Design and Evaluate a Process for Teaching Engineering Students about Heuristic Decisions and Cognitive Biases

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Abstract

In order to deal with challenges in daily activities and working hours, engineers need to be able to make decisions. Project failure, late work, and missed chances can all stem from bad decisions. Some of the many elements that influence decision-making and lead to choice errors include heuristic decisions and cognitive biases. These biases can be mitigated by providing decision-makers with greater information about them through training and education. As a result, educational institutions are a valuable resource in the development of good decision-making abilities. The next step in this research is to offer a method for teaching Engineering students about heuristic judgments and cognitive biases in the classroom, using a lecture and a final project. The method was created with the idea of student-centered learning in mind. A pre-survey, a post-survey, and a final survey were created to assess the improvement in decision-making during the process. Because they had more knowledge and could understand the influence of cognitive biases in decision-making, the results demonstrated that the knowledge transfer process could help decision-makers to make better decisions. Furthermore, several of them were inspired to dig deeper into issues and develop strategies for dealing with them.

Keywords

Heuristic decisions and cognitive biases, Decision-making, De-biasing, Transfer knowledge, Student-centered learning

1. Introduction

Albers et al. (2016) define decision-making as a problem-solving activity that might result in a good or terrible solution. In our daily routines and jobs, we make numerous decisions. Decisions are made with caution and analysis in specific instances. To deliver the best and most accurate outcome, all information and decision-making procedures are utilized. Decisions are made based on a feel of gut and experience in uncertain situations with limited information and a need for a quick response (Kahneman 2011). These decisions are made within limited boundary constraints, such as insufficient information or a rapid reply, necessitating the use of a heuristic strategy.

Heuristics can be viewed as a potential tool to aid decision-making in situations with limited boundary conditions (Kalnikait et al. 2013). They can, on the other hand, result in a decision error due to cognitive biases introduced in the field of economic behavior (Samson 2014). Figure 1 depicts a decoy effect, which is one of the cognitive biases in heuristic decisions. When presented with a third option that interferes in all ways with all options, consumers' preferences between the first two options tend to shift.

Figure 1. An example of the decoy effect

This effect can also be seen in the field of engineering during the product development process (Bursac et al. 2018, Tanaiutchawoot et al. 2019). Heuristic decisions are used to make many decisions in product development activities (Tanaiutchawoot et al. 2018). This effect may lead decision-makers to select a bad idea during the idea selection phase, resulting in a product failing in the market, spending a lot of time, and going over budget in the project. As a result, it is critical to avoid allowing them to influence their decision.

Raising a decision maker's awareness of where bias traps exist is a technique that attempts to reduce the negative impact (Kihlander and Ritzén 2012). Another method is to train decision-makers or increase their understanding of heuristics and cognitive biases (Croskerry et al. 2013). Knowing about them makes decision-makers more aware of them and less likely to fall into their traps. As a result, it is necessary to improve decision-making skills by transferring knowledge and training decision-makers. Methods and processes for training decision makers, on the other hand, vary depending on the strategy of a trainer and a group of decision makers.

The researcher understands the necessity of passing on information regarding heuristics and cognitive biases to reduce the risk of making a mistake, especially for all engineers. However, from the perspective of the researcher, a competent engineer begins at the institute. As a result, university education is a critical component in honing decision-making skills. In this study, engineering students are the primary group that will be instructed on heuristic decisions and cognitive biases. The following are a summary of the research objectives:
1) to develop a method for teaching engineering students about heuristic judgments and cognitive biases.
2) to assess the process's efficiency in order to provide students with additional information and the ability to deal with heuristic judgments and cognitive biases.

2. Literature Review

In this study, four themes are relevant: 1) fundamental understanding of decision making, 2) heuristic decisions and cognitive biases, 3) correcting decision mistakes from heuristics and cognitive biases, and 4) potential teaching and learning approaches.

2.1 The fundamental knowledge of decision making

Decision-making is the process of selecting among alternatives in order to accomplish the desired result (Eisenfuhr 2011). Decisions are sometimes made rationally, but other times they are not. To explain these behaviors with rapid and slow thinking, Kahneman (Kahneman 2011) suggested a dual-system theoretical framework. When a cognitive load is high or time is limited, fast-thinking, or system 1 thinking, is chosen. The thinking is based on freely available mental stuff. It's referred to as a hot effect. Slow thinking or system 2 thinking is more reflective, controlled, deliberative, and analytical than fast thinking. A mental function known as the cold effect controls and supervises decisions.

There are two primary models of decision-making that are used to describe the nature of decision-making. These two models are the rational model and the bounded rationality model (March 1994). Decisions in the rational model are often presumed to be reasonable. Decisions are made in response to certain circumstances, such as available options, results, and criteria. Decision-makers may choose the best option and put it into action (Towler and Keast 2009). In this model, the decision-making process consists of six steps: 1) recognizing the problem, 2) generating alternatives, 3) evaluating alternatives, 4) choosing an alternative, 5) implementing the choice, and 6) evaluating decision efficacy. In contrast, decisions in the limited rationality model are made by developing a partial list of potential solutions to a problem based on experience, intuition, or ideas from others. Because of time limits, expense, and the ability to digest information, decision-makers are unaware of the problem and do not even look for all viable alternative solutions. The phrase "bounded rationality" is then used to characterize a decision-maker who wishes to make the best judgments but frequently settles for less than the best (Simon 1997). The satisficing principle is one form of this paradigm. Decision-makers select the first option that meets the bare minimum of acceptability criteria without thoroughly researching all options (Nielsen 2011).

Heuristics can be used to influence judgments while satisfying. A heuristic is a rule of thumb that can assist a decision-maker in finding a solution in a complicated and uncertain situation (Moustakas 1990). Heuristics are utilized in our daily lives to solve a variety of difficulties, such as buying something. They can assist in simplifying difficult decision-making circumstances and, in many cases, make satisfying judgments. However, because this strategy is frequently dependent on judgment and intuition, it tends to oversimplify difficult situations or introduce bias into decision-making (Lunenburg 2010).

2.2 Heuristic decisions and cognitive biases

Tversky and Kahneman (1974) present heuristics in the context of choice biases. They offered three basic heuristics: representativeness, availability, and anchoring. The representativeness heuristic explains a choice bias that causes people to make mental errors by estimating probabilities and dangers depending on the category of the item, person, or activity in front of them (Virine et al. 2018). A represents B or the degree to which A is similar to B. When A is indicative of B, the likelihood that A came from B is considered high. When A is not similar to B, however, the likelihood that A came from B is considered low.

When decision makers make a judgment about the likelihood of particular events based on how easily they can recall them and acquire information that is most readily available in making a choice, they are using the availability heuristic (Redelmeier 2005). This heuristic is used to estimate product failures and anticipate the amount of product risk by assessing how simple it is to recall occurrences (Folkes 1988). When assessing a number under ambiguity, the anchoring heuristic frequently plays a role in decision-making. In situations when an estimated value is required, this is the foundation heuristic (Epley and Gilovich 2006). An estimation number is created by starting with a value and then adjusting it to get the final response, although modifications aren't always enough. This heuristic can, however, take various forms, such as an image or other non-numerical stimuli (Esch et al. 2009). Decisions can be inaccurate if the starting value is set up improperly or inappropriately (Virine et al. 2018).

Following the presentation of these three heuristics, many more forms of heuristics are offered, such as the decoy effect, status-quo bias, loss and gain, and so on. The decoy effect occurs while selecting a solution from a set of options. Using the asymmetrically dominated choice approach, the solution is chosen based on an offering from options rather than on absolute preferences. People's preferences for one alternative over another shift as a result of the addition of a third, similar but less appealing option (Samson 2014). The status-quo bias describes a scenario in which decision-makers prefer to retain the present condition rather than alter behavior unless there is a significant incentive to do so (Samuelson and Zeckhauser 1988). The greater the amount of experience of the decision-maker, the greater the effect of the status-quo bias (Burmeister and Schade 2007). Aversion to loss and gain might help to understand this behavior. This heuristic is a core element of the framing bias, which states that if two alternatives are presented as a difference between drawbacks and advantages in relation to the reference point, they will be evaluated differently (Beresford and

Sloper 2008). A prospect theory can be defined as a loss and gain scenario (Kahneman and Tversky 2013). Individuals would rather avoid losses than equivalent gains, according to the hypothesis, since losses have a bigger emotional impact than gains.

2.3 Improving decision errors from heuristics and cognitive biases

De-biasing and counter-biasing are two methods presented by Milkman and Brest (Milkman et al. 2009; Brest 2013) to overcome biases originating in System 1. De-biasing is a complicated approach that allows active System 2 to function instead of System 1. Introducing more discussion and challenge by evaluating the opposing reaction (Campbell et al. 2009), improving choice awareness (Kihlander and Ritzén 2012), and mentally distancing oneself from a unique scenario are some examples of techniques. Counter-biasing, on the other hand, pits one system's bias against another, as in Sunstein and Thaler's famous simple "nudges" (Sunstein and Thaler 2014).

Nudging is a technique for organizing choices that allow people to learn to make better decisions on their own without being inhibited. Jack (Soll, Milkman, and Payne 2014) has proposed two methods for regrading biases' resources: 1) influencing the decision-maker, and 2) changing the environment or option structure. Providing knowledge to the decision-maker, increasing choice awareness, and encouraging the decision-maker to think outside the box are all ways to influence the decision-maker. By training system 1 and system 2 thinking, these strategies attempt to improve the decision maker's understanding. The system is taught to create better intuitions based on experience and memory, while system 2 is trained to better manage system 1 in order for it to be aware of biases in various scenarios. A nudge approach can also be used to change the surroundings or decision structure. MINDSPACE is another way for modifying the decision structure, and it is comparable to NUDGES in terms of nudging (Dolan et al. 2010).

The stages of success for cognitive de-biasing may be divided into seven categories: lack of awareness of bias, awareness of prejudice, capacity to identify bias, contemplating a change, deciding to change, commencing measures to achieve change, and maintaining the change (Croskerry et al. 2013). However, one significant challenge to de-biasing is that most people are ignorant of the influence of unconscious variables on their thinking and may not notice the impact of biases on their decision-making. As a result, they see no need to modify their minds.

2.4 Potential teaching and learning methods

University classrooms are typically instructor-centered, which means that the instructor makes the majority of course decisions. The teaching technique, on the other hand, has been evolved by expanding the role of students in class by using the learner-centered approach (Wright 2011). The technique assists the student in planning and establishing the classroom with the instructor. A teacher or instructor serves as a midwife, coach, and maestro (Weimer 2002). Students should learn by doing and participating in learning activities that enhance learning, such as participating in a presentation and learning from one another.

When people take part in a problem-solving session, their learning experience expands. Students should be actively involved in the learning process for optimal learning. The pupils are intended to be passive receivers of knowledge, and the instructor can function as a facilitator without needing to be an expert in the specific material (Tärnvik 2007). When organizing classroom activities, the tasks students are required to complete to acquire the content should be prioritized over the chores teachers needed to do to prepare the class presentation (Salter et al. 2009). Based on these principles, the teacher-centered becomes learner-centered.

2.5 Conclusion

Heuristic decisions and cognitive biases have been studied in numerous sorts of studies in various applications and contexts, which can lead to conclusions that are both positive and negative. Potential approaches for dealing with these biases have been offered in order to enhance decision-making in the context of heuristic choices and cognitive biases. However, there is limited data and explanation regarding processes to enhance decision-makers understanding of them,

particularly among university students. University students should be taught decision-making skills so that they can use them in the future.

3. Methods

There are several strategies available to improve decision-making abilities and lessen the impact of heuristics and cognitive biases. The researcher chose to teach decision-makers through classroom instruction, which helps decision-makers become aware of heuristics and cognitive biases and create superior intuition.

Based on the researcher's experience as a lecturer professor in Industrial Engineering at Suranaree University, she is in charge of a decision analysis course. Within this course, a mechanism for transferring information about heuristics and cognitive biases, as well as evaluating the results, was created. The experiment was divided into two parts: 1) designing a process and contents to transfer knowledge about heuristic decisions and cognitive biases, and 2) designing an experiment to assess the efficiency of the process and methods to transfer knowledge about heuristic decisions and cognitive biases.

3.1 Develop a strategy and materials to help people learn about heuristic judgments and cognitive biases

Based on student-centered learning, knowledge regarding heuristic judgments and cognitive biases was communicated to students in two ways: the lecture and the final project. For four hours, the lecture was used in the decision analysis course. The study hypothesized that pupils had no fundamental understanding of heuristic judgments and cognitive biases. Figure 2 depicts content examples from the lecture and flowchart.

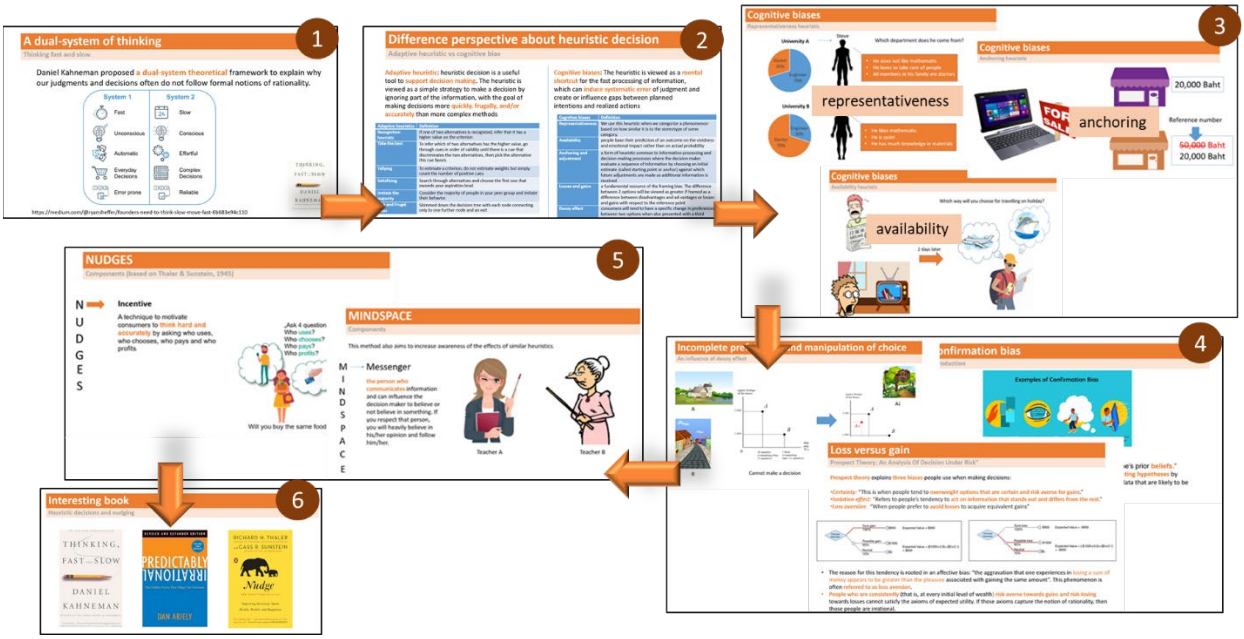

Figure 2. An example of flowchart and contents in the lecture

3.1.1 Introduction

The lecture began by introducing a dual-thinking system that includes quick and slow thinking. Following the introduction, students gained an understanding of the many sorts of thinking systems. They might also specify when and how these systems have an impact on decision-making. Then, inside the thinking system, heuristic choices and cognitive biases were incorporated.

3.1.2 Definition of heuristic decisions

Heuristic judgments were categorized into two categories. In the first category, heuristic decisions were characterized as a possible instrument to help decision-making with a quick reaction under limited information. The second category described heuristic decisions as a source of cognitive biases that caused decisions to be incorrect. These two classes were depicted briefly. However, this lecture focused on the second group's concept, which said that heuristic decisions might result in decision mistakes.

3.1.3 Fundamental heuristics and cognitive biases

With examples, three essential heuristics were conveyed to students: representativeness, availability, and anchoring heuristics.

3.1.4 Other general heuristics

The lecturer chose heuristics that are commonly used in a variety of applications such as economic behavior, health care, and management. The decoy effect, status-quo prejudice, confirmation bias, framing effect, and prospect theory were among the heuristics studied.

3.1.5 De-biasing technique

In the final half of the lecture, NUDGES and MINDSPACE were introduced and described to students as viable techniques to cope with cognitive biases by utilizing defects in individual decision-making and attempted to reliably influence people's behavior without denying any possibilities.

3.1.6 References

The last page of the lecture presented books from which students could learn more about this topic.

Following the lecture, students were given the final group project, which was divided into two sections. They had to discover one research paper regarding heuristic choices and cognitive biases, or NUDGES and MINDSPACE, for the first phase. They then summarized that paper and made a presentation about the objective, methodology, result, and discussion. They planned and completed a project in the second phase by choosing one of two topics: 1) exploring heuristic choices and cognitive biases, or 2) using NUDGES to change people's habits. Depending on the pupils, the application was different. They have around six weeks to finish the project. They gave a presentation in the classroom after that.

3.2 Design an experiment to evaluate the efficiency of the process and methods to transfer knowledge about heuristic decisions and cognitive biases

Three surveys were designed and developed to assess the efficacy of the process of transferring information about heuristics and cognitive biases by examining the effects of heuristics and cognitive biases on survey decision-making. There were three surveys in total: a pre-survey, a post-survey, and a final survey. The purpose of the pre-survey was to assess students' fundamental understanding of the topic before they began listening to the lecture. Following the lecture, all students were issued a post-survey to evaluate their decision-making progress. This survey will look at how effective lectures are in transferring content to students' short-term memory. In this phase, the effectiveness of long-term memory cannot be determined. The final survey was created to assess the students' understanding after they completed the final project. Figure 3 depicts an evaluation procedure.

Figure 3. The experiment includes three questionnaires for assessment (Pre-survey, Post-survey, and Final survey) as well as two strategies for information transmission to participants (Lecture and the Final project)

The surveys questions were divided into two sections. The first section was a direct inquiry regarding heuristics and cognitive biases. The question in the pre-survey was whether or not they were familiar with heuristics and cognitive biases. Questions in the post-survey and final survey were meant to gauge interest in this issue. The second half was an indirect inquiry designed to assess the role of heuristics and cognitive biases in decision-making. In the second half of the questions, the status-quo bias and the decoy effect were used to assess decision-making ability under the impact of various forms of heuristics and biases. Table 1 summarizes and presents the questions, choices, and significance of each alternative.

This experiment was carried out at the Suranaree University of Technology's decision analysis course 2021, which was an optional course for third-year Industrial Engineering students. This course had twenty students enrolled, and they were all participants in this experiment.

Table 1. Questions in the pre-survey, the post-survey, and the final survey

Part 1: A direct question			
	Pre-survey	**Post-survey**	**Final survey**
Question 1	Do you know about heuristic decisions and cognitive biases?	Do you think the *contents in the lecture/final project* help you to improve your decision?	
Alternatives of answer	o Yes o No (single answer)	o No o Yes, this *lecture/final project* helps me to be more careful in making decisions o Yes, this *lecture/final project* motivates me to apply the knowledge in daily life o Yes, this *lecture/final project* helps me to understand more about other people's decisions. o Yes, this *lecture/final project* motivates me to understand the effect of heuristic decisions and cognitive biases and aim to investigate and apply an efficient method to deal with them (multiple answers)	
Part 2: An indirect question			
	Pre-survey	**Post-survey**	**Final survey**
Question 2 (evaluate the status-quo bias)	Assume that you are a header of one project, your team normally spends 1 hour in a regular meeting. However, you have to ask your team for a special meeting. How long would you like to reserve for this special meeting?	Normally, you have a meeting every Tuesday. Today is Thursday and you get a new project that requires much time to be completed. The deadline is the next Wednesday? What will you do?	You took 2 years to find information to develop a new product. However, today you find new information that is contradicting to your previous information. What will you do?
Alternatives of answer (with bias)	o 1 hour o >1 hour o <1 hour	o waiting for the next regular meeting	o Ignore new information o Find information to contradict to new information
Alternative of answer (without bias)	o Cannot immediately make a decision	o check your team's schedule and make a meeting before the regular meeting	o find more information to check the reliability and accuracy of new information
Explanation	Information from the question is not sufficient to make a decision. If they decide based on the regular event (1 hour) without analyzing the current situation, they tend to have a bias. Therefore, all alternatives that refer to the initial numerics from the questions were bias alternatives.	If decision-makers wait for the regular meeting, that means they made a decision based on a routine activity without considering priority. Therefore, they have a status-quo bias.	If decision-makers try to reject new information by ignoring it or against it, they seem to be confident in the previous information and avoid changing their beliefs. That means they have a status-quo bias.

Question 3 (evaluate anchoring bias)	Q3.1 if you have to propose a budget to develop the system in the company, which is between 10,000 baht to 500,000 baht. How much budget would you like to offer if your team suggest 30,000 baht? Q3.2 if you have to propose a budget to develop the system in the company, which is between 10,000 baht to 500,000 baht. How much budget would you like to offer if your team suggests 300,000 baht?	Q3.1 From the previous project, your team can complete the project within 9 months. How long will you offer your customer to complete his project (from 1 month to 11 months)? Q3.2 From the previous project, your team can complete the project within 3 months. How long will you offer your customer to complete his project (from 1 month to 11 months)?	Q3.1 you have to propose a budget to proceed with a project about industrial safety. How much will you decide to propose the budget if the budget in the last project was 500,000 Baht? Q3.2 you have to propose a budget to proceed with a project about industrial safety. How much will you decide to propose the budget if the budget in the last project was 1,500,000 Baht?
Alternatives of answer (with bias)	Open answer (define number)		
Alternative of answer (without bias)	Cannot immediately make a decision		
Explanation	If decision-makers use the initial number to make a decision no matter the direct answer or adjust the number, they will be influenced by the decoy effect. They should analyze the details of the current situation. However, the information in the question is not sufficient to make a decision. Therefore, they should offer to postpone a decision.		

4. Results and Discussion

4.1 Numerical and Graphical Results

The findings are classified and provided in two sections depending on the portions of the survey, which are the results from the direct question and the results from the indirect question.

Part 1: Direct question

The initial section of the pre-survey results suggests that 100 percent of participants, or all of them, are unaware of the heuristic judgments and cognitive biases. Figure 4 depicts the results of the first part of the post-survey and the final survey.

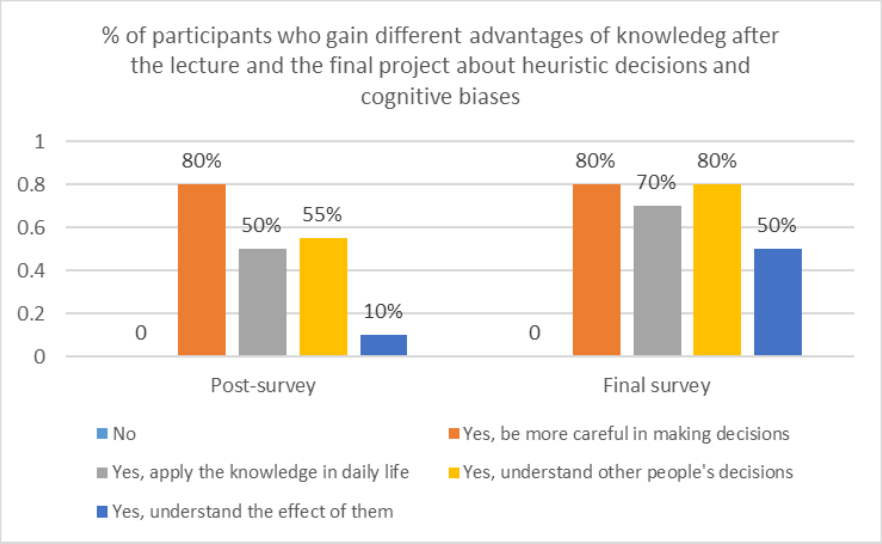

Figure 4. Results from the post-survey and final survey on the percentages of participants who obtain distinct benefits from different knowledge transmission strategies

After learning about heuristic decisions and cognitive biases in the lecture, 80 percent of participants say that the lecture helps them to be more cautious when making a decision. After the lecture, 50% and 55% of them feel inspired to implement the information in daily life and learn more about other people's decisions, respectively. However, only 10% of them are motivated to comprehend their influence on decision-making and strive to discover or implement an efficient technique to cope with choice biases.

Following completion of the final project, participants' perspectives alter, as seen by the final survey findings. Eighty percent of them also acknowledge that the final project helps them make better selections. 70% of them want to use what they've learned in their everyday lives. Eighty percent of them want to know more about other people's actions, and fifty percent want to know the consequences and how to deal with them. Some of them intend to write their bachelor's thesis on the subject. These findings show that teaching students about heuristics and cognitive biases through lectures and final projects might help them become more aware of and comprehend them. This process of information transfer not only enhances students' awareness of heuristics and cognitive biases but also stimulates them to study and research more about them. The findings were unclear after learning in the lecture, but the efficiency of this procedure may be observed more clearly when students finished the assignment, as evidenced by the final survey. This approach, on the other hand, might modestly engage participants' drive to comprehend and cope with their repercussions.

Part 2: Indirect question

The questions in this section are designed to assess the impact of heuristics and cognitive biases on decision-making when participants have varying levels of knowledge. The percentage of participants who chose the bias response or not in the pre-survey, post-survey, and final survey from Question 2 is shown in Figure 4. (the influence of status-quo bias).

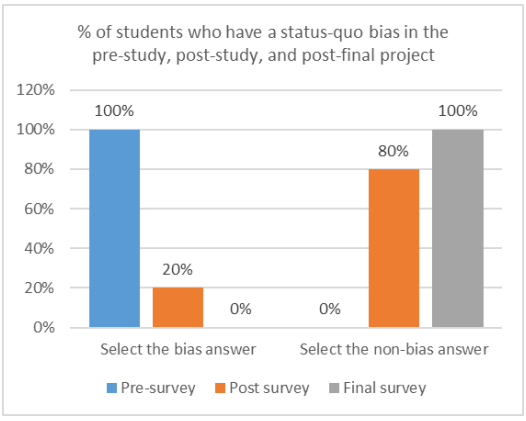

Figure 5. Results from the pre-survey, post-survey, and final survey to demonstrate the percentage of participants who selected and did not pick the bias option

In Question 2, the results of three surveys show that 100 percent of participants made a choice bias in the pre-survey (select the bias answer). After learning about heuristics and cognitive biases, 20% of them still chose the biased response. After completing the final assignment, however, no participants chose the biased response. That is, after completing the process of transferring information about heuristics and cognitive biases, participants would be able to detect the effect of heuristics and cognitive biases in decision making. As a result, people can avoid making biased decisions.

The purpose of Question 3 was to assess the impact of the anchoring heuristic on decision-making. The outcomes are then divided into two categories. The first stage, as depicted in Figure 5, was to determine the proportion of participants in the pre-survey, post-survey, and final survey who determined the numeric values for the response. The answer of a certain number is characterized as a choice bias because participants make a decision and alter the number based on

the original number offered in the inquiry without evaluating and obtaining more information. The needed response that demonstrates no bias in decision making is "cannot make a choice right away." Table 2 displays the highest, lowest, and average of these values.

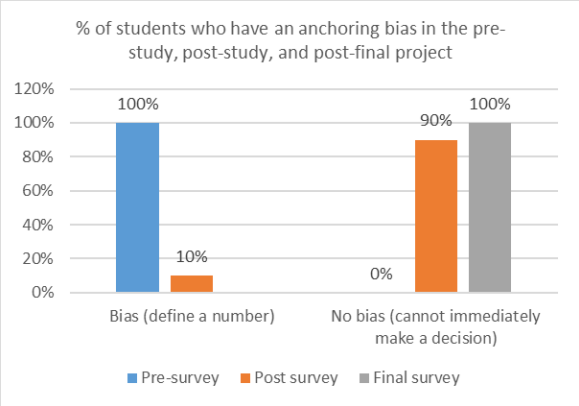

Figure 6. Pre-survey, post-survey, and final survey results to show the percentage of participants that chose and did not choose the bias option

Table 2. Maximum, lowest, and average number from participants who specify the number for the answer in the pre-survey, post-survey, and final survey

	Pre-survey		Post-survey	
	Proposed 30,000	**Proposed 300,000**	**Set 9 months**	**Set 3 moths**
Max	500,000	500,000	11	11
Min	29,999	250,000	8	2
Average	99,000	337,000	10	4.5

Figure 6 and Table 2 reveal that 100 percent of participants identify a number based on the first information. If the starting number is high, they define a high number as well. On the other hand, if the beginning number is low, they define a low number. Even though students learned about heuristics and cognitive biases in the lecture, 10% of them continue to exhibit the same behavior, according to the post-survey results. Nonetheless, no participants specify the number or value after completing the final project, as stated in the Final survey. On the other hand, none of them have a decision bias. The results of Question 3 show that participants can perceive the effect of heuristics and cognitive biases on decision-making at the end of the knowledge transfer process.

The results indicate that simply transmitting their knowledge of them through the lecture is insufficient to persuade decision-makers to be aware of and deal with them. The final project might be used to assist participants to understand and appreciate the role of heuristics and cognitive biases in decision-making.

4.2 Limitation and suggestions

This experiment, on the other hand, is judged based on a small number of questions and participants. Part 2's indirect question should be expanded and diversified. Furthermore, the number of participants was limited. If the number of participants is increased, the results will be more trustworthy.

5. Conclusion

Knowledge of heuristic choices and cognitive biases is critical for improving decision-making skills and avoiding decision mistakes. Educating a decision-maker is a technique for improving the efficiency of System 1 and System 2

thinking. The researcher advocated merging the lecture and the final project in the decision analysis course to transmit knowledge of heuristics and cognitive biases. The lecture is the first approach of introducing students to heuristic decisions and cognitive biases so that certain students have a better understanding of them and are aware of them while making judgments. This approach only exhibits a successful de-biasing in the second phase, which is bias awareness. In the process of transmitting knowledge, self-learning is implemented by examining several articles and developing the final project. These strategies motivate students to seek out further information on their own and to be able to use that information in a real-world setting by completing projects. Students are aware of cognitive biases during decision-making and can avoid them after this process of transferring knowledge about heuristic decisions and cognitive biases. Some of them are inspired to do additional research and study. This is the initial step in raising decision makers' awareness of heuristics and cognitive biases, as well as beginning change methods, which is the sixth stage of de-biasing success.

For the following experiment, however, the number of volunteers should be raised. The number and variety of questions in the survey used to assess decision-making performance should be enhanced. Furthermore, there is no assessment to ensure that students can apply what they have learned in class to their everyday lives and potential employment. To put it another way, we can't say that the process of transferring heuristic and cognitive bias information has reached the seventh level of de-biasing success (maintaining the change).

References

Albers, A., Reiß,N., Bursac, N., and Breitschuh,J.,15 Years of SPALTEN problem solving methodology in product development. *DS 85-1: Proceedings of NordDesign 2016,* pp. 411-420, Trondheim, Norway, August 10-12**,** 2016.

Beresford, B., and Sloper, P., Understanding the dynamics of decision-making and choice: A scoping study of key psychological theories to inform the design and analysis of the panel study, *Social Policy Research Unit*, University of York York, 2008.

Brest, P., *Quis custodiet ipsos custodes? Debiasing the policy makers themselves*, The Behavioral Foundations of Public Policy. Princeton University Press, 2013.

Burmeister, K., and Schade, C., Are entrepreneurs' decisions more biased? An experimental investigation of the susceptibility to status quo bias. *Journal of Business Venturing,* vol. 22**,** pp. 340-362, 2007.

Bursac, N., Tanaiutchawoot, N., Rapp, S., Albers, A., Breitschuh, J., and Eckert, C. Decision heuristic in pge-product generation engineering. In *Proceedings of the twelfth International Tools and Methods of Competitive Engineering Symposium (TMCE),* pp. 385-394, Las Palmas de Gran Canaria, Spain, May 7-11*,* 2018

Campbell, A., Whitehead, J., and Finkelstein, S., Why good leaders make bad decisions. *Harvard business review,* vol. 87**,** pp. 60-66, 2009.

Croskerry, P., Singhal, G., and Mamede, S., Cognitive debiasing 2: impediments to and strategies for change. *BMJ quality & safety,* vol. 22**,** pp. ii65-ii72, 2013.

Dolan, P., Hallsworth, M., Halpern, D., King, D. and Vlaev, I. MINDSPACE: influencing behaviour for public policy, Available: http://www.instituteforgovernment.org.uk/publicati, January 4, 2010.

Eisenfuhr, F., Decision making. *Academy of Management Review,* vol. 19**,** pp. 312-330, 2011.

Epley, N., and Gilovich, T., The anchoring-and-adjustment heuristic: Why the adjustments are insufficient. *Psychological science,* vol. 17**,** pp. 311-318, 2006.

Esch, F. R., Schmitt, B. H., Redler, J., and Langner, T., The brand anchoring effect: A judgment bias resulting from brand awareness and temporary accessibility. *Psychology and Marketing,* vol. 26**,** pp. 383-395, 2009.

Folkes, V. S., The availability heuristic and perceived risk. *Journal of Consumer research,* vol. 15**,** pp. 13-23, 1988.

Kahneman, D., and Tversky, A., *Prospect theory: An analysis of decision under risk. Handbook of the fundamentals of financial decision making: Part I,* World Scientific*,* 2013.

Kahneman, D., *Thinking, fast and slow*, 1st Edition, Farrar, Straus and Giroux, New York, 2011.

Kalnikaitė, V., Bird, J. and Rogers, Y., Decision-making in the aisles: informing, overwhelming or nudging supermarket shoppers? *Personal and Ubiquitous Computing*, vol. 17, no. 6, pp 1247–1259, 2013.

Kihlander, I., and Ritzén, S., Compatibility before completeness—Identifying intrinsic conflicts in concept decision making for technical systems. *Technovation,* vol. 32**,** pp. 79-89, 2012.

Lunenburg, F. C., THE DECISION MAKING PROCESS. *National Forum of Educational Administration and Supervision Journal*, vol. 27, no. 4, 2010.

March, J. G., *Primer on decision making: How decisions happen*, A Division of Simon and Schuster,New York, 1994.

Milkman, K. L., Chugh, D., and Bazerman, M. H. How can decision making be improved? *Perspectives on psychological science,* vol. 4**,** pp. 379-383, 2009.

Moustakas, C. *Heuristic research: Design, methodology, and applications*, Sage Publications,New York, 1990.

Nielsen, H., *Bounded Rationality in Decision-making: How Cognitive Shortcuts and Professional Value May Interfere with Market-based Regulation,* Manchester University Press, New York, 2009.

Redelmeier,D. A.,The cognitive psychology of missed diagnoses. *Annals of internal medicine,* vol. 142**,** pp.115-120, 2005.

Salter, D. D., Pang, D. M. Y., and Sharma, D. P., Active tasks to change the use of class time within an outcomes based approach to curriculum design. *Journal of University Teaching & Learning Practice,* vol. 6**,** no. 4, 2009.

Samson, A., *The behavioral economics guide 2014*, Behavioral Economics Group, London, 2014.

Samuelson, W., and Zeckhauser, R., Status quo bias in decision making. *Journal of risk and uncertainty,* vol. 1**,** pp. 7-59, 1988.

Simon, H. A., *Models of bounded rationality: Empirically grounded economic reason,* MIT press, Cambridge, 1997.

Soll, J. B., Milkman, K. L., and Payne, J. W., *A user's guide to debiasing*, Wiley-Blackwell Handbook of Judgment and Decision Making, 2015.

Sunstein, C. R., and Thaler, R. H., *Nudge: Improving decisions about health, wealth, and happiness*, Penguin Books, United State, 2014.

Tanaiutchawoot, N., Bursac, N., Rapp, S., and Albers, A., Investigating the Influence of the Decoy Effect in Pairwise Comparison in Terms of Idea Selection in the Product Development Process. *In Proceedings of the Design Society: International Conference on Engineering Design,* vol. 1. no.1, pp. 1195-1204, 2019.

Tanaiutchawoot, N., Rapp, S., Bursac, N., and Albers, A., IP-Integrated Product Development Project's Decision-Making Leads to Heuristic Behaviour. In *2018 IEEE International Conference on Engineering, Technology and Innovation (ICE/ITMC),* pp. 1-8, Stuttgart, Germany, 17-20 June, 2018.

Tärnvik, A., Revival of the case method: a way to retain student-centred learning in a post-PBL era. *Medical teacher,* vol. 29**,** pp. e32-e36, 2007.

Towler, M., and Keast, S., *Rational decision making for managers: An introduction*, *Business and Manager, New York*, 2009.

Tversky, A., and Kahneman, D., Judgment under uncertainty: Heuristics and biases*, science,* vol. 185**,** no. 4157, pp. 1124-1131, 1974.

Virine, L.,Trumper, M., and Virine, E.,Heuristics and biases in project management,*PM World J,* vol.7**,** pp. 1-11, 2018.

Weimer, M., *Learner-centered teaching: Five key changes to practice*, John Wiley & Sons, 2002.

Wright, G. B., Student-centered learning in higher education. *International Journal of Teaching and Learning in Higher Education,* vol. 23**,** pp. 92-97, 2011.

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