Class Behavior on Quizzes that include a Prisoner's Dilemma Bonus Question

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Abstract—In this work, we tested class behavior on a prisoner's dilemma bonus question over ten quizzes spread out through the semester. The prisoner's dilemma bonus question was a viral internet phenomena that appeared in 2015 used by Professor Dylan Selterman. We took this idea and asked, what would class behavior be like if this question appeared more than once during a class? We provided this bonus question over ten quizzes in a second year digital design course. Our original hypothesis was that students would talk among themselves, and eventually, they would agree to cooperate to get a small bonus. However, after the semester long experiment we observed that the class never got any bonus points. Not only was this the case, but we observed a number of behaviors as related to these quizzes.

In this paper, we describe the nature of these quizzes, the associated prisoner dilemma bonus question, and the various observed behaviors of students. Also, we attempt to supply a number of hypotheses of why we think students behave as they did, but many of them have no evidence.

1. Introduction

In this work, we use the prisoner's dilemma problem[5] for a group, called the n-person prisoner's dilemma[12], as a bonus question on ten quizzes. The basic idea for the bonus is that students can choose between two options where one potentially results in a large bonus value (50%) and the other in a small bonus (10%). If a large percentage of the class take the small bonus choice as defined by a threshold then everyone gets the bonus they chose, but if too many students select the big bonus then nobody gets any bonus.

This idea is based on a viral post highlighting Professor Dylan Selterman using such a question on one of his assignments (where Selterman credits Dr. Stephen Drigotas as the originator of this idea). For the sake of a fun experiment, we decided to take this idea further and investigate how this type of bonus question impacts bonus points over a number of quizzes. Our hypothesis is that students may start out by being greedy and nobody getting a bonus, but over the course the class would cooperate to get some bonus points.

Over the 2016 semester in a class, we provided our prisoner dilemma bonus question on ten quizzes. The results of this experiment were that the class never received bonus for any quiz. Additionally, we observed almost half of the students changed their behavior throughout the semester. In this work, we provide a number of theories on why students would make different bonus choices for this type of problem, but our data shows that none of these are true.

Finally, we make no great claims about the pedagogical value of this experiment. However, in the class, we collect this data and present it to the students as a segue artifact to a discussion on how important it is to work together as an engineering class, and that fellow students in a class are not so much competitors, but will be future colleagues and are valuable friendships that students should make earlier than later.

The remainder of this paper is organized as follows: section 2 examines previous research into extra credit, bonus questions, and the prisoner's dilemma problem used in classes. We then describe, in section 3, the details of this experiment including the phrasing of the bonus question and the class it is used in. In section 4, we describe the results, and in section 5 we conclude the paper and describe some future work.

2. Background

Student motivation's in a class is a tricky aspect to deal with[7], and our goal in this work is not to delve deeply into this domain. Extra credit, however, is used by some teachers as a reward and is desired by students. Norcross *et. al.*[9] were one of the earlier researchers who investigated how courses use extra credit and perceptions of both student and faculty to the idea of having extra credit. Not surprisingly, the above work by Norcross concludes students liked extra credit and teachers did not.

Extra credit has been reported on in a number of publications in its use to improve exam performance[8,10], participation[11], attendance[13], research participation[4], and in general[2]. To our knowledge, there is no significant research as related to bonus questions as extra credit of study.

The prisoner's dilemma problem has been used in classes as simulation games to teach various ideas on game theory and decisions[1,6], but the problem, to our knowledge, has not been used as extra credit in courses in the literature.

3. Bonus Question Experiment

To implement this study, we had students in a 2016 Digital System Design course at the 200 level complete 10 quizzes (as normal) that included the n-person prisoner's dilemma bonus problem (with IRB approval). The quizzes are low-stakes assessment that is used to test students on their understanding of the past week's material. The quiz has the following properties and implementation details:

- Each quiz is worth 1 point towards the student's total points of 100.
- Each quiz asks one question similar to the ones in the previous week's problem set(s).
- Students have 10 minutes to complete the quiz.
- If students complete the previous weeks problem sets and submit them, they receive partial marks.
- If students do not complete the problem sets, then they receive no partial marks, but can get a perfect score for a correct solution.
- There are 10 quizzes over the semester.

The bonus question on each quiz has the following phrasing:

"Circle either: A= +0.5 OR B= +0.1 - If greater than 10% of the class picks "A" then nobody gets any bonus points."

Students select either "A" or "B" from the above bonus question, and the data is collected for the entire class on each quiz. We remove students who both did not do the problem set and did not score perfect on the quiz. Then depending on the percentages of "A" and "B" choices, we add the bonus points to each of the quiz scores if the class as a whole does not surpass the 10% threshold of "A" choices. In some cases, a student might not circle "A" or "B". For these cases, we assume that a student chooses "B", and we use this result in the collected data.

This course is offered in at the 200 level and is done by electrical and computer engineering undergraduates. Other students can take the course as a general technical elective depending on their major and the course typically is composed of 40% electrical, 40% computer, and 20% other. This course is part of the undergraduate curriculum at a predominantly undergraduate engineering degree college at Miami University.

4. Results and Analysis

The results of this experiment are provided for the 2016 year in this section as well as some analysis on why these results were found.

Table 1 shows the class bonus question results. Column 1, 2, 3, 4, and 5 show the quiz number, quiz focus question, and stats on population and their selections between "A" and "B", respectively. The most important number is column 6 that contains the percentage of students who selected "A" in relation to the threshold - 10%. Therefore, we can see that for 2016 class, no bonus points were awarded. The same behavior was observed for more than just the 2016 class, but we did not have IRB approval to report that data.

In table 1, Column 3 shows the total population participating for each quiz. This number decreases from the original 60 students in the class for a number of reasons. A small percentage of students drop the course, and some students are absent and miss quizzes, but these do not account for all the decrease. The larger factor is that the difficulty of the quiz increases as the course progresses and around 25% or more of the students never do the problem sets, and so, many of these students are not counted in the stats because they do not get perfect on their quizzes.

Our original hypothesis, which we call the *developing altruistic tendency theory*, is that the students as a whole will eventually cooperate enough to get a bonus. However, as illustrated in table 1, this is not the case. So, the question is, do students make more rational choices in selecting their bonus for particular reasons that relate to the individual quizzes, or are students following particular behaviors independent of this assessment?

We make two possible explanations for the results based on a rational behavior perspective[3]. The first explanation is that it is possible that depending on how well a student thinks they are doing, they may be more likely to choose "A" if they think they will do poorly on the quiz - we call this the *catch-up theory*. The second explanation is that some students who know what they are doing and will likely perform well on a quiz will choose "A" so that they prevent poor performing students from getting any bonus and keep a bigger difference between them and weaker performing students - we call this the *differentiate theory*. In either case, we would expect a correlation between quiz performance and the students bonus selection. Our analysis shows that neither theory happens.

Table 2 shows some additional data on students behavior. In particular, the three categories are those students who never changed their picks (rows two and three), those students who changed their picks (rows four and five), and those students who changed their picks permanently (rows six and seven). Additionally, for the 21 students who changed from "A" to "B" and "B" to "A" not permanently, the average number of "A" choices made by this group is 3.3 with a standard deviation of 2.4. In all, there is a large portion of the class changing their picks, but we have not come up with a reason why.

Table 1: Base Results for Bonus Question over 10 quizzes

Quiz Number	Topic	Population	#A selections	#B selections	% of As
1	Syllabus	60	14	46	23%
2	CMOS Transistors	53	13	40	25%
3	Karnaugh Maps	56	14	42	25%
4	Karnaugh Maps	45	8	37	18%
5	Verilog HDL	30	7	23	23%
6	Two's Compliment	45	10	35	22%
7	Multiplexers	45	7	38	16%
8	Finite State Machines	32	8	24	25%
9	Finite State Machines	37	10	27	27%
10	Finite State Machines	42	11	31	26%

Table 2: Additional data on student behavior

Behavior	Number of students
Always picked "A"	3
Always picked "B"	28
Switched "A" to "B"	24
Switched "B" to "A"	26
Switched "A" to "B" permanently	3
Switched "B" to "A" permanently	5

5. Conclusion

In this work, we observed the behavior of a class on a bonus n-person prisoner's dilemma question over ten quizzes. Once all the data was collected, we observed that the class never got any bonus points. In reality, the class was not even close to getting bonus points when the threshold was set at 10%. Within the class a number of behaviors were observed including those who maintained their choices throughout the semester and those who changed. The data, however, showed no trends on why particular choices were made.

As stated in the introduction, this study is mainly for the interest of what would happen as opposed to providing any pedagogical insight. We, however, have used these results to bridge a discussion into why the class as a group could not work together, and then framed the discussion to the importance of the class cooperating with each other as opposed to competing. This is the first class for the students in which the majority of students are majoring in electrical and computer engineers, and it is important that this group begins to cooperate and learn each others names as they will be together for the next three years.

In future, our plan is to increase the threshold slightly to 15% for the bonus questions and to intervene halfway through the semester to show results of the classroom's current performance on the bonus.

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