Playing Games:
The Importance of Activities in the Science Classroom

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Abstract

By encouraging interaction and discussion, this board game endeavors to increase student comprehension and retention of biological facts and concepts. A unit was designed to create an engaging learning experience to pique student interest in the legal and ethical issues surrounding genetic technologies as well as assess the game's success as a teaching tool. A lesson plan focused on the genetic and cellular aspects of new genetic technologies was presented to two 10th grade biology classes and two 12th grade AP biology classes. All four classes were presented with the same lesson plan. One class of each grade served as a control, participating in a more traditional oral review the day following the lesson. The experimental class of each grade played the board game in place of the standard review session. A pre/post-test assessment method was employed to determine the effect of playing the board game on student comprehension and retention of material. Both the control and experimental classes showed significantly higher post test scores than their respective pre test scores. This result indicates learning occurred within both the control and experimental groups of each grade. However, the post-test scores of each experimental group increased by a significantly greater amount than that of each respective control group, implying that the students who played the board game experienced an educational benefit beyond the traditional lesson plan and review. Significantly higher test scores coupled with positive reviews from both college and high school student players show that this board game achieved its goal of both teaching and engaging interest. It can be easily modified for college courses as well as adapted to cover other biology topics.

Introduction

"Some activities are so rigidly scripted that students do not have to employ any reasoning skills…" (Windschitl, 2009). One name for this is the 'cookbook lab,' an activity that can be completed without comprehending what was done. To combat this, game play was designed to lead students to practice applying lesson facts in new situations and to create discussion points that further critical thinking, engaging students through proven methods of motivation and instruction.

Classroom Tested

Class periods were randomly assigned to either a control group or a gaming group. Both treatment groups took a 30 point pretest at the beginning of day one before receiving a traditional lecture. On day two the control group participated in a verbal review that consisted of a teacher led question-and-answer session. The gaming group was given one period to play the board game. Both groups were given the same test at the end of day two (Fig. 1).

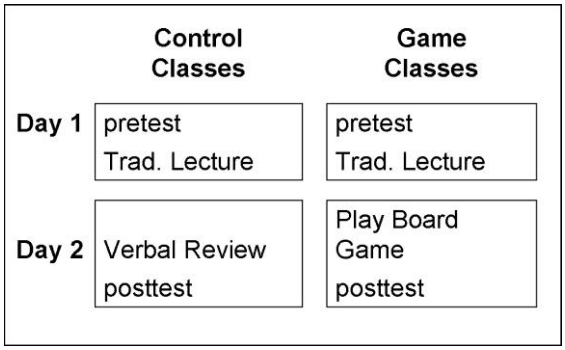

Figure 1. Diagram of pedagogy used in each group.

A pre/post testing method was used to assess the success of this board game as a teaching tool. Pre/post testing is designed to assess academic progress during an instructional unit. Pretest results establish a baseline of student knowledge for comparison with later posttest results. The test assessed student understanding of vocabulary words and application of facts and concepts. Scores were then analyzed using Fisher's Analysis of Variance (ANOVA). Graphical representation of each assessment (Fig. 2) illustrates that the mean posttest score for the game group is higher than that of the control group.

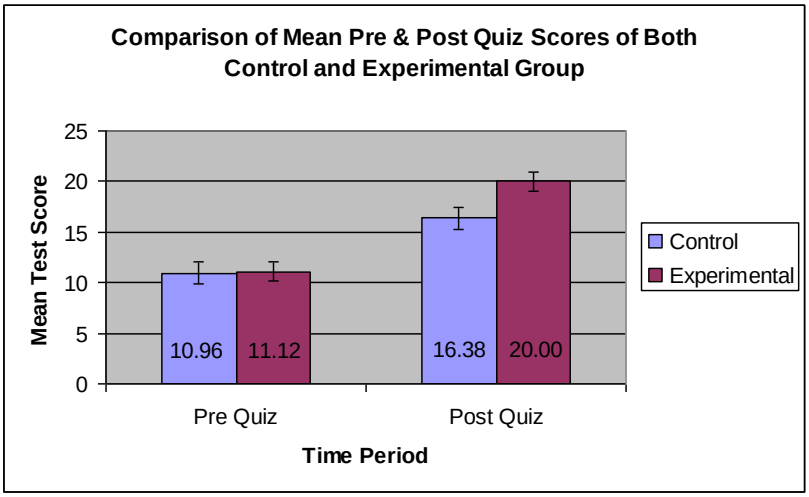

Figure 2: The mean pretest scores for both groups are not significantly different as seen in this figure and by the p-values reported below. The mean posttest scores for both groups are significantly different according to the p-values reported below. The experimental group had a mean posttest score significantly higher than that of the control.

As a means of control, the pretest scores for both groups were evaluated against each other. This analysis showed no significant difference *(p-value = 0.92)* between the pretest scores of the two groups, verifying that both classes started with the same base knowledge (Table 1). Next, pretest scores were compared to posttest scores within treatment groups. A significant difference *(p-value = 0.001)* was seen between pre and posttest scores of the control group and also between pre and posttest scores of the experimental group *(p-value <0.000).* Both classes did have significantly improved posttest scores

demonstrating learning did occur in both classrooms (Table 2). Finally, A significant difference *(p-value = 0.019)* between posttest scores of both groups indicate the amount of learning experienced by the experimental group is significantly different from that of the control group (Table 1).

Comparing the control group to the experimental group			
	DF	F Value	P Value
pretest	40	0.01	0.922
posttest	41	5.97	0.019

Table 1. Pretest scores of the control are not significantly different from those of the experimental group. Posttest scores of the control are significantly different from those of the experimental group.

Comparing Pre-test to Post-test scores within treatment groups			
	DF	F Value	P Value
Control	49	13.33	0.001
Game	32	36.26	<0.000

Table 2. A significant difference was seen between pre and posttest scores of the control group and also between pre and posttest scores of the experimental group.

Both classrooms experienced learning— as shown by increased posttest scores for both treatments— however analysis indicates that the experimental group demonstrated a greater amount of learning. Improvement of test scores was significantly greater in the experimental group, suggesting an added benefit from playing the board game in place of a verbal review. The validity of these findings is supported by the pretest scores showing no significant difference between the two groups. This indicates the groups were equivalent before the unit began and improvement in test scores is more likely due to the lesson plan and type of pedagogy used for review rather than chance.

These results support a conclusion that the board game created a deeper understanding of the material. One teaching strategy that may account for the board game's influence is adapting to multiple learning styles. By providing students with visual, auditory, and kinesthetic cues this type of review satisfies learners of every type while a verbal review does not (Piaget 1958).

Bloom's Taxonomy is a model for creating measurable lesson objectives. For this research the pre/posttest and game cards were written to encourage thinking at all levels of the taxonomy. Analysis of specific test questions indicates that students from the control group could correctly recall definitions or facts from the lecture; however, they missed questions requiring the application of this knowledge to new situations. The experimental group showed the ability to think critically and apply facts, thus operating at a higher cognitive domain (Bloom 1956).

Many instructors are just as frustrated by educational games that do not actively engage students as they are by entertaining games that have no educational value (Chimeno 2006, Hogle 1996). By utilizing known education and motivation strategies, the design of this game can address both of these concerns. Integrating this type of teaching tool, with possible future technology, into the classroom may lead to a more enduring understanding of subject matter. Future testing for this board game would include larger samples sizes and delayed post testing to see if the same level of performance is still possible several weeks after playing the game.

Student/Game Interaction

Students play on teams that function as their own society. The game consists of the board and three card types. A die is rolled to determine the amount of spaces the team will move their play piece and board spaces determine what happens next. Spaces correspond to one of the three card types or can be blank. Ending a move on a card space requires the team to draw that card type.

Trivia cards are intended to reinforce scientific facts and concepts from the lesson plan and correspond to the knowledge and comprehension levels of Bloom's Taxonomy. Below is a sample trivia question from the genetic technology unit.

Q: Define the term carrier as it applies to heredity

A: A person with heterozygous genotype who is not affected by the genetic disorder but may pass it on.

The second card type, Karma cards, work the same as "Chance" cards in the board game *Monopoly*. These cards have two parts, a humorous story that is meant to convey lesson information in a new way, and a second part with directions for game play. This card type adds an element of luck to the game, creates more opportunity for teams to encounter Trivia card spaces, and introduces students to possible consequences of developing genetic technologies. (Example below)

Cowzilla!!
You're transgenic cows are growing out of control.

Go back 5 spaces and round them up

The third type of card, the Ethics card, gives players the opportunity to choose what they will and will not allow in their "society." Each Ethics Card provides a discussion prompt and the team must work together to reach a decision or ruling. Each discussion prompt is phrased to encourage thinking from the synthesis and evaluation tiers of Bloom's Taxonomy. A team must discuss and create "laws" for a total

of four Ethics cards in order to win but cannot participate in discussion if they have not answered trivia questions correctly.

A group of scientists has engineered a strain of wheat that produces its own pesticide. Environmentalists are concerned this crop could have serious detrimental effects on the ecosystem.

What possible side-effects are the environmentalists worried about?
How should this new technology be handled?
How will your country settle the dispute?

Instructor's Notes

Class size

This activity is suitable for classes of 12 to 30 students. Teams function best with four to six students and the board game can support three to five teams. The game will play faster for smaller classes so more cards will be necessary. Large groups may need to have a time limit imposed on discussions to keep the game moving forward.

Game Design

To create an educational board game similar to the one in this study, begin by choosing a lesson or unit that has plenty of discussion prompting topics. Divide lesson material into tiers based on Bloom's Taxonomy. Facts and details that are to be learned with little interpretation can be used for Trivia Cards. Lesson topics suitable for Ethics Cards are those that involve application or analysis of straight forward facts or those that create controversy. To create Karma Cards, use lesson information to write good luck/bad luck events. The board itself should have spaces randomly assigned and be decorated in accordance with the lesson or unit theme.

Expansion

Students can be assigned to build the game themselves. This provides more reinforcement of lesson topics and can scale the difficulty for advanced courses. Science Pedagogy courses for education students will also benefit from this expanded exercise as they can be learning science content, Blooms Taxonomy, and activity creation simultaneously.

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About the Author

Kristen Sargent is a graduate of Westminster College, New Wilmington, PA. She is currently in her first year of high school teaching. Her interests include literacy in science and inquiry based learning methods. She is very happy to have had this opportunity to share her undergraduate research in a professional setting.