

THE BENEFITS OF GAME USE IN A SIGNAL PROCESSING GRADUATE CLASS

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ABSTRACT

It is important in the age of the INTERNET and video games to keep students engaged in the classroom. One way of doing this is through the use of games and simulations. TABOOTM is a card game which involves getting players to say a keyword without saying five forbidden words¹. This can be adapted for any number of different subjects. In this paper the game was adapted for use in "Detection and Estimation" (EENG663) class at the Air Force Institute of Technology (AFIT). A study was conducted to see if there is a difference in the scores of the final examination for two different groups. Data was obtained on the students. Their project, midterm and final exam scores were recorded. Group one took EENG663 without the additional game preparation, group two had the additional review given right before the final exam. A statistical analysis of the scores is presented in this paper. Some students also completed a survey that asked their opinions on using the game in the classroom. Results show that there was a statistically significant difference in the mean final exam scores for the two groups.

Index Terms— games, education, review, graduate, analysis

1. INTRODUCTION

There has been a push in the past few years to increase the number of students entering and retained in the field of science, technology, engineering and math (STEM). In a STEM retention study of selective universities (ACT score 21-27) only 33% of students graduated after five years [1]. This has prompted research into ways to improve the number of students that actually graduate with STEM degrees [2], [3], [4], [5]. According to Singer [6], activities that actively engage students are activities where professors replace part of the lecture with activities that invite student participation. The reference highlights the importance of diversifying teaching practices in order to continually engage students in STEM fields and suggests that overall evidence supporting active learning is strong. Pedagogical advantages to using games in the classroom has been well documented throughout the years and their use is supported by a range of learning theories [7], [8].

The use of games, simulations and multi-media projects is a form of active learning. Active learning, in which the student is an active participant in their learning experience, leads to the student

being engaged in the classroom. Alternatively, passive learning is a more traditional or lecture-based way of teaching and it is more difficult to keep students engaged [9]. A good example of implementing games in the classroom may be found in Paulson et al. [9], "For example, when students are introduced to the concepts of "laws of nature" and "the scientific method," it is hard to convey through lectures the nature of scientific work and the fallibility of inductive hypotheses. Instead, students play a couple rounds of the Induction Game, in which playing cards are turned up and either added to a running series or discarded according to the dealers pre-conceived "law of nature". Students are asked to "discover" the natural law by formulating and testing hypotheses as the game proceeds."

A literature review on the use of games in graduate level classes produced results for business, education, English, science and management [10], [9], [11], [12], [3]. However, a further refinement of this search to include engineering graduate level courses did not provide any helpful results. Since the use of a board game to review for an exam in a graduate level signal processing class is not well documented, this paper will attempt to fill in the gaps.

We will analyze the effects (if any) from supplementing a traditional review for a final examination with an adaptation of the game TABOOTM, herein called DETABOO. Classes that participated in EENG663 for the past two years at the Air Force Institute of Technology (AFIT) were chosen for this analysis. The first class (group 1) did not participate in the supplemental DETABOO review, while the second class (group 2) did. The authors are interested in identifying any similarities or differences in the scores of exams and projects for these two years. Additionally, a survey was given to several students in the class which participated in DETABOO to gauge their opinions on playing DETABOO in the classroom.

2. DETABOO

The game took place during a typical class period of approximately fifty minutes. 122 DETABOO cards (see example; Figure 1) are divided equally among two teams of about ten students, but conditions may vary as long as the ratios stay the same. Additionally, a buzzer, card holder and hour glass timer (from TABOOTM game set) were used. The rules for DETABOO are shown below.

1. Divide class into two teams, each team chooses a Clue Giver (CG). Cards are placed in a blind so that only the CGs may see each others cards and their teams may not. Each student rotates and takes a turn as CG. Each CG should be able to get through about five cards before the sand falls through the hourglass.

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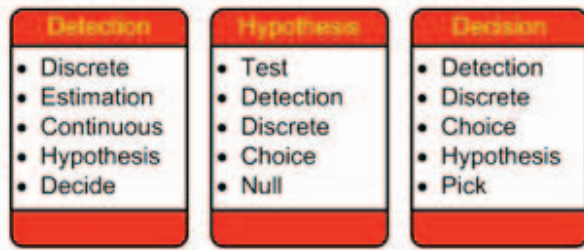


Fig. 1. Example of DETABOO cards

2. Team A's CG starts with a stack of cards and Team B's CG sits beside Team A's CG. Team A's CG draws a card. The word at the top of the card is the "Guess Word" that Team A's CG is trying to get their team to say. The five words below this are words that the CG may not use to describe the word.
3. Team B's CG sounds a buzzer if Team A's CG says one of the "Forbidden Words" or breaks a rule. Rules include; no gestures, noises, "sounds like", initials, abbreviations and no using parts of the "Forbidden Words" or "Guess Word". If a CG is "buzzed" their team will lose a point. Players may pass on cards, but this will also lose them a point.
4. Each time the team shouts out the correct guess word they are rewarded with a point, this goes until the timer runs out. Once the time has elapsed the CGs switch roles and Team B's CG proceeds with clues to their team. The teams rotate like this until teams run out of cards, the team with the most points wins. Each student has a chance to be a CG.

The basic TABOOTM cards were adapted for use in the EENG663 class and some example cards are shown in Figure 1.

3. SURVEY

A survey was given to group two to assess their opinions on participating in DETABOO as a supplemental review for the final examination. Students were asked to rank statements regarding the use of DETABOO in the classroom. Answers were scored based on a Likert scale from one to five, with one representing "strongly disagree", three representing "neutral" and five representing "strongly agree". The five questions listed in Table 1 all begin with: "I feel that".

Due to the nature of the classes at AFIT, it was not possible to survey all students as several had already left. Every attempt was made to obtain as many surveys as possible, but our sample size for the surveys is only seven. Since no actual analysis is being done with these results sample size should not be a concern. This survey was to gauge students opinions on using DETABOO. Ideally future surveys would be given to the students before they left the class. Summary results of the survey are shown in Table 1. Each question is listed on the side and above three categories, NEUTRAL, AGREE and DISAGREE are displayed. Here we combine "mostly agree" with "agree" and "mostly disagree" with "disagree", since they both are similar responses. The percentage of respondents in each category is listed in the cells. Rows sum to 100%.

The majority of students felt that DETABOO was a good supplement to the traditional lecture style review, with only one student reporting negatively. This is interesting since the majority of students did not feel that playing the game helped their performance. No students felt that the game hurt their performance on the final exam.

Table 1. Survey Results

QUESTION	DISAGREE	NEUTRAL	AGREE
1-DETABOO was a good compliment to the review.	14%	14%	72%
2-Time would have been better spent with more traditional review.	14%	43%	43%
3-DETABOO helped my performance on the final exam.	86%	14%	0%
4-DETABOO hurt my performance on the final exam.	71%	29%	0%
5-Professor should use this in the future.	14%	43%	43%

When asked if the professor should continue to use DETABOO in future classes the majority of students reported positively. In general it seems that students responded positively to using DETABOO as a supplement to the traditional final exam review. No student felt that they were harmed by playing DETABOO. It seems that students welcome a break from the traditional review, even if it is of no direct benefit to them. Obviously the implications of this study are limited given the small sample size. However since negative impact appears to be minimal it would seem that no harm would be felt by students if the professor continued to use DETABOO in the classroom.

4. DESCRIPTION OF DATA AVAILABLE FOR GROUPS

The subjects of interest here are two groups of students at AFIT; students who participated in DETABOO and students that did not participate. These graduate students took one of two classes. Group one attended class during the winter term 2009 and did not participate in DETABOO as a supplemental final exam prep. Group two attended class during Winter Term of 2010 and did participate in the additional DETABOO review, before their final exam. Thus for this study we will assume both test groups are homogeneous, except with regards to their DETABOO experience. All exams and projects were of equal difficulty, although they were modified slightly to avoid students knowing the answers to questions from previous years exams and project. Due to the nature of classes at AFIT we will assume all of our subjects are drawn from the same sample population. The demographics of the sample population are shown below.

1. 90% of group are military officers
2. 95% of the group are male
3. Range in age from 20-40
4. Majority have Bachelors and/ or Masters in Engineering
5. All were Masters or Doctoral students in engineering fields

5. STATISTICAL ANALYSIS

We will attempt to answer several different questions. Our primary research question is: What are the effects (if any) on adding a supplemental final exam prep in the form of DETABOO?

Table 2. Descriptive Statistics-Final Exam

Group	n	Mean	Std. Dev	Min	Max
No DETABOO	18	67.94%	15.98%	42%	92%
DETABOO	18	77.67%	15.91%	44%	94%

5.1. Initial Data Analysis

An initial examination of the final exam scores will be helpful to see if our research question is justified. Initial data analysis identified two possible outliers in our data set. These outliers contained the most extreme studentized residuals, see Kutner et al. [13] for further explanation on this procedure. Table 2 provides the descriptive statistics. The data show that the mean final exam score is higher for those students that participated in DETABOO than for those that did not. Additionally, both the minimum and maximum test scores for group two are larger than those values for group one. It is reasonable to assume that there is a difference in the mean final exam scores for the two groups.

5.2. T-test

A T-test is used to look for differences in the mean for the midterm, project and final exam score for each group. Refer to [14] for a general description of T-tests. An important step prior to performing the T-test is to establish our significance level (α) and calculate the degrees of freedom. The criterion used for rejecting the null hypothesis, α , is defined as the probability of a Type I error or “false positive”. A Type I error would occur if we concluded that the mean scores differ when in fact they actually do not.

$$\alpha = P(\text{Type I error}) = P(\text{Reject } H_0 | H_0 \text{ is true}) \quad (1)$$

$$d.f. = n_1 + n_2 - 2 \quad (2)$$

The choice of a level of significance is not based on any mathematical, statistical or substantive theory. It is a choice which is purely arbitrary for our research since we can not attach a cost to either a Type I or Type II error [15]. Thus we will set our significance level to $\alpha = 0.10$. The probability of a Type II error, β , is generally not defined but the reader may refer to [16] for further explanation. A Type II error occurs if we concluded that the mean scores did not differ when they actually do differ. The actual amount of variability in the sampling distribution of T depends on the sample size. This dependence is expressed by degrees of freedom ($d.f.$). For each parameter we are estimating we lose a $d.f.$. Thus if we are estimating two means we would lose two degrees of freedom.

Having established the initial parameters, we may proceed with calculations of the test statistic, T , and p-value. The T-statistic is the ratio of how much our data mean scores differ from each other by their total standard error. This is compared to a critical value, T_0 , and a decision on whether to reject the null hypothesis is made if the $T - stat$ falls outside of the rejection region, defined on the right hand side of Equation (4). T_0 may be found by looking at a standard T-table available in many statistics texts. The p-value or observed significance level is the probability of observing a value of the test statistic that is at least as extreme the test statistic that was calculated from our data, assuming the null hypothesis is true [16]. When the null hypothesis is rejected the result is said to be statistically significant. The T-test statistic and p-value are calculated using Equations (3)-(4) respectively.

Table 3. T-test results for differences in all scores for both groups

Null Hypothesis	T-stat	d.f	p-value
$H_0 : \mu_{P_2} = \mu_{P_1}$	0.73	34	0.47
$H_0 : \mu_{MT_2} = \mu_{MT_1}$	-0.78	34	0.45
$H_0 : \mu_{FE_2} = \mu_{FE_1}$	1.8289	34	0.04

$$T = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \quad (3)$$

$$p - value = P(|T| > T_0) \quad (4)$$

where $\bar{x}_i$ is the mean exam score of group i , ($i \in \{1, 2\}$), s_i^2 is the variance of data from group i , and n_i is the sample size of group i , with $n_1 = n_2 = 19$. With 34 degrees of freedom, and $\alpha = 0.10$, we have $T_0 = 1.306$. Our rejection region is, $T < -1.306$ or $T > 1.306$. For any value that falls outside of this region we would reject the null hypothesis and conclude that there is a difference in the mean scores for the two groups.

Table 3 gives the corresponding null hypotheses, $T - stat$, ($d.f$) and $p - value$ for project (μ_P), midterm (μ_{MT}) and final exam (μ_{FE}) scores respectively. The alternative hypothesis for the final exam scores is: $H_1 : \mu_2 > \mu_1$, that the students in the group two scored better on the final exam than those group two. For final exam we choose a one-sided hypothesis since we are interested in showing that scores for group two are greater than group one. For both the midterm and project scores our alternative hypotheses is that there is no difference in the mean scores, $H_1 : \mu_2 \neq \mu_1$, here a two-sided hypothesis is used because we are interested in any difference in the two groups.

For project and midterm scores we fail to reject the hypotheses at an $\alpha = 0.10$ level. There is insufficient evidence to conclude that there is a difference in mean scores of the two groups for the project and midterm scores. The T test for the final exam score has a $p - val = 0.04$. Thus, at an $\alpha = 0.10$ level we would reject the null hypothesis and conclude that the mean final exam scores for those students who had DETABOO was greater than for those that did not have DETABOO.

In order to quantify the difference between the mean test scores, we may look at the quantile values for both groups [14]. Figure 2 is a graphical representation of the quantile final exam values for each group. For every quantile, students in the additional review group scored higher on the final exam than those students without the review. This means that if a student scored in the 50th quantile on the final exam; they received a 72% on their final if they did not play DETABOO but an 84% if they did play. It should be noted that we did not show quantile calculations on the other variables because their corresponding T-test were not statistically significant.

From the two previous results we can conclude that for our two groups, there is a difference in mean final exam scores and those that had DETABOO appear to score better on the final exam..

5.3. Regression

Another way to examine the effects of participating in DETABOO is through the use of a simple linear regression. Regression is the study of dependence. Linear regression is the most commonly used type of regression and implies a linear relationship between the independent and dependent variables [13].

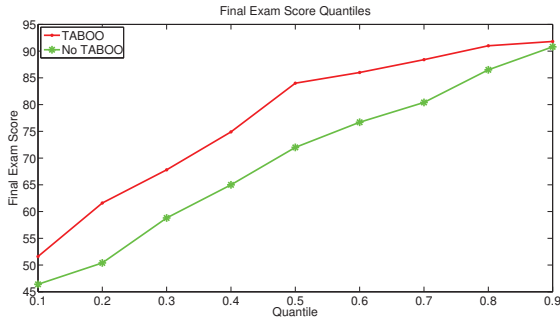


Fig. 2. Quantile Plots of Final Exam Scores for both Groups

Table 4. Regression Results

Coefficient	Value	Std. Error	T-Stat	p-value
β_0	67.94	3.76	18.08	< 0.0001
β_1	9.72	5.31	1.83	0.08

Equation (5) gives the initial model that we wish to examine. With Y_i being our final exam score (our output) and X_i is a dummy variable representing whether or not the student played the game (input). The regression coefficients (β_0 , β_1) were calculated by MATLAB, refer to Weisberg's text [8] for equations.

$$Y_i = \beta_0 + \beta_1 X_i \quad (5)$$

where,

$$X_i = \begin{cases} 1, & \text{DETABOO} \\ 0, & \text{NO DETABOO} \end{cases} \quad (6)$$

Here, β_0 represents the constant coefficient, β_1 is the coefficient associated with the indicator variable. Table 4 gives the results of a regression analysis for Equation (5). The fit for our model would be,

$$\hat{Y}_i = 67.94 + 9.72(X_i). \quad (7)$$

At an $\alpha = 0.10$ level our β_1 coefficient is significant. We may conclude that those students who had DETABOO review on average, increased their final exam score by approximately 9.72%.

6. CONCLUSION AND FUTURE WORK

Through our statistical analysis we have shown a significant difference in the final exam scores for students in the two sample groups. Further, it was shown that on average students that had DETABOO scored approximately ten points better on their final exam than those students that did not participate. It was also shown there was no discernible difference in students midterm and project scores. This shows it is reasonable to assume that both groups of students performed equally in all aspects of the class except for the final exam scores where those with DETABOO performed better. With such a small sample size we are cautious in our interpretations. However, since the implications of this study will not have detrimental effects to the students the authors feel that this analysis serves its purposes. Since much research exists tauting the benefits of active-learning in the classroom [6], the authors feel that implementing this type of review would have a positive effect on students. This agrees with our survey results. Students respond positively to playing DETABOO

and recommended that the professor continue to use it, even though they believed that playing DETABOO gave them no advantage on the final. This might suggest that students welcome a change to the traditional type of engineering graduate level classes. The authors would like to expand the scope of the study to include classes the professor will teach during the 2011-2012 school year. This would provide the authors with more test data as well as more survey results that would be beneficial in future analysis.

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