Teaching Decision Analysis: Enhancing Student Comprehension through the Class Preparation Picker Technique

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Abstract: The academic discipline of decision sciences, integral to systems engineering, management, and business, faces a challenge in effective pedagogy due to overly complex or overly simplistic course examples. As a result, students either do not understand or do not appreciate the usefulness of the course material. This paper proposes the Class Preparation Picker technique, which allows students to apply the course material to the making of a complex decision – whether or not to complete their homework. This technique uses a lottery that consists of tickets that contain each student's name. If a student's name is drawn, their homework is collected and graded. If the homework is satisfactory, the lottery receives a ticket that requires no one to submit their homework. Alternatively, if the homework is unsatisfactory, the lottery receives a ticket that requires everyone to submit their homework. This lottery was implemented in a senior-level decision analysis course. Over the course of the semester, students realized that they were making a hard decision and started to apply the techniques taught in the class to support their decision making. This experiential decision-making process increased the student's appreciation for decision analysis, while also encouraging students to better prepare for class.

Keywords: Decision Analysis; education; curriculum; class-preparation; experiential learning

1. Introduction

The discipline of decision science has become increasingly important in today's complex world. The decisions that individuals, organizations, and governments face have grown increasingly intricate, often involving numerous variables, uncertainties, and ethical considerations. Decision sciences provide a structured and systematic approach to navigate this complexity, empowering individuals and organizations to make informed choices that can lead to better outcomes (Kochenderfer 2015). The skills related to decision science provide individuals with the analytical tools and critical thinking skills necessary to address the multifaceted challenges of the modern world whether it is related to optimizing supply chains, managing financial risks, or crafting public policies (Parnell et al. 2013).

This paper presents an experiential learning approach for integrating a hard decision into an undergraduate decision analysis course through the use of a new technique – termed the Class Preparation Picker. This technique leverages a lottery, where an assignment is collected from a single student during each class meeting. Not only is the student's course grade directly impacted by their homework performance, but the game rewards and penalizes the entire class based on whether or not an individual student completed their assignment. It is proposed that the use of this game uses the complex dynamics of the classroom to force students to make a hard decision; in doing so, they are able to better understand the intricacies of decision sciences.

In the spring of 2019, the Class Preparation Picker was implemented in a senior-level, undergraduate decision analysis class. This paper details the development, implementation, and assessment of this experiential technique.

1.1 Overview of Decision Sciences Curricula

The academic discipline of decision science has experienced remarkable growth and recognition across universities worldwide, with many institutions establishing dedicated programs to meet the increasing demand for expertise in this field. As observed by Clemen and Reilly (2014), many universities, now include decision science courses as part of their industrial engineering, systems engineering, or business management degrees.

Howard and Abbas (2016) provides an overview for what is covered in a decision sciences program. Fundamentally, a decision sciences course equips students with essential knowledge and skills for effective decision-making. It begins with fundamental concepts like decision theory, covering decision-making under uncertainty, probability theory, and utility

theory. This sets the groundwork for more advanced topics. In the intermediate stage, students explore decision analysis, learning techniques for decision modelling, scenario analysis, and sensitivity analysis to evaluate choices and risks. They also study risk management to handle uncertainty. Advanced sections focus on optimization, game theory, and data analytics, enabling students to tackle complex, real-world problems. Case studies illustrate applications in business, healthcare, finance, and public policy. Savage (2003) states that by the course's end, students should have a solid foundation in decision sciences, ready to approach various decisions with analytical rigor and informed judgment.

1.2 Challenges with Teaching Decision Sciences

The science of decision making is foundational based on human psychology and has a number of theories underlying it. The teaching of these theories requires the use of examples that allows students to understand how to apply these theories to the real-world (McCarthy et al. 2010). However, a large issue arises from the selection of these problems; in particular, there is a tendency to rely on overly simplistic examples to help students grasp fundamental concepts. As Griffiths (1983) points out, simplification is a useful pedagogical tool for introducing complex topics; however, it can inadvertently hinder students' ability to appreciate the true value and applicability of decision sciences in tackling real-world, complex decisions. When instructors consistently present students with easy decisions that can be intuitively solved, it may lead to a misleading perception that decision sciences are primarily about making straightforward choices.

The danger in that approach is that it fails to prepare students for the intricacies of applying decision sciences to the challenging, multifaceted decisions they will encounter in their professional lives. As discussed in Howard and Abbas (2016), real-world decisions often involve a multitude of variables, uncertainties, trade-offs, and ethical considerations that are notably absent in simplified classroom examples. As a result, they may underestimate the importance of employing rigorous decision analysis techniques when faced with difficult choices, which can have significant consequences in various fields, from business to healthcare and public policy. However, the use of real-world complex examples that would require decision sciences are often difficult for students to grasp.

2. Class Preparation Picker

2.1. Overview of Technique

The authors suggest a novel technique, termed the Class Preparation Picker, which forces students to make a hard decision. The decision is a common one for students – whether or not to prepare for a lesson. However, this technique uses the dynamics of the classroom to complicate this decision.

At the start of the semester, the syllabus provides students with the required reading and a set of homework problems to be completed prior to each lesson. The homework problems were based on the reading; together the reading and the homework assignments could be completed in under an hour. At the start of each class, a lottery is held, where a student's name is drawn at random as shown in Figure 1. The selected student is then required to turn in their homework assignment for a grade. If the student does not have their assignment, an "Everyone has to turn in their homework" ticket is added to the lottery. If the student does have their assignment, a "No one has to turn in their homework" ticket is added for the next lesson's drawing. For simplicity, these tickets are referred to as ALL and NONE in this paper. Note that in both cases, the ticket with the student's name is returned to the lottery. Additionally, students were not given access to the contents of the lottery, leaving them to speculate the number of ALL and NONE tickets that could be chosen.

Students earn additional incentives for having multiple lessons in a row where the selected students have completed the assignment. The number of NONE tickets added to the lottery corresponds to the length of the streak. So, if for three consecutive lessons, the selected students produce their homework assignment, the lottery will have received six NONE tickets (one for the first lesson, two for the second lesson, and three for the third lesson). An identical process is done for streaks where students fail to have their homework assignments but with ALL tickets. Note that if an ALL or NONE ticket is drawn, the streak ends.

It is important to note that students do not want positive streaks to end because of the exponential nature of adding more and more NONE tickets. Additionally, students want to end negative streaks immediately, so the chances of ALL tickets are limited.

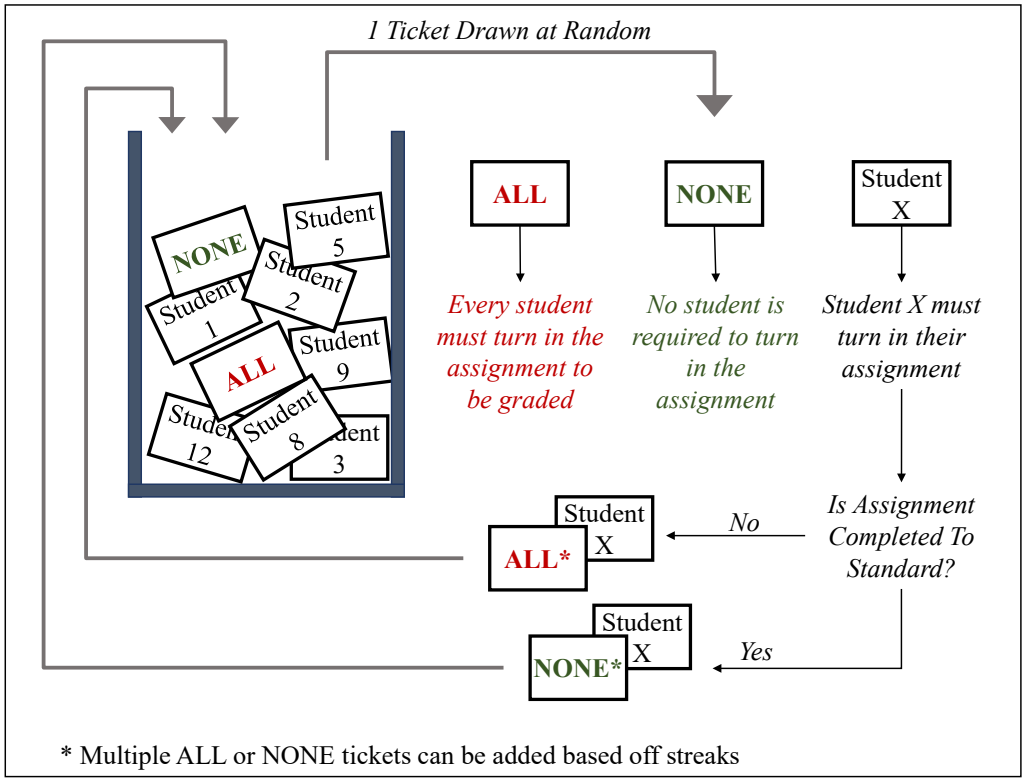


Figure 1. Schematic for the Class Preparation Picker, which is based on a lottery game that provides both individual and group rewards and penalties.

Each submitted homework was graded on a five-point scale. If the homework indicated that the student understood the material from having performed the reading, they would receive the five points. At the end of the semester, five percent of a student's course grade is tied to a grade(s) given to their homework assignment(s) if their name was drawn and/or if an ALL ticket is drawn. The student's grade for their homework completion is related to how well they do on the assignments that they were selected to turn in. If they were only selected once, then their class preparation grade is based solely on that one assignment. If they were selected twice, each assignment has a 50 percent weight, and so on. If a student went through the entire semester without having to submit their homework, they automatically get full credit. However, this is mathematically unlikely.

Safeguards were established to protect students. Instructors allowed students with valid issues preventing assignment completion to approach them before class, resulting in their names being excluded from the lottery for that lesson. Additionally, students had the option to submit a blank assignment, providing anonymity and preventing potential harassment from classmates for not completing their assignments.

2.2. Analysis of Decision Made for Class Preparation Picker

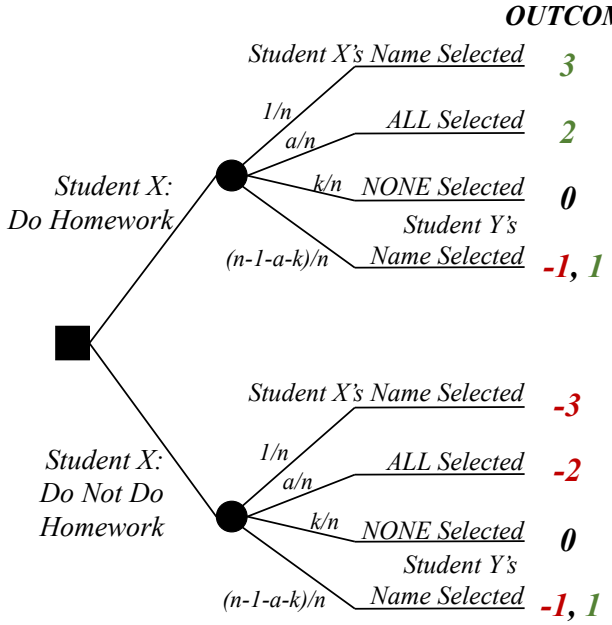
Each lesson, the students face the decision tree shown in Figure 2, which shows the outcome of whether or not students complete the necessary preparation assignment. Note that a student built out this decision tree in class to justify his decision of not doing his homework after his name had been drawn. That student identified that there are seven different outcomes that are possible given the lottery and the student's choice.

The outcomes are primarily positive if the student opts to do their homework. A negative outcome is still possible if a different student's name is drawn, and they did not complete the assignment. Similarly, most of the outcomes are negative if the student decides not to do their homework.

An informal polling at the end of the semester asked students to assign a dollar value to each of the seven outcomes shown in Figure 2 along with a monetary equivalent cost associated with their doing their homework. The resulting analysis

indicated that in almost every situation, the student should choose to do their homework. This is in large part due to a desire to avoid a negative outcome due to social obligation. However, they also acknowledged that these values would shift over the course of the semester based off their competing requirements from other courses.

The concepts underlying the Class Preparation Picker aligns with several key classroom concepts. When making their decision to complete their assignment are either consciously or subconsciously building the decision tree shown in 2. As they evaluate it, they have to apply different concepts including risk, expected value, and imperfect information (i.e., how many of their classmates are completing the assignment).



Outcome	Impact on Homework Grade	Impact on Lottery
3	Improve	Add NONE Ticket
2	Improve	-
1	No Change	Add NONE Ticket
0	No Change	-
-1	No Change	Add ALL Ticket
-2	Decreases	-
-3	Decreases	Add ALL Ticket

n = number of tickets
a = number of ALL tickets
k = number of NONE tickets

Figure 2 Decision tree faced by an individual student when deciding whether to complete their homework.

3. Theory

3.1. Experiential Learning

The overarching goal of the Class Preparation Picker is to promote experiential learning, forcing students to decide whether or not to prepare for class. This decision is further complicated by the group dynamics of the classroom, since an individual student's decision to complete or not complete their assignment will impact the content of the lottery for the rest of the class. The theories underlying experiential learning is that students learn best through experience and real-world application of course material (Chickering 1977). Generally, experiential learning has gained significant traction in higher education, driven by universities being more heavily tied to businesses, a desire for graduates to have tools and skills that they can immediately apply in the workforce, and better understanding of learning theories (Bartle 2015). Further, experiential learning at its core involves requiring students to make decisions; as such, the incorporation of experiential learning is highly appropriate for a decision science course (Herremans and Murch 2003).

Much of modern experiential learning theory is based on the work by Kolb (2014), which included the framework shown in Figure 3. Fundamentally, the Class Preparation Picker offered an opportunity for experiential learning, providing an opportunity for students to make a hard decision for each class, following the framework outlined by Kolb. In doing so, they have to actively apply the material that they were learning in class, even at a subconscious level. Furthermore, these decisions are context-dependent since the content of the lottery changes, along with their competing obligations, resulting in the students having to make different decisions each time. The lottery further includes a large element of risk, which makes the activity more engrossing. Additionally, the students uncover that they are applying course material to making the decision,

allowing them to explore this real-world problem through inquiry. Finally, the social obligation related to the lottery forces students to critically reflect prior to making each decision, resulting in a better analysis of their decision.

Gentry (1990) additionally lays out the necessary components of an assignment to effectively promote experiential learning. This includes that the exercise must be applied, participative, interactive, whole-person emphasis, have contact with environment, include variability and uncertainty, maintain structure, gather student evaluation of the experience, and provide feedback to students. The Class Preparation Picker has each of these components. Most notably, the lottery system of the Class Preparation Picker provides both structure and uncertainty.

One of the important aspects of experiential learning is reflection, ensuring that the students go back and understand the decisions that they made (Sharlanova 2004). The Class Preparation Picker was set up such that has new concepts are introduced in the course, students were given the opportunity in class to discuss and reflect about how that concept was related to their decision making. Not only did this reflection allow them to better understand the concept, but it allowed them to apply those concepts to later decisions.

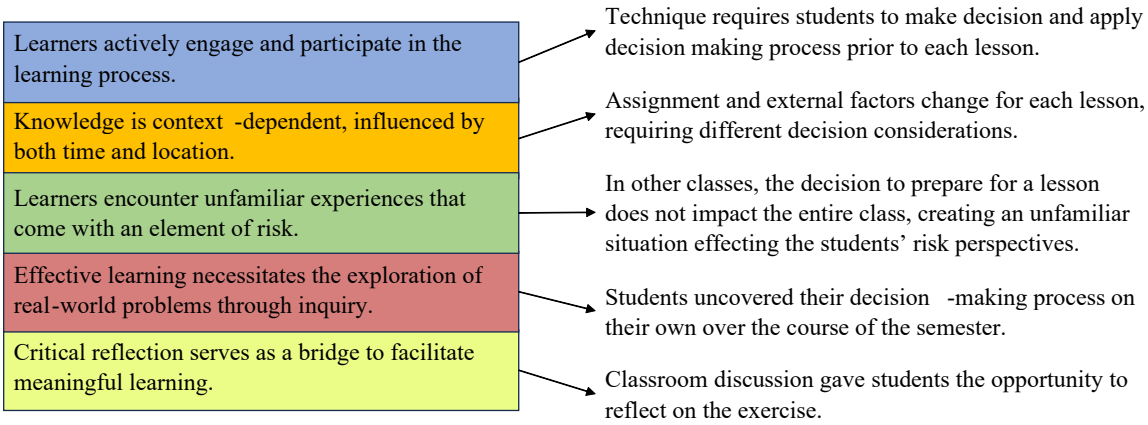


Figure 3. How the Class Preparation Picker aligns with the framework set out by Kolb (2014) for the requirements for effective experiential learning.

3.2. Comparison to Other Teaching Techniques

The goal of the Class Preparation Picker is to force the students to make a hard decision prior to each class to support experiential learning. However, there are a number of other techniques that have been used to accomplish this same goal in the teaching of decision sciences.

Decision science courses often use the Monty Hall problem, where students is asked to choose one of three doors, one of which conceals a positive outcome, while the other two contain negative outcomes (Krauss and Wang 2003). After the student makes their initial choice, the teacher opens one of the doors containing a negative outcome. The student is then given the opportunity to switch their initial choice to the other unopened door. The paradoxical result is that switching doors increases the chances of winning the prize, illustrating the concept of conditional probability and the importance of revising decisions based on new information. Often the positive outcome in courses is tied to course points or a monetary reward to ensure that the student has buy-in on the game.

Another common technique is the Keynsian beauty contest, where students are asked to choose a number between 0 to 100. The winning number is determined not by the participants' individual preferences but by the average guess of all participants. Participants are encouraged to guess a number that they believe others will guess, often leading to a convergence toward lower numbers in a bid to predict the average guess. This exercise highlights the idea of iterated thinking and the significance of anticipating the behavior of others when making decisions, which is a key aspect of game theory and decision analysis (Gao 2008). A variant of this game has students guess 2/3 of the average, as opposed to the average, which further complicates the game (Karmann and Lehmann-Waffenschmidt 2001). Similar to the Monty Hall problem, the reward for winning is often something that the students desire such as bonus points or a monetary reward.

Such problems are common in decision science courses; however, they are typically used at the lesson- level, as opposed to being weaved into the entire course. Also, these techniques, though they allow the students to experience making a decision, they are somewhat contrived. Teachers introduce the Class Preparation Picker at the start of the semester; however, actual discussion and analysis is held off until later in the semester, allowing students to self-uncover the decision-making process that they are doing for the course. This level of reflection positively reinforces the course concepts (Grossman 2009).

4. Implementation

This technique was implemented in select sections of SE385: Decision Analysis during the spring of 2019. SE385 consisted of 9 sections, with each section containing approximately 18 students. Four of the sections, consisting of 71 students, served as the control group that used more traditional techniques to promote class preparation.

The remaining five sections, consisting of 86 students, served as the variable group, which implemented the Class Preparation Picker. The control and variable groups had the same schedule, syllabus, and major graded events. Additionally, students were provided the same preparatory homework problems and reading but the control group did not require any problems to be turned in at the beginning of class. Instead, in the control group, the homework problems were only reviewed based on student request, and five percent of each student's course grade was allotted to individual performance on occasional reading quizzes that covered key concepts from previous lessons and the class preparation material.

The study was exempt from an Institutional Review Board since it met the criteria under 32CFR219.101(b)(1) for a study on the practice of teaching and learning. However, the data collection still adhered to the strict guidelines set in 32CFR219. Two sets of surveys were given to the students. The first survey was given following the midterm and looked primarily at student preparation for each lesson. The second survey was the end-of-course survey which included questions that assessed student's appreciation for decision analysis. Additionally the study accessed student grades in the course and their grade point average (GPA) prior to taking the course to determine if this technique had an impact on their performance in the course.

5. Results

5.1. Analysis of Survey Responses

Students were asked questions about their class preparation in surveys midway through the semester and at the end of the semester. The responses to questions related to the Class Preparation Picker are compiled in Table 1. The survey revealed that the sections utilizing the Class Preparation Picker prepared for 75 percent of the classes, whereas the other sections only prepared for 41 percent. This indicated a statistically significant increase in the amount of preparatory work with the inclusion of the Class Preparation Picker. The survey also indicated that students were motivated to prepare for class due to the Class Preparation Picker. However, it also shows that a number of students still decided to not complete their homework assignments even with the implementation of the Class Preparation Picker.

Table 1 Survey results for questions related to Class Preparation Picker

Survey Question	Standard Section	Section with Class Preparation Picker
What percent of lessons did you complete the requirements from the syllabus (midterm)	Average: 41 % Conf Int: 33 % - 48 %	Average: 75 % Conf Int: 69 % - 80 %
The Class Preparation Picker encouraged you to complete the required lesson preparation (midterm)	Yes: 0 No: 0 N/A: 68	Yes: 56 No: 8 N/A: 0
Because of the Class Preparation Picker, I was more likely to complete the homework and reading than I otherwise would have (end of semester)	Yes: 0 No: 0 N/A: 48	Yes: 60 No: 31 N/A: 0

The end of the semester survey also included the free-response question, ”How has this course affected your decision making, day-to-day and/or long-term.” The responses were analyzed as having a positive or negative sentiment, with the results shown in Figure 4. The survey results indicate that students in sections that used the Class Preparation Picker was significantly more likely to give a positive response relative to the standard sections. This is likely due to the students being required to make a hard decision as part of the course, providing them the opportunity to apply the methodologies of the course. Further, the classroom discussion allowed students to reflect on the material, allowing for a more experiential experience. Meanwhile, students in the control group did not have that option, so were basing their opinions off the in-class examples, which are often difficult for students to relate to.

One interesting trend is that though the students in the sections that used the Class Preparation Picker were more prepared for class and more enthusiastic about the lesson material, their performance did not change. Figure 5 plots the individual component of each student’s grade in the course, based on the midterm and final exam, against their GPA prior to the class. The shape of each point indicates the section that the student was in, and the line in the plot indicates the expected grade based off the GPA. As expected, students with a higher GPA tended to earn a higher grade in the course. Figure 5 indicates that there was no significance correlation between the grade in class and whether or not their class used the Class Preparation Picker (p-value of 0.243). This is most likely due to instructors not changing their teaching strategies to take advantage of the increased enthusiasm and preparation.

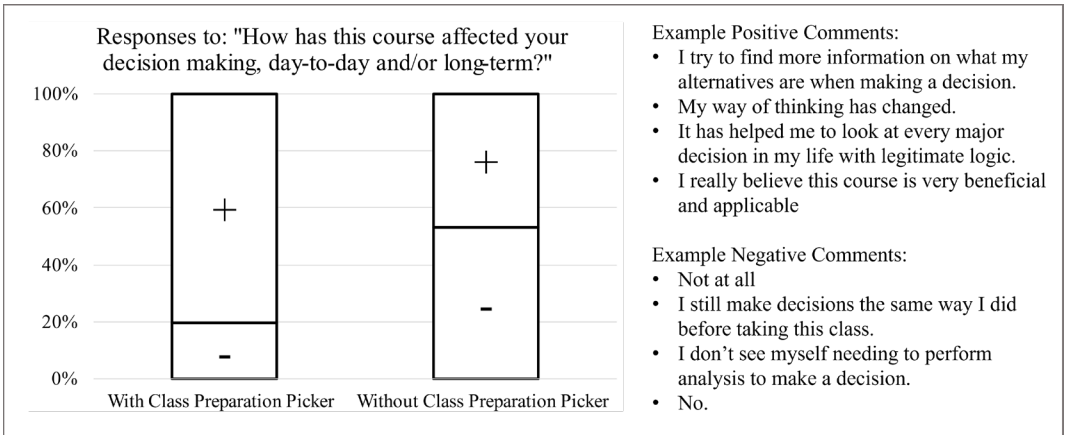


Figure 4. Responses to survey question: “How has this course affected your decision making, day-to-day and/or long-term” for control and variable group.

5.2. Instructor Observations

In addition to the surveys, the instructors also noted that the students took the game very seriously, and that the advantages and disadvantages of preparing for class were considered prior each lesson. The instructors reported the following observations:

- A student told his instructor that for the first time, he felt a moral obligation to prepare for class.
- In a discussion about complex decisions, multiple students cited the decision as to whether or not to prepare for class as an example of a hard decision that had numerous complexities.
- One student asked if their instructor could discuss expected value in terms of the Class Preparation Picker. The class then spent 15 minutes developing a model for the decision to complete their homework based on expected value.
- During a class discussion on risk, a student selected to use the decision as to whether or not do their homework as a decision that incurs a level of risk. This led to a class discussion where we gauged the risk adversity of the students in the course.
- A student was selected who had not completed his assignment. He chose to tell his classmates that he did not complete the assignment, explaining that he thought his probability of being selected was low. He went to the board and drew out his decision tree (Figure 2), and the class had a good discussion on imperfect information (he had assumed that there were more NONE tickets than were in the lottery).

• In a thought experiment, students discussed the value of a tracker visible to the students but not the instructors, where students could enter whether or not they decided to prepare for class. This led to a discussion about the value of information.

Generally speaking, a large number of students treated the Class Preparation Picker as an opportunity to apply their decision-making skills. Discussions with students at the end of the semester found that a handful of students developed quantitative tools and decision trees for this decision; however, almost every student said that they qualitatively assessed their choices to decide whether or not they should prepare for the class.

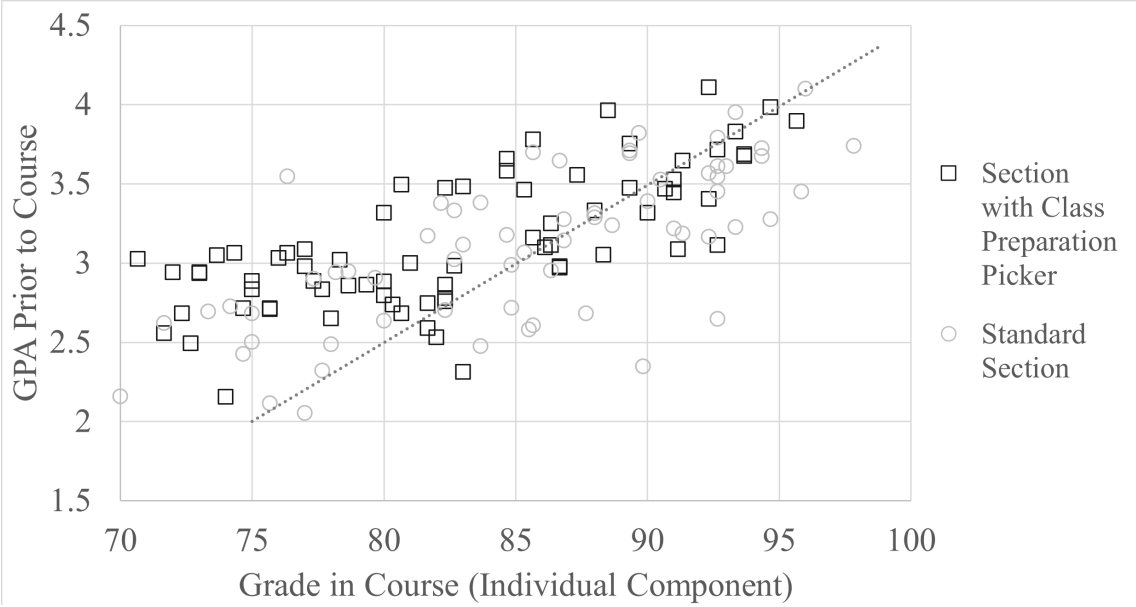


Figure 5. Plot of individual student GPA against the individual component of their grade in SE385 for the variable and control groups.

6. Discussion

6.1. Analysis of Results

The results from the surveys support that students were coming to class more prepared with an increased appreciation for decision sciences due to the use of the Class Preparation Picker. However, the analysis of course grades found no significant correlation between the sections with the Class Preparation Picker and those that did not use it.

A major inference can be made from this analysis—the instructors did not appropriately leverage the Class Preparation Picker. They did not capitalize on student's increased enthusiasm towards decision sciences, nor did they account for students coming to class better prepared. Indeed, the instructors retaught much of the material that was covered in the preparatory assignments in both the variable and control groups. This method of teaching has become the standard procedure used by most instructors, to ensure that all students at least learn the basic material. Additionally, many of the graded events, to include the exams, were similar to previous years graded events. These assignments were written for students that would have aligned with the control group; as such, they did not account for the changes in students due to the Class Preparation Picker.

6.2. Limitations of Study and Future Work

The Class Preparation Picker was implemented in a military academy, which provides students with military training in addition to their four-year undergraduate education. As such, some of the success with the Class Preparation Picker may be attributed to the university's culture, which emphasizing teamwork and camaraderie among students, as they live in barracks and undergo military training. To assess the technique's broader applicability, it should be replicated at a more traditional university setting. Additionally, the small class sizes (capped at 18 students) in this study were conducive to its effectiveness. In larger classes, the impact may be diminished, as the likelihood of getting one's name drawn is low, potentially requiring multiple ticket draws.

Perhaps the largest outcome from this study was that instructors did not properly leverage student enthusiasm or preparation in their lessons. Future work should identify methods to better leverage class preparation and enthusiasm, while still ensuring that students are receiving the appropriate level of support in understanding the material.

7. Conclusions

This study presented the design and implementation of the Class Preparation Picker, which was implemented into an undergraduate Decision Analysis course. This technique, which utilized a lottery system with communal impact, forced students to face a hard decision before every lesson – whether or not they should complete their preparatory work. Over the course of the semester, students would experientially realize that they were making a hard decision and would apply the techniques taught in the class to help them make the proper decision.

Surveys indicated that students indeed had a more positive viewpoint of decision analysis from the use of the Class Preparation Picker. Indeed, several students opted to draw out full decision trees to support their daily decision to do their homework. Meanwhile, most students used the more qualitative tools taught in the course. Regardless, most students decided to show up to class prepared. The more positive viewpoint of decision analysis and the increased class preparation were not properly leveraged by instructors, resulting in no changes in course performance from the Class Preparation Picker. Regardless, the Class Preparation Picker has the potential to be a useful tool for teaching decision sciences.

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