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Sun, L., & Grant, C. (2012). Teaching Higher on Bloom's Taxonomy: Experience in Introduction to Graphical Communications Course. , (). Retrieved from <https://commons.erau.edu/publication/166>

Sun, L., Grant, C., "Teaching Higher on Bloom's Taxonomy: Experience in Introduction to Graphical Communication Course," ASEE SE Section Annual Conference, Starkville, MS, April 1-3, 2012.

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Teaching Higher on Bloom's Taxonomy: Experience in Introduction to Graphical Communications Course

Lulu Sun¹[Christopher D. Grant²]

Abstract –Introduction to Graphical Communications is designed to familiarize the student with the basic principles of engineering drawing, to improve three dimensional visualization skills, and to teach the fundamentals of a computer aided design program. Much of the instruction is focused on knowledge and comprehension, low levels of Bloom's taxonomy. However, the students' ability to use this knowledge and comprehension to explore real engineering design is unknown. This paper includes the implementation of Bloom's taxonomy in the Introduction to Graphical Communications course, and shows how students are moved up Bloom's taxonomy by including a group final project into the course. Students are required to form the team, research the product they want to design, design their power point and present their work as a team. The team project enables and challenges students to work on highest level of Bloom's taxonomy by emphasizing teamwork, exploring real engineering design problem, and enhancing their oral and written skills.

Keywords: Graphical communication, CATIA, drawing, teamwork.

INTRODUCTION

Bloom's taxonomy is a commonly accepted taxonomy of cognitive skills, that is based on the level of student understanding necessary for achievement or mastery [1]. The system can be used to evaluate the objectives of the course curriculum and class activity. Introduction to Graphical Communications is one of the largest classes taught in the 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 teach the fundamentals of a computer aided design program (CATIA). Much of the instruction is focused on knowledge and comprehension, low levels of Bloom's taxonomy. The instructor shows students step by step how to understand the principles of orthographic projection, section, auxiliary views, dimensioning, and tolerancing, to build a model, and to make sure they can follow and understand the procedure. However, their ability to use this 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. The six levels of the Bloom's taxonomy are described as follows [2-3]:

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.

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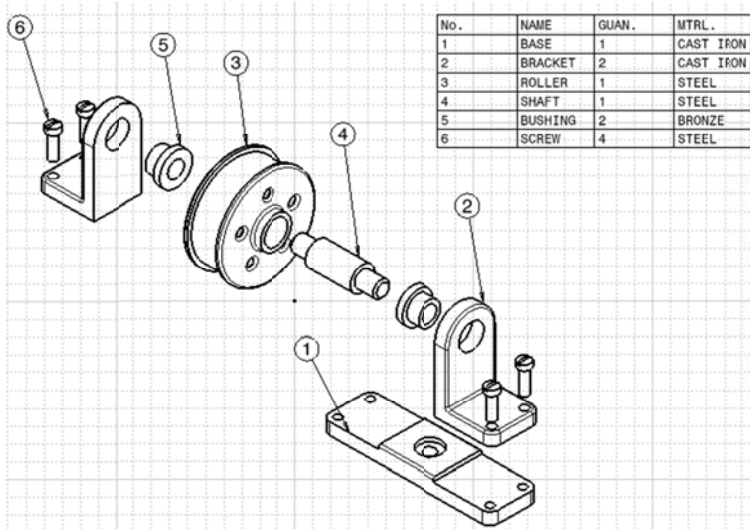
36 Our current curriculum gives students much practice in the low levels of knowledge, comprehension, and
37 application. Students do not have opportunities to practice their analysis, synthesis, and evaluation skills, which can
38 enhance their thinking and creative skills and enable them to succeed in today's competitive engineering
39 environment.

40 This paper includes the implementation of Bloom's taxonomy in the Introduction to Graphical Communications
41 course in the spring and the fall semesters of 2011, and shows how students are moved up Bloom's taxonomy by
42 including a group final project in the course. Instead of following the instructor's directions to accomplish an
43 individual design project, students are required to accomplish a team-based project by researching the product they
44 want to design, building the assembly product, and presenting their work at the end of the semester. This team-based
45 project enables and challenges students to work on highest level of Bloom's taxonomy by emphasizing teamwork,
46 exploring real engineering design problem, judging the design criteria, and enhancing their oral and written skills.
47 An end-of-semester survey was implemented to collect student's feedback regarding the team project initiation. The
48 results suggest that taking Bloom's Taxonomy into account in course design is worthwhile.

49 **Current Curriculum and Course Structure**

50 The goal of the Graphical Communication course is to familiarize the student with the basic principles of drafting
51 and engineering drawing, to improve three-dimensional visualization skills, and to teach the fundamentals of a
52 computer aided design program. After course completion, students will know the character and application of the
53 various lines used in engineering drawing; be able to relate a scaled drawing to actual size and be able to produce
54 drawings to scale; develop the ability to make acceptable freehand sketches with special understanding of the
55 importance of proportions; know the principles of orthographic projection and apply these principles to construct
56 multiview drawings; understand the principles of isometric projection and apply these principles to isometric
57 drawings; understand and draw auxiliary views; understand and draw interior view of an object as a section view;
58 develop the techniques and rules of dimensioning and tolerancing, and be able to apply these skills to a drawing; be
59 able to read and understand basic blue print; be able to understand and use CATIA as a computer aided drafting tool
60 to produce multiview, isometric, auxiliary and section views.

61 As a three-credit course, students meet the instructor twice a week with each class lasting two hours. The first hour
62 of each class is the scheduled lecture time and after the lecture, students are allowed to use the rest of class time to
63 ask questions and complete their assigned homework. During the 14-week semester, students learn the principle of
64 orthographic projections and apply the principles to multi-view drawings by hand in the first four weeks. After this,
65 CATIA-a 3-D computer aided drafting tool is introduced, followed by auxiliary views, section views, dimensioning,
66 and tolerancing. A common final individual assembly project as an application under the direction of the instructor
67 is given to the students to test their problem solving skills. Normally, students need to complete at least ten parts and
68 assemble them following the constraint requirements. Figure 1-2 show the exploded and 3-D view of previous
69 individual projects respectively.



70
71 Figure 1a. Exploded view of the roller guide.

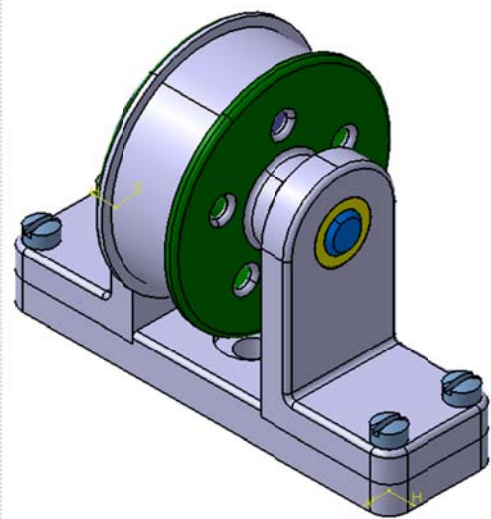
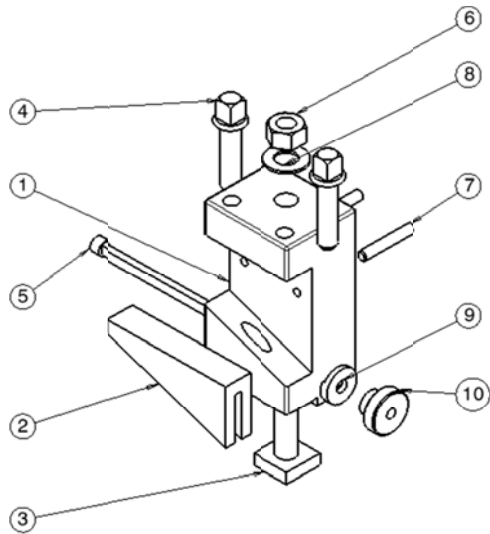
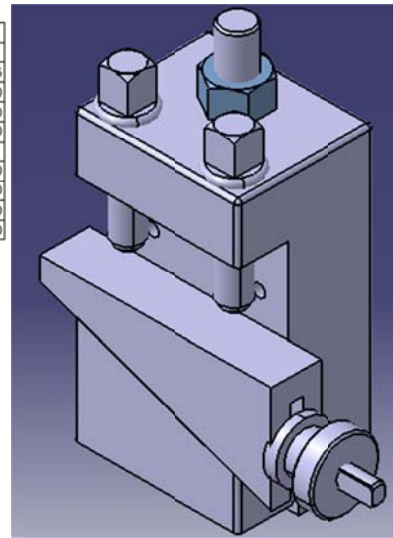


Figure 1b. 3-D view of the roller guide.



PART #	PART NAME	REQ'D	MAT
1	TOOL POST BODY	1	CI
2	WEDGE	1	SAE 1045
3	BOLT	1	SAE 1040
4	TOOL POST SCREW	2	SAE 1040
5	ADJUSTING SCREW	1	SAE 1040
6	HEX NUT	1	-
7	SET SCREW	2	SAE 1040
8	WASHER	1	SAE 1040
9	WASHER	1	SAE 1040
10	ADJUSTING NUT	1	SAE 1040



72
73 Figure 2a. Exploded view of the tool post.

Figure 2b. 3-D view of the tool post.

74 From the end of course evaluation, it was learned that students could follow the directions and accomplish the
 75 individual project on time. However, they felt a guided project lacked challenge, and that they would like to design a
 76 more complex model by themselves. According to the Bloom's taxonomy, a guided individual project is considered
 77 as an application which can be used to test student problem solving ability and satisfy ABET requirement. However,
 78 at this level students could not transfer material learned in the classroom to real life situations [4]. They would be
 79 more frustrated when they are confronting an open ended design. To change this situation, an open ended team
 80 design project was initiated starting the spring semester of 2011. Students can choose design topic and form a team
 81 of three or four. They are expected to use considerable skills learned in the class or by themselves to achieve their
 82 own goals with minimum assistance from their instructor. The students' design is evaluated by their peers and the
 83 instructor against a defined specification. This level of study is considered at the highest level of the Bloom's
 84 taxonomy-evaluation. It is expected that students could transfer the classroom learning to real-life situations after the
 85 completeness of the final project.

86 TEAM PROJECT OUTCOMES

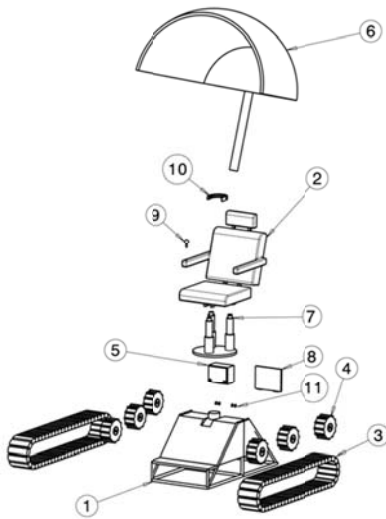
87 There were 26 students enrolled in the spring of 2011 and 35 students enrolled in the fall of 2011 in the courses for
 88 this study. As a team of three or four, they were able to choose their design partners and finished their design project
 89 within three weeks. The teams needed to first present their design idea to the instructor for approval to make sure
 90 that each team has a unique design product and there is no duplicate design. Students must do a certain amount of
 91 research to include the up-to-date technology in their product to emphasize eco-friendly design and cost efficiency.
 92 The product must involve new design and must not be available in today's market with each assembled product
 93 needing to include at least ten parts and each part designed individually. The role of the instructor is as a facilitator
 94 to ensure student projects delivered on time and the guidance is limited to the minimum. All dimensioned drawing
 95 sheets, 3-D part models, and power-point slides must be submitted on Blackboard before the beginning of the last
 96 day of the class. On the last day of the class, students dress up to present their work as a team. Each presentation
 97 lasts 8-10 minutes, and is followed by 2-minutes Q&A time. Peer evaluation and team evaluation forms were given
 98 to the students to evaluate their peers work, and team. At the end of the presentation, the instructor summarizes the
 99 student projects. A survey was implemented to collect students' feedback regarding their satisfaction with the final
 100 project, and their comments on how to improve the delivery of the final project. During the two semesters, there
 101 were a total of 16 projects designed by 60 students. The project topics are listed in Table 1. Figure 3-8 show the
 102 exploded view and 3-d view of student team projects.

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 gym bike	Hovercraft	Solar powered wheelchair	Plasma propelled Spacecraft

103

Table 1. Student project list.



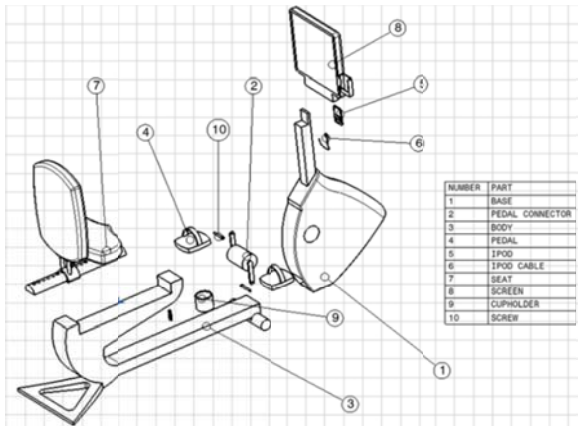
NUM.	PART	QUAN.
1	CHASSIS	1
2	CHAIR	1
3	BELT	2
4	GEAR	6
5	BATTERY	1
6	SOLAR UMBRELLA	1
7	LIFT	1
8	BATTERY DOOR	1
9	JOYSTICK	1
10	HEADSET	1
11	SCREW	8



104

105 Figure 3. Exploded view of solar powered wheelchair.

Figure4. 3-D rendered solar powered wheel chair



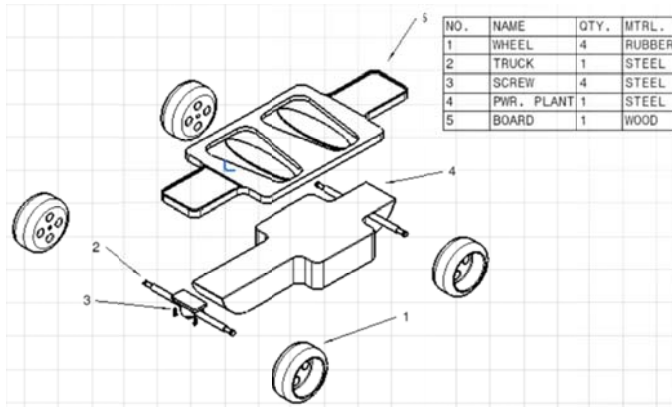
NUMBER	PART
1	BASE
2	PEDAL CONNECTOR
3	BODY
4	PEDAL
5	IPOD
6	IPOD CABLE
7	SEAT
8	SCREEN
9	CUPHOLDER
10	SCREW

106

107 Figure 5. Exploded view of self-propelled gym bike.



Figure6. 3-D view of self-propelled gym bike



108

109 Figure 7. Exploded view of solar powered skate vehicle

Figure 8. 3-D rendered Sun-go skate vehicle

110

ASSESSMENT

111 An end-of-semester survey was implemented to collect students' feedback regarding the team project. In spring and
 112 fall semester of 2011, 42 out of 61 students filled out the survey at the end of the semester. Final project satisfaction
 113 data was analyzed, as shown in the Figure 9. From the chart, we can see that the majority (37/42) of students
 114 enjoyed the final project design. The dissatisfaction percentage is decreased from 7% in the spring semester to 4% in
 115 the fall semester, mainly because, based on student's feedback, the project requirement and design guideline were
 116 clearly specified in the fall semester as compared to the direction given in the spring semester. Students rated the
 117 final project highly as a chance to understand an engineering design process. They enjoyed designing their own
 118 product, working with different classmates, and challenging themselves. They believed that they learned more from
 119 the final project by exploring tools which was not covered in class time, teaching themselves the communication
 120 skills, working as a team, enhancing their presentation skills. The main complaint was the limited time assigned to
 121 the project. Since there were only three weeks left for the project, they felt they could do much better if more time
 122 could be assigned. Some student responses are shown as follows:

123
124
125
126
127
128
129

- 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.

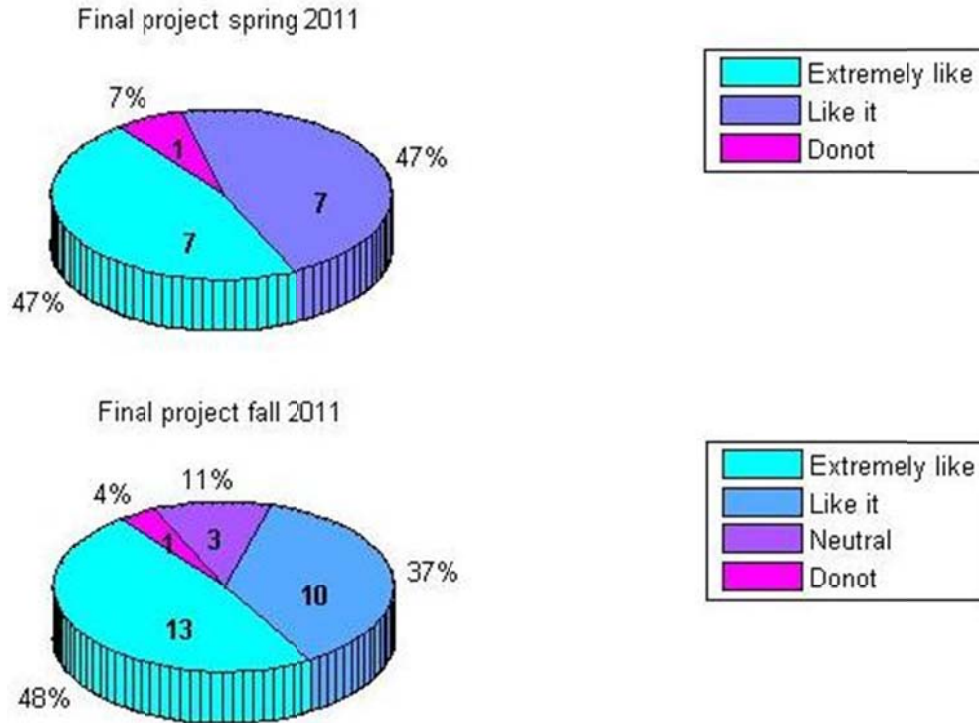


Figure 9. Two - semesters final project satisfaction analysis

CONCLUSION

This paper has presented a transition from a guided individual project to a team-based open ended project by following Bloom's taxonomy. An end-of-semester survey was implemented to collect student's feedback regarding the team project initiation. 69% students filled out the online survey at the end of two semesters. Students have responded positively to the final team-based project design. 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 final project direction and rubric are needed to provide a detailed explanation regarding the submitted files and presentation expectation.

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160 **Christopher Grant**

161 Dr. Grant is the Associate Dean of the College of Engineering and Chair of the Freshmen Engineering Department.
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168 awareness of engineering and have well-qualified students enroll in engineering programs.