Starting in Reverse

Dr. Lisa A. Riedle, Dr. Jill M. Clough
University of Wisconsin - Platteville

Reverse engineering, a group project utilized in the utilized in the University of Wisconsin - Platteville's freshman engineering courses. Three years ago the college of engineering implemented a freshman engineering course. There were a variety of objectives: retention, getting them involved in the college of engineering as freshmen, group projects, oral and written communication skills, and design experience.

The first year the course was taught a great deal of latitude was given in selecting topics for the group projects. This resulted in reports and presentations that were not of high quality. Student groups complained of boring topics, difficulties in finding information, conflicts among group members, and troubles determining the project's direction. The authors agreed the project needed to be revised. In addition, it was thought that a project which provided a hands-on experience and encouraged students to use their creativity might have a positive impact on retention. "Reverse" engineering provided the opportunity for students to work with a familiar object and determine how it was made, how it worked, and how it could be improved.

Results of the reverse engineering projects were positive. The quality of reports and presentations improved, and the percentage of students retained in engineering also improved. Allowing students to start with a familiar object an relate it to engineering may be an excellent opportunity to explain the various disciplines and phases of engineering. The projects also improving retention of freshmen students while building interpersonal, communication, and creative problem solving skills.

I. Background

GE 102 Introduction to Engineering is a relatively new course at UW-Platteville. The course is designed to 1) provide a broad overview of the engineering profession, 2) describe the engineering programs available at UW-Platteville, 3) familiarize students with campus resources, 4) encourage students to participate in campus activities and professional organizations, 5) encourage students to make a connection with an engineering faculty member, and 6) provide an introduction to software which is readily available on campus. . The course is required of all new engineering and pre-engineering students. Historically, about 420 students enroll in GE 102 in Fall semesters. In Fall 1996, ten sections of the course were taught by eight different engineering faculty members. In Spring semesters there is one section of GE 102. Grades in the course were based on students' participation, assignments, a faculty interview, activities, and a group project. Each instructor covered similar material, but the exact content and structure of the class were left to individual instructors.

Each of the authors had taught the course in Fall 1994 with some success and some frustration. One major source of frustration was the group project. In Fall 1994, students were encouraged to select an

engineering related topic. Students then wrote a brief paper and made a presentation to the class. Projects ranged from a discussion of how the Egyptian pyramids were built to how the Tacoma Narrows Bridge collapsed and from how of the space shuttle Challenger exploded to how to build a hovercraft from a leaf blower. Many students had difficulty identifying an appropriate topic, finding information related to the topic, working as a group, writing a paper, and/or presenting the project to the class. Several groups complained that the topic was boring. From the instructor's view, the reports tended to be superficial and sometimes were not clearly linked to engineering. While giving their presentations, the students were nervous and many simply read their report to the class.

As instructors, this project did not fulfill our expectations. It was hoped the project would provide students an opportunity to see the excitement and importance of engineering as well as giving the students a chance to work together creatively and use available resources to gather their information. The authors discussed the project and how it could be improved. It was decided that the main item needing revision was the project topic. The revised project would retain the basic requirements of the project -- working in a group, preparing a written report, and making an oral presentation. Looking back at the reasons students give for deciding to study engineering, many indicated interest in how things work or why something works the way it does. Reverse engineering provided an avenue for students to study a common object, to determine how it operated, and consider why the object was designed as it was. This use of common objects combined with the hands-on of determining how it worked was expected to challenge and interest students.

II. Purpose

Prior to the inclusion of GE 102 Introduction to Engineering, most beginning engineering students faced several semesters of mathematics, chemistry, and physics courses with very little contact with the individual engineering disciplines. During those semesters of math and science, some students got discouraged and may not have had a sense of being a part of the engineering programs. These students sometimes did not continue to pursue an engineering degree. One purpose of the Introduction to Engineering course was to help students feel connected to the engineering programs. It was hoped that the course would encourage students to persevere through the semesters of calculus, chemistry, and other sciences.

One of the benefits of incorporating a project in the Introduction to Engineering course was to expose students to a hands-on engineering-related activity early in their academic careers. In developing a group project for new students, several desirable attributes were identified. 1) A successful project would be viewed by students as interesting and challenging. 2) Students would have ready access to information. 3) The project's scope would allow for some in-depth investigation, but not require detailed analysis. 4) The project would be open-ended and encourage students to be creative as well as analytical. 5) The project would provide a hands-on experience related to engineering. 6) Students would be able to prepare informative reports to build written and verbal communication skills. 7) Students would give short, oral presentations using at least two different visual aids.

With such a project, students might be able to glimpse the excitement of engineering design and analysis early in their academic careers. In addition to improving GE 102, such a project may also have a positive impact on students' decisions to pursue an engineering degree rather than declaring another major.

III. Method

Since the Fall 1995 semester, the authors have used a project which utilizes a "reverse engineering" philosophy. Reverse engineering provides an opportunity for students to examine an object from an engineering viewpoint. To avoid previously experienced problems, topics were assigned. To ease information gathering, topics were familiar objects -- household items and children's toys. To ensure that projects were engineering-related, groups were given a basic set of considerations to start their investigation. To organize the project groups, each student was given a list of the objects and indicated their top three choices. To ensure that groups made progress, each group had one meeting outside of class with Dr. Clough to discuss what had been accomplished and what to do next. To assist in report preparation, specific guidelines were given regarding report structure.

Prior to the semester, familiar objects were purchased at a secondhand store. Fifteen objects were purchased for less than fifty dollars. Objects included household items and toys. Some of the objects used are listed in Table 1. Some objects could perform their intended function. Others were clearly in need of repair.

Table 1. Objects Used As Project Topics

Household Items	**Toys**
Toaster	See 'N Say
Personal Vacuum	In-line Skates
Mini-blinds	Etch-A-Sketch
Electric Razor	Bumble Ball
"Roller" Coasters	Wind-up Boat
Polaroid Camera	
Hair Dryer	

In preparation for the project, students were asked to complete the brief questionnaire shown in Table 2. The purpose of the questionnaire was to determine students' level of familiarity with reverse engineering, brainstorming, and problem solving processes. After completing the questionnaire, students were given a brief introduction to reverse engineering and an overview of the engineering problem solving process. Project report and presentation requirements were also discussed.

Table 2. Preliminary Questionnaire

1. What is "reverse engineering"?
2. What is brainstorming?

3.	Describe the problem solving process.

Groups were then randomly given one of the objects. As each group received its object, the First Reaction Worksheet, shown in Table 3, was completed. This sheet gave the group some initial direction and allowed the recording of some basic information about the object. Groups met for a few minutes to compare schedules and determine a convenient time for group meetings outside of class.

Table 3. First Reaction Worksheet

1.	What is it? Describe the object using words and sketches.
2.	What is the object's purpose?
3.	What materials were used to produce the object?
4.	How do you think it works?

Students kept one copy of this worksheet and gave one copy to the instructors. Students were also given a list of questions to consider. Some of the questions are shown in Table 4.

Table 4. Questions About the Object

1.	Who would use this object?
2.	Does this object pose any risk to the safety of the user?
3.	Could other materials be used to manufacture the object?
4.	How was the object manufactured?
5.	Could the object be modified to serve another purpose?
6.	How much did the object cost to manufacture?
7.	What would you expect the object's retail price to be?
8.	How could the object be improved?

Each group answered these questions and studied their object. During this class period, a technician was present to assist students in disassembling the objects. For some objects, it was a simple matter of loosening screws. Other objects required more elaborate and creative methods. A camera was also available, so students could take slides of the object and its components. It was recommended that each group take some slides of the object before attempting to disassemble it. Several groups then used the slides as visual aids during their presentation.

During the next several weeks students worked on this project. Each group was required to meet at least once per week outside of class. Occasionally, groups were allowed to use class time to discuss the project. Groups also scheduled a progress meeting with Dr. Clough. These meetings allowed groups a

chance to discuss their progress, problems, maintain direction and purpose for the written and oral reports. A plan of what to accomplish for the final report and presentation.

Each group found its own direction during the course of the project.

At the end of the project, each group produced a written report and made an oral presentation using at least two visual aids. All groups used the original object as one visual aid. The second visual aid ranged from slides of components to a cardboard model of an electric razor's cutters. As shown in Table 5, students completed a brief evaluation of the project.

Table 5. Evaluation Questionnaire

1.	Have you enjoyed working on your semester project? Why or why not?
2.	Have you learned anything from these projects? Please give examples.
3.	How do these projects relate to engineering?

IV. Results

This reverse engineering project met most of the intended objectives. Most students reported the project was interesting and fun. There were no complaints regarding the availability of information. Each group defined its own direction. The group studying a hand-held hair dryer focused on modifying their object and suggested adding a ground-fault interrupter to the hair dyer's plug. The See 'N Say group evaluated the safety of the toy and used their nieces and nephews as test subjects. Another group researched cost and popularity at a variety of locations across the country and discovered that in-line skates are more expensive in the West and South than in the Midwest due to differences in climate and length of the skating season. During initial disassembly, minor injuries occurred but no permanent harm was done to student bodies. Yet another group had extreme difficulty gaining access to the interior of their object, an Etch-A-Sketch. Eventually one group member became so frustrated he repeatedly slammed the object on the floor. When the Etch-A-Sketch did open, a large cloud of silvery dust escaped, much to the dismay of the dorm room's occupants. Not knowing the composition of the dust, the group carefully packaged as much of it as possible and then made an appointment with their chemistry professor. That professor helped the group run a series of simple experiments to determine the dust's properties. The group discovered that an Etch-A-Sketch is filled with aluminum dust. These students stated that they gained more from that chemistry experience than in their regularly scheduled laboratory projects because "it was fun".

From the instructor's view, the project reports were engineering-related and well organized. Students were less nervous while giving presentations because the topic (their object) was very familiar and the expectations had been well defined. Every group had a unique object. Students made good use of visual aids during the presentations and no group read its report to the class. Fewer students reported problems working within their group. There were virtually no complaints that the topic was boring or that information could not be located.

V. Future Directions

To determine whether this project using reverse engineering has a positive effect on retaining new students, students completing this project have been tracked. During the past two years, about 85 percent of the students completing this project in the Fall semesters register as engineering students for the Spring semesters. Historically, only about 63 percent of new students return for a second semester as an engineering student. This type of project may assist efforts to retain a higher percentage of new students in engineering.

There are a wide variety of objects available for study during a reverse engineering project. Reverse engineering is an excellent tool for allowing new students to participate in a hands-on activity and study an object from an engineering viewpoint. When teaching Introduction to Engineering again, the authors will continue use this reverse engineering project with minor revisions and will continue to track students.

JILL M. CLOUGH is the Program Coordinator and an Associate Professor in Industrial Engineering at the University of Wisconsin-Platteville. She teaches courses in simulation, facility design, and fundamentals of industrial engineering in addition to introduction engineering. Dr. Clough earned B.S., M.S., and Ph.D. degrees in industrial engineering from The University of Iowa. She has taught at UW-Platteville since 1985.

LISA A. RIEDLE is an Associate Professor of Civil and Environmental Engineering at the University of Wisconsin-Platteville. She teaches courses in construction, the capstone design course, and introduction to engineering. Dr. Riedle holds a B.S. in mining engineering from UW-Platteville, M.S. in civil engineering and Ph.D. in mining/civil engineering from The University of Alabama. She has taught at UW-Platteville since 1990.