TEACHING ENGINEERING WITH GAMES

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Abstract:

Various games are used in two engineering courses. The games are used in Structural Theory CE342 which is a Civil & Environmental Engineering junior level course, and in Engineering Design & Graphics E101 which is a freshmen level required engineering course. The games consist of computer games and printed puzzles that are used to teach specific and general engineering concepts. The computer game SBGAME is used in Structural Theory to teach intuitive sketching of beam shear and bending moment diagrams. Other puzzles have been created by the instructor. The puzzles teach a wide range of topics including three-dimensional visualization, perspective, mechanics, construction methods, invention, and design. Games are used in the freshmen year to improve retention, class attendance, and student enthusiasm. The games replace dry lectures about physical geometry with fun activities. The class instruction platform is changed from lecture into cooperative learning.

Introduction:

Engineering can be fun! Games were used to teach engineering principles enthusiastically so as to improve student attendance and retention. The games are created by the instructor. One game is a computer game written specifically for the purpose of teaching structural theory.

The two affected courses have had difficulty in the past. Student attendance and enthusiasm has been low. The students commonly called the E101 course a "blow off." Few students had positive comments about their freshmen experience. This has influenced retention of freshmen as sophomores. Research has shown that the freshmen year is a good time to promote interest in engineering [1] although most programs wait until the junior year to bring in much design content. That is why UDM is redesigning all of its freshmen level engineering courses and having "fresh blood" teach the courses.

Students will have many opportunities to meet and work with their fellow students. This has been shown to have a big effect on improving retention, especially upon female engineering students. [1] Another effect on retention is student identification with a department. [1] When students meet and interact with a professor in their chosen field this spurs identification or loyalty to a department.

The methods of cooperative learning were used extensively because research shows that students learn more by cooperating than they do by competing or working individually. [2] The basic elements of cooperative learning are: making all students believe that they cannot succeed unless their group succeeds, while keeping individuals accountable for their own

work; face-to-face learning and teamwork. [2]

Graphics:

The E101 Engineering Design and Graphics course is a freshmen level course where students learn visualization techniques. The students also have team design experiences. Only about half of the UDM students have experience in visualization through high school drafting courses. Games or puzzles are used to prepare the students for visualization and for using software such as AutoCAD and IDEAS.

Games are used both as reinforcement of lecture material and to present material. Perspective is taught in a one hour session. Perspective is discussed for ten minutes by the instructor, then the students are broken into groups and given a puzzle. See Fig. 1. Certain objects are shown drawn with errors in perspective view. The instructor tells the students to identify the incorrect object and redraw it correctly. Student groups work on the game face-to-face for 25 minutes, then for 15 minutes student groups present their solutions. The groups are called to the front overhead projector where they mark the corrected perspective view.

The basic elements of cooperative learning are used in this exercise. The groups of students are called randomly to the front of the class. A twelve sided die was used to prevent instructor bias. Then within the group one student was randomly chosen to present the solution. Obviously the individual is accountable, but the group is also accountable since they know they will be embarrassed if their representative cannot fully explain the solution.

During this game as well as in the other games the students sometimes disagree about the answer. The students argue in the spirit of academic inquiry. Usually the groups with the correct answers are able to explain to the other groups the basis for their answer. Occasionally the instructor has to step in to aid the discussion. Students need to be reminded of the terminology of the vanishing point and horizon line.

The entire session is taught interactively except for the first few minutes of presentation. The students must think and reason throughout the session. They become conditioned to arrive at class in a mood for learning.

Games or puzzles are used to teach visualization during many class sessions. They can be used as a warm-up exercise, as a mid-class refresher, or throughout the class. The visualization concepts that are taught with games are: perspective, orthogonal views, mentally rotating objects, and describing hidden features. Figure 2 shows visualization puzzles.

The method for using the games is usually similar to the method described for perspective, although students are not often called to the blackboard to sketch their answer. It is only when there is a disagreement or when they lack the vocabulary to express their answer that they need to do sketches.

Because some students are more adept and finish the games quickly, it is necessary to provide additional optional work after the game so that students will not be idle. Since the games are given to the students on photocopied pages, it works well to assign the front side of the paper and put optional exercises on the back. It is important that all student groups finish and understand the material. This means that all but the slowest group will have begun the optional material.

It was found that most students do the optional work because they enjoy the games. However, some students will sit and softly talk after completing their work. This isn't to be discouraged since students must know their group partners to

be an effective team.

The optional games are more rigorous since it is the faster students who have reached them. The optional games are also sometimes less related to the course. Many of the optional games are related to mechanics, gears, and pulleys that could be used in a mechanics course.

Student Feedback:

The students were surveyed anonymously to get their opinions on using games in the classroom. The questions and some responses are shown below.

"Do you usually enjoy the games?"

Yes: 88%, Sometimes or No: 12%.

"Did the doing the games help you visualize the workbook assignments?"

Yes: 35%, Somewhat: 47%, No: 18%.

"Should I use more or fewer games next year?"

More: 40%, Same: 27%, Fewer: 33%.

Random responses to the questions are shown below.

"It's fun. You can get together with your classmates."

"They're kind of helpful but somewhat tedious."

They help "build up the sense of visualization and perception."

"Kinda hoakey, but fun."

"They got your mind going."

"It's a good way to break the ice."

"They are pretty cool."

"It was alright but some of the games were stupid."

A more rigorous method to determine the effectiveness of using games would be to compare the scores of the students from one year to the next. However, this isn't reliable since this course was completely changed including the types of homeworks assigned.

Structural Analysis:

A graphical computer program, Shear and Bending Game (SBGAME) was used to teach shear and bending moment diagrams in the junior level Structural Analysis course. The game displays diagrams of beams with supports and loads. The program questions the students about the shape of the shear and/or bending moment diagrams. Students enter the shape with numbers that correspond to the curve shape. The program responds to a correct answer by drawing the segment of the diagram. A database of explanations is used to respond to incorrect answers.

Students play the game in pairs in class. The students compete with each other by answering the questions alternately. The purpose of the game is to teach the students to be capable of intuitively performing a beam analysis. This helps correct the problem that students rely on equations and can't recognize when their answers are wrong.

US Copyright Law:

The US Copyright Law [3] provides for "fair use" or legal right to use copyrighted material by teachers and students. However, there are limitations to fair use. This is relevant to using puzzles in the classroom since it is the authors desire to hand out materials copied from books and magazines for the students to work on.

An instructor may make multiple copies to hand out in the classroom. However, the fair use right never allows copying of consumables like workbooks and puzzles, since photocopying replaces a purchase.

This makes preparation for using games much more difficult. Either an instructor must make his or her own puzzles or must contact a copyright holder for permission to use puzzles. Several magazines, such as *Games,* and books with suitable puzzles are available in bookstores.

Summary:

Games were used for about four hours of class time during the Graphics course. Most of the students enjoyed the games. Sixty-seven percent of the students said that the same number or more games should be included. Upon consideration of this the instructor plans to continue using about the same number of games in future years. A few students commented that some of the games weren't applicable or useful. Therefore, the instructor will be more selective to find the games that are most relevant to the course.

The author grants permission to use any material in this paper for educational purposes. The shear and bending game SBGAME may be obtained from the author by emailing a request to "hobackas@udmercy.edu".

References:

[1] Hoit, M., Ohland, M., "The Impact of a Discipline-Based Introduction to Engineering Course on Improving Retention," J. of Engin. Educ., Vol. 87, No. 1, Jan. 1998, pp. 79-85.

[2] Johnson, D. W., Johnson, R. T., Smith, K. A., "Maximizing Instruction Through Cooperative Learning," Prism, Feb. 1998, pp. 24-29.

[3] "Copyright Law of the United States of America," Title 17 of the US Code, Section 107, 1977 and as amended.

Author Biography

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