SURVIVOR: CLASSROOM

A Method of Active Learning that Addresses Four Types of Student Motivation

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Phil Wankat[1] succinctly states the importance of active learning in the classroom as "Involved students learn!" As a result of the dissemination of overwhelming evidence supporting active learning, more engineering faculty (including, presumably, almost all of those who would choose to read this paper) are using active learning in their classrooms.[2-4] A survey conducted by Brawner, *et al.*,[5] indicated that 60 percent of responding engineering professors used some active learning. While the benefits of active learning are clear, simply breaking students into small groups to work on problems during class does not automatically address the pervading issue of student motivation. Biggs and Moore[6] classify four primary types of motivation:

- **Intrinsic** — *learning because of natural curiosity or interest in the activity itself*
- **Social** — *learning to please the professor or your peers*
- **Achievement** — *learning to enhance your position relative to others*
- **Instrumental** — *learning to gain rewards beyond the activity itself (better grades, increased likelihood of getting a high-paying job, etc.)*

As such, an active-learning activity that addresses all four of these motivational categories would be useful. Unfortunately, professors tend to assume that things that would motivate them will also motivate their students. The problem is analogous to issues with learning styles in engineering education: Professors tend to teach the way *they* prefer to learn, which negatively impacts the learning of students with different preferences.[7-9] Not all students are inherently thrilled with solving energy balances, even when working in groups with their peers.

Of course, motivation is a far more complex series of cognitive processes than can be completely addressed with a single activity. Bandura[10] emphasizes the motivational importance of self-efficacy—the belief that "one can bring about positive results through one's own actions[11]"—by stating that self-efficacy impacts how much effort people offer and how long they will persevere when faced with obstacles. Ponton, *et al.*, [12] argue that it is paramount for a professor to incorporate strategies that enhance efficacy. Therefore, all students who participate in the learning activity must practice relevant exercises that develop both their skills and their confidence in their own abilities.

Ten years ago when I was teaching my first class, the sophomore-level materials and energy balances course, I was fortunate enough to have dinner with Rich Felder one evening and to talk about pedagogy and learning styles. The next day, I broke my class into small groups and in-

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stead of my lecturing to them about the problem, they solved it themselves. I was happier. Most of the students were happier. And they seemed to be learning more, but too many of them never really engaged in the activity. Assigning roles for team members helped, but it did not fix the problem. The student evaluations were very positive, but the students who did not engage during the active learning exercises were disproportionately represented in the group that did not make it to their junior year. The challenge was to find an activity that would motivate a wider range of students so the entire class would engage actively in the group problem solving. The pedagogical literature[13-15] shows that student involvement has a significant impact on student success and satisfaction.

Wankat and Oreovicz[16] proposed using quiz games modeled after popular formats such as *Jeopardy* or Trivial Pursuit as an active-learning alternative to lecture, but these games lend themselves better to knowledge-based questions than to problem solving. I have used the *Hollywood Squares* format in a materials science class for such questions, but it did not seem appropriate for a materials and energy balances class. Susan and James Fenton[18] at the University of Connecticut developed a very effective game called "Green Square Manufacturing" that came closer to meeting the needs of the class, but it did not necessarily address all four motivational factors, nor did it have the pop culture tie-in that I wanted. Finally, the idea of adapting a version of the CBS "reality" game show *Survivor* came to me. With inspiration and a little preparation, a game that met my needs was developed.

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THE GAME

Students in the materials and energy balances class are broken into "tribes" of seven to eight people. At Rowan, this usually results in three tribes, but the number of tribes does not substantially alter the flow of the game. The tribes sit together much as they would in any group problem-solving exercise. If inadequate space is available, the tribes may self-segregate into smaller subgroups. Each tribe names itself.

The team members are permitted to have their textbook, notes, a calculator, and pencil and paper with them, but the book and notes must be closed at the beginning. I write a problem on the board, but they must not look up any values or begin writing until I say to begin.

Once they begin solving, the first tribe that has an answer to the problem has a member raise a hand. The other teams stop and the first team reveals its answer. If it is correct, that tribe has immunity and it does not lose a member. If the answer is wrong, the tribe cannot win immunity and the remaining tribes continue with the problem until one tribe successfully solves the problem or all but one tribe has provided an incorrect answer. To avoid issues of round-off or interpolation, I accept any answer within five percent of my answer. A representative from the successful tribe goes to the board to present the solution to the problem, so that the rest of the teams can consider their solution strategies.

At the end of the first problem, one tribe has earned immunity and every other tribe must lose one member. The method for elimination that seems to work best is

- In the first round, tribe members vote off a member of their own tribe
- In the second round, the tribe with immunity votes off a member of each of the other tribes
- In the third round, one member of each tribe is randomly eliminated by drawing a name

If there are more than three rounds, the steps are repeated in order. In the television show, the tribe members always vote off a person of their own tribe, but initially I was reluctant to allow voting at all. I worried that feelings would get hurt, self-efficacy would be damaged, and the students who most needed the reinforced problem solving would be eliminated the quickest. The students, however, were unambiguous: They wanted to vote.

As it turns out, the alternating system described above cures many woes. In almost every tribe, there is one player who wants to leave the game (for a variety of reasons). This person is almost always voted off first. Absent students are also assigned to a tribe and they are also quickly voted off. When the victorious tribe votes a member off of another tribe, they uniformly take out the strongest students. The random round is, of course, random. Ultimately, the average students who have enough skills to solve the

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problems, but who genuinely benefit from reinforcing the concepts, survive the longest.

Students who have been eliminated in any round are given the task of designing and solving a problem to be used in later rounds. Thus, while they are no longer participating in the main activity, they remain actively engaged in team-oriented problem solving. More importantly, they discover that they are not only capable of solving problems, but can also create new ones. These students spend much of the time reading the textbook (in many cases for the first time), looking for a problem idea. Because they must provide a solution as well, their problem-solving skills are also reinforced.

In a typical 75-minute class, there is enough time to get through about six rounds of the game. Speeding up the elimination process would allow for more rounds, but the students seem to thoroughly enjoy that aspect of the game and it provides adequate time for the eliminated students to develop their own problems. At the end of the first class, the tribes are dissolved, and all of the players who have not been eliminated become part of a single tribe.

The team dynamics are fascinating to watch. In some tribes, each member attempts the problem on his or her own, then the first one who finishes speaks for the team. In other tribes, the players assign roles. One or two people look up values from the tables while another sets up the problem. For less trivial problems, some teams take a few seconds to discuss solution strategies before diving in.

The second day of the game involves solving the problems as individuals, but otherwise the flow is the same. A problem is placed on the board, the first person who finishes it either receives immunity or fails to solve the problem, and the round continues. Players are eliminated by vote of the tribe in the first round, by choice of the player with immunity in the second, and by random draw in the third. The cycle repeats until a single player remains and is crowned as the grand champion. Groups of eliminated players develop and solve the problems used throughout this round.

The successful students are rewarded with bonus points on the 200-point final exam. Every player who survives to the second day gets three points, every original member of the champion's tribe gets two points, and the champion gets an additional five points. The bonuses are additive, so the champion will wind up with 10 points (five percent), while everyone else will get between zero and five points. In three years of playing the game, the bonus points have never altered the final course grade of the grand champion, but students battle ferociously for them all the same.

LINKS TO MOTIVATION AND SELF-EFFICACY

Intrinsically motivated students gladly participated in the activity because they liked the activity itself or were genuinely interested in solving new problems. The socially motivated students worked hard on the problems because they did not want to let their teammates or the professor down. Achievement-oriented students wanted to win because it was a contest, often independent of the reward or interest in the material. Finally, students with instrumental motivation tendencies wanted the bonus points in hopes of improving their final grade in the class.

In terms of self-efficacy, the weakest students are voted out in the first round, but soon find themselves successfully writing problems that will be used later in the game. As the game progresses, the students gain confidence in their ability to write and solve problems. The strong students who are eliminated in the second round recognize why they were eliminated and help the weaker students with aspects of the newly created problems.

STUDENT FEEDBACK

On the course evaluations at the end of each semester, the students were specifically asked the question, "Was *Survivor* helpful in developing an understanding of the subject matter?" On a five-point Likert scale with five representing extremely helpful and one representing not helpful, the mean responses to that question were 4.70 in 2001, 4.77 in 2002, and 4.80 in 2003. Specific student comments have included:

- *"The game made the course interesting."*
- *"Playing the game helped to stimulate thinking."*
- *"Game was fun for a change."*
- *"Creating our own problems was especially helpful."*

SUMMARY

The game show *Survivor* has been adapted and used for three years as a means of introducing active, team-oriented problem solving into a sophomore-level course on energy balances. The game provides incentive for students from all four motivational forms (intrinsic, social, achievement, and instrumental). By having students who have been eliminated continue to participate through developing new problems that are used in the game, the entire class remains engaged throughout the activity. Based on several key observations:

- *The students self-report that the game was beneficial and increased their motivation;*
- *The game was designed specifically to address different motivational styles;*
- *I (and other professors who have used the game) have directly observed that the level of participation increased in problem-solving activities;*
- *Performance of the students in subsequent thermodynamics classes improved after the game was introduced;*

I believe the game has provided an effective method of reinforcing problem-solving methodologies, as well as being extremely popular with students.

SAMPLE QUESTIONS

Used in *Survivor*-Model Active Learning Game

1. *One mole of a mixture containing 20% ethanol and 80% water at 20°C and one atmosphere is to be cooled to 4°C.*

   How much heat must be removed from the system?

2. *Given the following chemical reaction*

   Dahmene (g) + 20 IQ (g) $\rightarrow$ Newellium (g)

   What is the heat of combustion for gaseous Dahmene if the heats of combustion for Newellium and IQ are -4130 kJ/mol and -246 kJ/mol, respectively?

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