Playing Games:

The Importance of Activities in the Science Classroom

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Introduction

The goal of this project was to create a board game that, by engaging student interest in the legal and ethical issues surrounding genetic technologies, would increase students' comprehension and retention of lesson material. A lecture aimed at understanding new genetic technologies was presented to two 10th grade biology classes and two 12th grade AP biology classes.

A pre/posttest assessment method was employed to determine the effect of the board game on student comprehension and retention. Post test scores of the experimental group increased by a greater amount than that of the control group, implying that the students who played the board game experienced an educational benefit beyond the standard lecture and review type lesson. Student feedback collected during formal (high school research participants) and informal settings (college peers) was enthusiastic and supported the hypothesis that a board game would encourage deeper engagement and interest.

Significantly higher test scores coupled with positive reviews from both college and high school students show that the game achieved its primary and secondary goals.

Materials and Methods

A pre/post testing method was used to assess the success of this board game as an instruction-enhancing tool. A 30 point test was created to measure student performance before and after the two day unit. The test assessed student understanding of vocabulary words and application of facts and concepts. **(Fig. 1)** Scores were then analyzed using Fisher's Analysis of Variance (ANOVA)

***Figure 1**. Sample Pre/Post test questions*

2.) Write a sentence or two explaining the difference between therapeutic and reproductive cloning.

4.) Circle One: True or False?

The genetic material of a clone may not be exactly identical to that of the original subject because of environmental factors.

Class periods were randomly assigned to either a control group or a gaming group. Both treatment groups took the 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. 2)**

***Figure 2.** Diagram of pedagogy used for each group*

	Control Classes	Game Classes
Day 1	pretest Trad. Lecture	pretest Trad. Lecture
Day 2	Verbal Review posttest	Play Board Game posttest

Game Play

Game play was designed to be simple—possible to learn the rules and play in 45 minutes—but also incorporate proven methods of motivation and instruction. Students play on teams that function as their own society. The ultimate goal of game play is for students to apply information from the lesson plan to trivia questions (serious and humorous) and prompt discussion of ethical considerations.

The game board itself has two separate tracks, one follows the outside edge of the board and the other branches off to cut through the center. These two paths have an unequal proportion of opportunities to land on spaces that require the application of lesson plan information to ethical scenarios. The central path provides an increased chance to land on these Ethics card prompts. A team must discuss and create "laws" for a total of four Ethics cards in order to win. This makes the central path optimal. But in order to be granted access to the central path, teams must land exactly on a Trivia card space and answer the question correctly.

As mentioned previously, the game consists of three card types. Trivia cards are intended to reinforce scientific facts and concepts from the lesson plans and correspond to the knowledge and comprehension levels of Bloom's Taxonomy. **(Figure 3a)**

Figure 3a.

Q: What does the term carrier mean?

A: Any person with heterozygous genotype who is not affected by a 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 new information not included in the lesson, 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. **(Figure 3b)**

Figure 3b.

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. **(Figure 3c)**

Figure 3c.

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?

***Figure 3. (a)** Example of trivia card questions. (One of 30)*
***(b)** Example of Karma card scenario. (One of 20)*
***(c)** Example of Ethics card discussion prompt. (One of 16)*

Results

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. Graphical representation of each assessment **(Figure 4)** illustrates that the mean posttest score for the game group is higher than that of the control group. Based on these results, it can be concluded that significantly more learning — as measured by an assessment of understanding and retention of material— occurred in the class that played the board game.

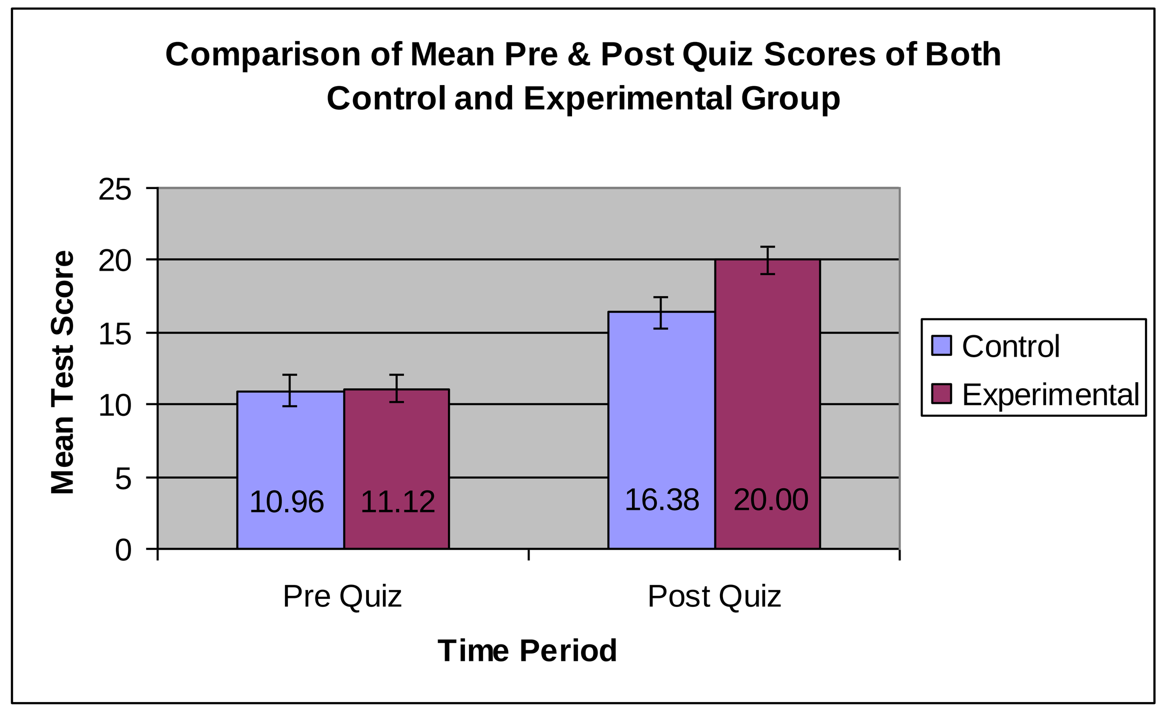

***Figure 4:** The mean pretest scores for both groups are not significantly different as seen in this figure and by the p-values reported below. The mean posttest scores for both groups are significantly different according to the p-values reported below. The experimental group had a mean posttest score significantly higher than that of the control group.*

The pre and posttest scores were analyzed using Fisher's Analysis of Variance (ANOVA) on Minitab. 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 group are not significantly different from those of the experimental group*
Posttest scores of the control group 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.*

Conclusions

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 indicate 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 large samples sizes and delayed post testing to see if the same level of performance is still possible several weeks after playing the game.

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