a 2D technical drawing. Additionally, students are required to create 3D and 2D drawings of the models in the CADD course and manufacture the mechanical components that are presented in the models in the Manufacturing Processes course. The models will serve as common teaching tools that will help students to develop a strong correlation between technical drawings and manufacturing processes. The instructors of both courses will coordinate the teaching materials so that students can always reference the teaching materials in both courses and are learning the materials at the right pace.

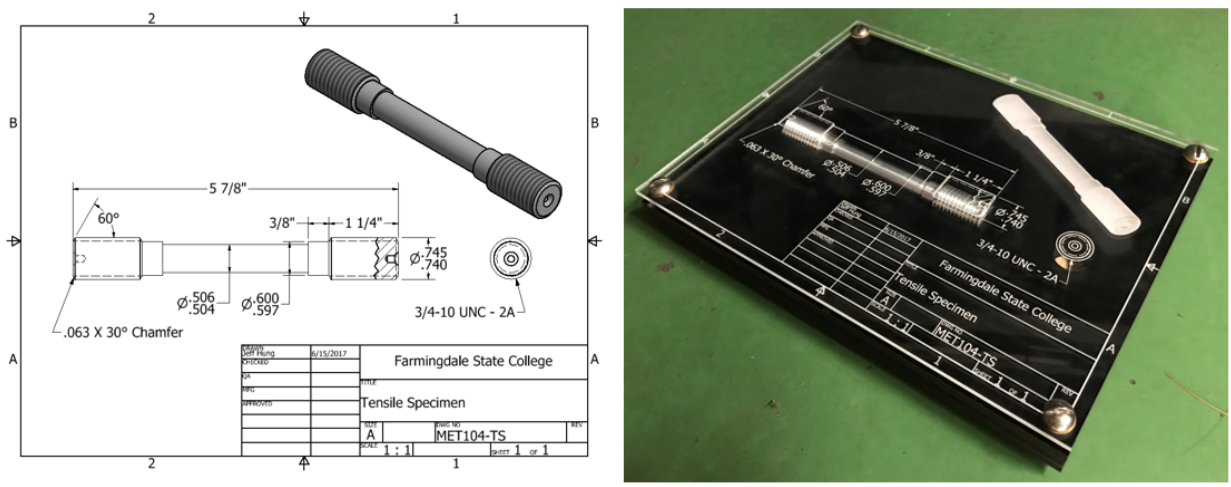

Figure 3: Tensile test specimen demonstration model

The second activity in this community is a joint project between the courses. The instructor of CADD will assign a product design project to CADD students. The project requires students to design 3D computer models of parts that assemble to the student projects that are machined in Manufacturing Processes. Students in CADD will be able to verify their designs physically by 3D printing instead of visualizing their designs on computer screens. The instructors in both courses will work closely with the students to indicate the design requirements of their project. This joint project will provide students with a real-world experience in product development. The students will experience the difference between 3D computer models, 3D printed prototypes, and actual assembled products.

Most of the MET courses require a proficiency in 3D modeling and a firm knowledge of manufacturing, particularly in their Senior Project course where the students are expected to design test fixtures for their research work or develop an actual product for industrial or commercial purposes. Therefore, the proposed pedagogy also sets the groundwork of applied learning for MET students and provides them the solid foundation in Mechanical Engineering Technology.

Conclusions

This paper reviewed the two different approaches implemented to the Computer Aided Drafting and Design course in the Mechanical Engineering Technology Department at Farmingdale State

College. Both the Revised Bloom's Taxonomy-based approach and Learning community approach is currently being applied during the Fall 2017 semester. All three instructors continuously monitor and collect student feedback on the projects. Based on students' feedback both projects will be revised and implemented in the Spring 2018 semester as well as during the future academic years.

In addition both Revised Bloom's Taxonomy-based approach and Learning Community approach can be designed to fit other mechanical engineering courses to provide students continuous applied learning experience.

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