Publications

1-2012

Open-Ended Project Learning Experience in Graphical Communication

Lulu Sun
Embry-Riddle Aeronautical University, sunl@erau.edu

Christopher Grant
Embry-Riddle Aeronautical University, grantch@erau.edu

Follow this and additional works at: https://commons.erau.edu/publication

Part of the Engineering Education Commons

Open-ended Project Learning Experience in Graphical Communication

Lulu Sun
Freshmen Engineering Department
Embry-Riddle Aeronautical University

Christopher D. Grant
Freshmen Engineering Department and Civil Engineering Department
Embry-Riddle Aeronautical University

Abstract

This paper includes the implementation of Bloom's taxonomy in the introduction to graphical communication course and shows how students are moved up Bloom's taxonomy by changing previous guided individual final project to open-ended projects. Instead of following the instructor's direction to complete the model design, students are required to research the product they want to design, and build the model by themselves. The open-ended projects enable and challenge students to work on higher level of Bloom's taxonomy by emphasizing design creativity, exploring real engineering design problem, and enhancing their oral and written skills.

Introduction

Bloom's taxonomy is a commonly accepted taxonomy of cognitive skills developed by Benjamin Bloom (1956), which is based on the level of student understanding necessary for achievement or mastery. The system can be used to evaluate the objectives of the course curriculum and class activity. Introduction to Graphical communication is one of the largest classes taught in Freshmen Engineering Department at Embry-Riddle Aeronautical University, with an average enrollment of 500 students a year. The course is designed to familiarize the student with the basic principles of drafting, engineering drawing, improve three dimensional visualization skills, and fundamentals of a computer aided design program-CATIA. Much of the teaching is focused on the knowledge and comprehension, low levels of Bloom's taxonomy. Instructor shows students step by step how to understand principle of orthographic projection, section, auxiliary views, dimensioning, tolerancing, build a model and make sure they can follow and understand the procedure. But their ability to use knowledge and comprehension to explore real engineering design is unknown.

In the 1950s Benjamin Bloom and his colleagues formulated a classification system of educational objectives based on the level of student learning. Researchers discussed the six levels of the Bloom's taxonomy including Felder (2004) and Jones (2009):

1.   Knowledge. Recalling material you have learned.

2. Comprehension. Demonstrate the understanding of the terms and concepts.

3. Application. Apply the learned information to solve the problem.

4. Analysis. Break things apart so that relationships are understood.

5. Synthesis. Put together parts to form a new whole.

6. Evaluation. Make critical judgments, rate ideas or objects and to accept or reject materials based on standards.

Our current curriculum gives students much practice in the low levels of knowledge, comprehension, and application. Students do not have opportunities to practice their analysis, synthesis, and evaluation skills, which can enhance their thinking and creative skills and enable them succeed in today's competitive engineering environment.
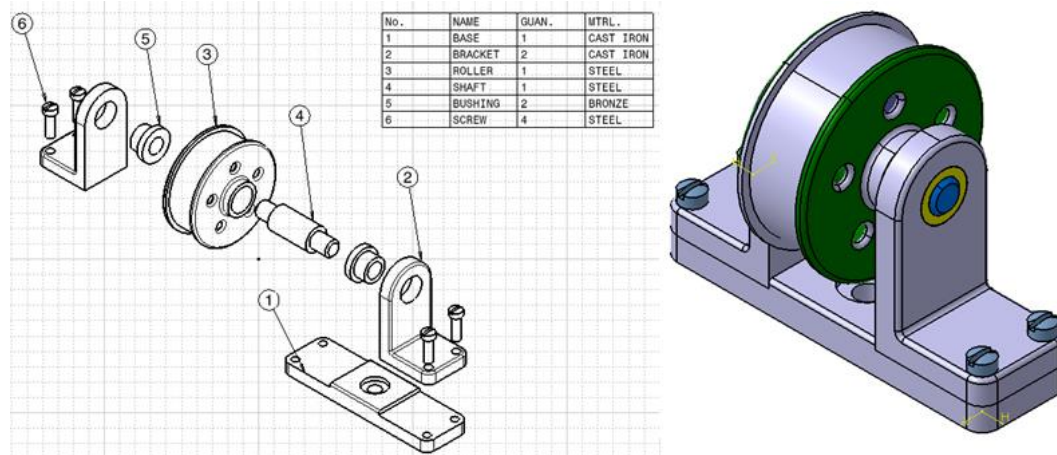
This paper includes the implementation of Bloom's taxonomy in the introduction to graphical communication course in the spring and the fall semester of 2011, and shows how students are moved up Bloom's taxonomy by including more challenging assembly projects into the course. Instead of following instructor's direction to accomplish an individual design project, students are required to accomplish one individual airplane project and one team-based project. To the airplane project, students can choose whatever airplane they want to design and finish the assembled airplane in 3 weeks. After they finish the airplane project, they will start their team-based project. They need to research the product they want to design, build the assembly product, and present their work at the end of the semester. Since 90% of students are freshmen who study aerospace engineering, it is believed that by designing an airplane it will enhance their understanding of airplane structure and aerodynamics mechanism. Team-based project enables and challenges students to work on highest level of Bloom's taxonomy by emphasizing teamwork, exploring real engineering design problem, judging the design criteria, and enhancing their oral and written skills. An end-of-semester survey was implemented to collect student's feedback regarding the two projects initiation. The results suggest that taking Bloom's Taxonomy into account in course design is worthwhile.

Current Curriculum and Course Structure

The goal of the Graphical Communication course is to familiarize the student with the basic principles of drafting, engineering drawing, improve three dimensional visualization skills, and fundamentals of a computer aided design program. After the completion of the course, students will know the character and application of the various lines used in engineering drawing; be able to relate a scaled drawing to actual size and be able to produce drawings to scale; develop the ability to make acceptable freehand sketches with special understanding of the importance of proportions; know the principles of orthographic projection and apply these principles to construct multiview drawings; understand the principles of isometric projection and apply these principles to isometric drawings; understand and draw auxiliary views; understand and draw interior view of

an object as a section view; develop the techniques and rules of dimensioning and tolerancing, and be able to apply these skills to a drawing; be able to read and understand basic blue print; be able to understand and use CATIA as a computer aided drafting tool to produce multiview, isometric, auxiliary and section views.

As a 3-credit course, students meet the instructor twice a week. Each class lasts 2 hours long. The first hour is the scheduled lecture time. After the lecture, students are allowed to use the rest of class time to ask questions and complete their assigned homework. During the 14-weeks semester, students will learn the principle of the orthographic projections and apply the principles to multi-view drawings by hand in the first 4 weeks. After it the introduction to CATIA-a 3-D computer aided drafting tool will be introduced and followed by the auxiliary views, section views, dimensioning, and tolerancing. A common final individual assembly project as an application under the direction of the instructor will be given to the students to test their problem solving skills. Normally students need to complete at least 10 parts and assemble them following the constrain requirements. Figure 1shows the exploded and 3-D view of previous individual project respectively.

No.	NAME	GUAN.	MTRL.
1	BASE	1	CAST IRON
2	BRACKET	2	CAST IRON
3	ROLLER	1	STEEL
4	SHAFT	1	STEEL
5	BUSHING	2	BRONZE
6	SCREW	4	STEEL

Figure 1. Exploded view of the roller guide and 3-D view of the roller guide

From the end of course evaluation, we learned that students could follow the direction and accomplish the individual project on time. But they felt a guided project was lack of challenge and they would like to design a more complex model by themselves. According to the Bloom's taxonomy, a guided individual project is considered as an application, which can be used to test student problem solving ability and satisfy ABET requirement. However, at this level students could not transfer material learned in the classroom into real life situations as discussed by Farris and Lane (2005). They would be more frustrating when they are confronting an open ended design. To change this situation, starting in the spring semester of 2011, an individual open-ended

airplane project and an open-ended team design project were initiated. To the airplane project, students need to design the airplane wing and jet engine following the instructor direction, after it students will accomplish the rest of the parts and assemble their own airplane. The design is evaluated by the level of the complexity by the instructor and the teaching assistant. This level is considered as the synthesis level according to Bloom's taxonomy. To the team-based project, students can choose design topic and form a team of 3 or 4. They are expected to use considerable skills learned in the class or by themselves to achieve their own goals with minimum assistance from their instructor. Their design is evaluated by their peers, and the instructor against a defined specification. This level of study is considered as the highest level of the Bloom's taxonomy-evaluation. It is expected that students could transfer the classroom learning to real situations after the completeness of the final project.

Project Outcomes

There were 26 students enrolled in the spring of 2011 and 35 students enrolled in the fall of 2011. To the airplane project, students were given three weeks before they started the team-based final project to design their own airplane. After they learned how to build the airplane wing and the jet engine by following the tutorial given by the instructor, they were on their own to explore the different tool bars or icons by themselves to accomplish this project. Figure 2 shows the rendered pictures of student designs. Since this is an open-ended project, students can be creative and learn more as they desire.

Figure 2. Rendered airplane model

To the team-based project, as a team of 3 or 4, they were able to choose their design partners and finished their design project within 3 weeks. The teams need to first present their design idea to

the instructor and the idea must be approved by the instructor to make sure that each team has a unique design product and there is no duplicate design. Students must do a certain amount of research to include the up-to-date technology in their product to emphasize the eco-friendly design and cost efficiency. The product must involve the new design and is not available in today's market. Each assembled product needs to include at least 10 parts. Each part is designed individually. The role of the instructor is a facilitator to ensure student projects delivered on time and the guidance is limited to the minimum. All dimensioned drawing sheets, 3-D part models, and power-point slides must be submitted on the Blackboard before the beginning of the last day of the class. On the last day of the class, students dressed up to present their work as a team. Each presentation lasted 8-10 minutes long and followed by 2-minutes Q&A time. Peer evaluation and team evaluation forms were given to the students to evaluate their peers work, and team presentation work. At the end of the presentation, instructor would summarize and conclude student projects. A survey was implemented to collect student feedback regarding their satisfaction of the final project and their comments on how to improve the delivery of the final project. During the two semesters, there were totally 16 projects designed by 60 students. The project topics are listed in the Table 1. Figure 3-4 show the exploded view and 3-d view of student team projects. The projects students finished are listed in the table 1.

Table 1. Student Project List

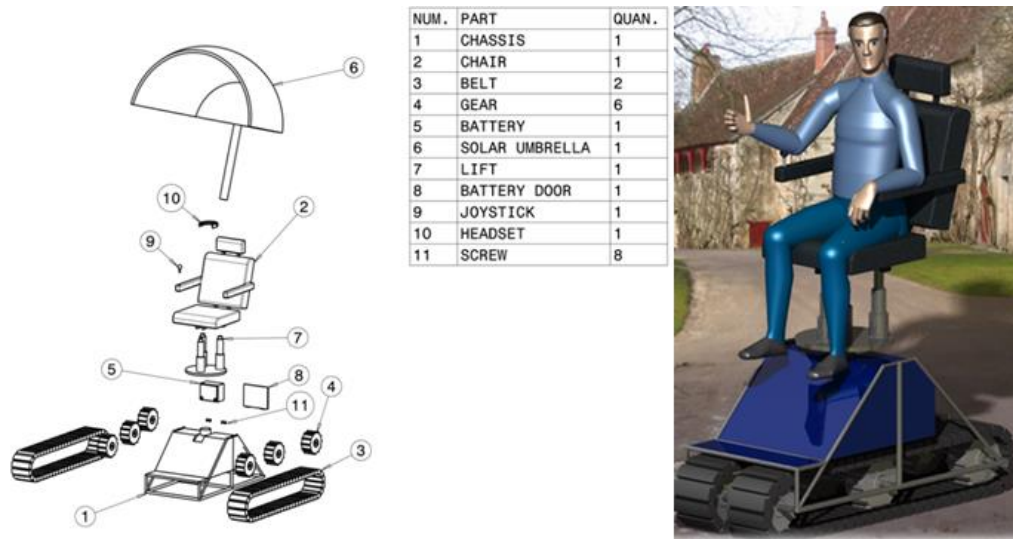|			
Eco-friendly Skateboard	Sun-go Skate	A future bicycle	Jet engine powered bicycle
A better keyboard	CAD mouse	A perfect office chair	Space Relay Power System
A rocket board	Light year Jetpack	Eco Cruiser	Hover board
Self-powered elliptical	Hovercraft	Solar powered wheelchair	Plasma propelled Spacecraft

NUM.	PART	QUAN.
1	CHASSIS	1
2	CHAIR	1
3	BELT	2
4	GEAR	6
5	BATTERY	1
6	SOLAR UMBRELLA	1
7	LIFT	1
8	BATTERY DOOR	1
9	JOYSTICK	1
10	HEADSET	1
11	SCREW	8

Figure 3. Exploded view and 3-D view of solar powered wheel chair

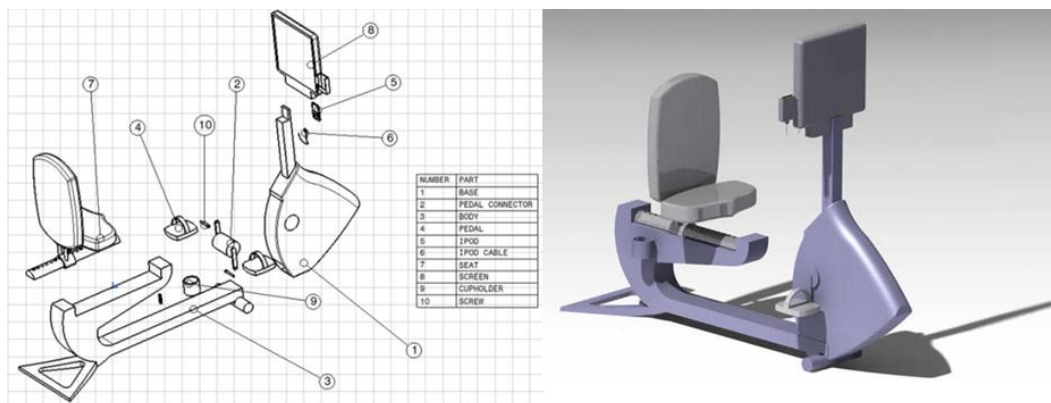| NUMBER	PART
1	BASE
2	PEDAL CONNECTOR
3	BODY
4	PEDAL
5	IPOD
6	IPOD CABLE
7	SEAT
8	SCREEN
9	CUPHOLDER
10	SCREW

**Figure 4. Exploded view and 3-D view of solar powered wheel chair**

ASSESSMENT

An end-of-semester survey was implemented to collect student's feedback regarding the open-ended project initiation. In spring and fall semester of 2011, there were 37 out of 61 students who filled out the survey at the end of the semester. Figure 5 shows the airplane satisfaction analysis in spring and fall semester of 2011. Since the majority students are aerospace engineering major, the airplane design was greatly welcomed by the students. Overall over 85% students like the airplane project and only 1 student showed the unlikeness in the two surveys. Some student responses are shown as follows:

- It is pretty much a perfect opportunity for students to put their knowledge into this exiting project.
- More knowledge of CATIA to make the plane more detailed.

- A bit more time to do it.
- The grading rubric.

From student response we can see that they are eager to learn more and design a better airplane, even though as an introductory level course the content of CATIA covered in the class is restricted by the limited class time.
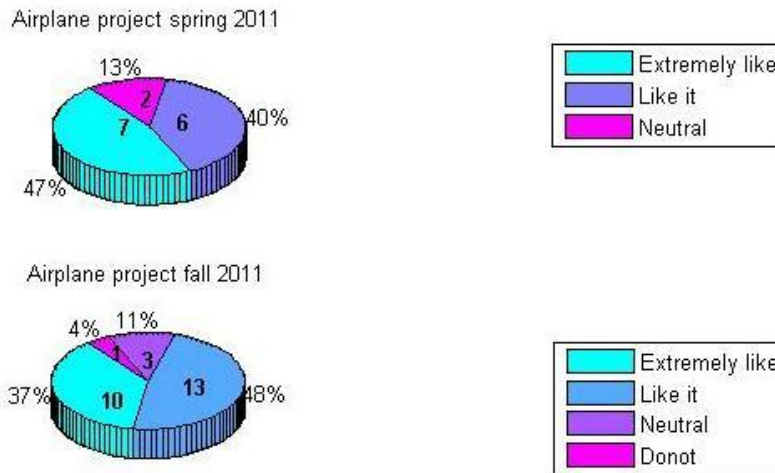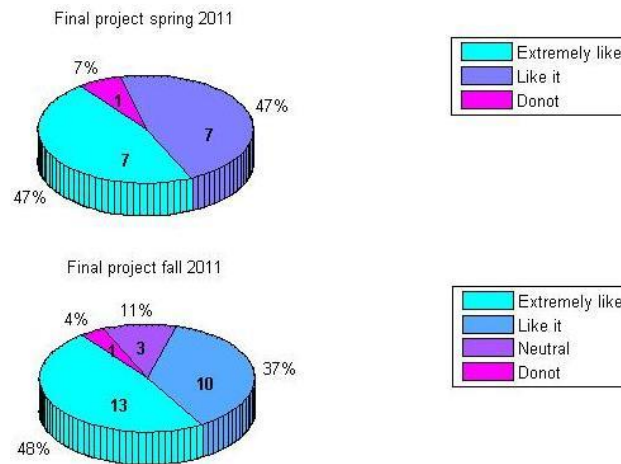

Figure 5. Two - semesters airplane project satisfaction analysis

Final project satisfaction data was analyzed in the Figure 6. From the chart we can see that the majority (37/42) of students enjoyed the final project design. Students highly rated the final project as a chance to understand an engineering design process. They enjoyed designing their own product, working with different classmates, and challenging themselves. They believed that they learned more from the final project by exploring tools which was not covered in class time, teaching themselves the communication skills, working as a team, enhancing their presentation skills. The main complaint was the limited time assigned to the project. Since there were only three weeks left for the project, they felt they can do much better if more time could be assigned. Some student responses are shown as follows:

•   I enjoyed the fact that we got to choose our own topic for the final project. I enjoyed choosing something that was interesting to me but that was also challenging.

•   It was cool to work with new people and build something new.

•   I liked it, thought it was interesting.

•   The final project was great!

•   More time so that students can create more complex products.

•   More defined parameters as to what needs to be turned in and what is expected of the presentation.

Figure 6. Two - semesters final project satisfaction analysis

Conclusion

This paper has presented a transition from a guided individual project to an airplane self-design project and a team-based design project by following Bloom's taxonomy. An end-of-semester survey was implemented to collect student's feedback regarding the open-ended project initiation. 61% students filled out the online survey. Students have responded positively to the two open-ended projects. It is believed that by teaching higher level of Bloom's taxonomy students would gain more solid knowledge and improve their ability to transfer the classroom material to real-life product design. Based upon student feedback, more time will be given to the students to produce more complex models. A revised project direction is needed to provide a detailed explanation regarding the submitted files and presentation expectation.

References

Bloom, B.S. (1956). *Taxonomy of educational objectives: Handbook I: Cognitive domain*. New York; Toronto: Longman.

Farris, J and Lane, P. (2005). *Reality Learning: Teaching Higher on Bloom's Taxonomy*, Proceedings of the 2005 American Society for Engineering Education Annual Conference & Exposition.

Felder, R M. and Brent, R. (2004). *The ABC's of Engineering Education: ABET, Bloom's taxonomy, Cooperative Learning, And So On,* Proceedings of the 2004 American Society for Engineering Education Annual Conference & Exposition, Session 1375.

Jones, K. O., Harland, R., Reid, J. M.V., and Bartlett, R. (2009). *Relationship Between Examination Questions and Bloom's Taxonomy*, 39th ASEE/IEEE Frontiers in Education Conference, Session W1G.