THE INFLUENCE OF KNOWLEDGE ABOUT HEURISTIC DECISIONS AND COGNITIVE BIASES IN ENGINEERING STUDENTS AND JUNIOR ENGINEERS: CASE STUDIES FROM GERMANY AND THAILAND

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ABSTRACT

Understanding heuristics and cognitive biases might lessen their impact since they can cause decision errors. From the responses to the survey for case studies, this study aims to investigate the fundamental understanding of heuristics and cognitive biases in engineering students and junior engineers from Germany and Thailand. The results indicated that the majority of participants knew very little about them. In a brief lecture, only few students from Germany knew about them. They had less of an impact on students who already knew them than on those who did not. However, engineers were unaware of them and are able to limit their effects. That implies that they can manage cognitive biases' effects without being aware of them. Therefore, experience is another crucial element in lessening the impact of biases. The behavior can also impact how much cognitive biases influence decision-making. Culture and environment affect the way of thinking. Although the finding suggests that knowledge is not the primary element in decreasing the impact of heuristics and cognitive biases, it is still vital to explain and further study the level of knowledge and the effectiveness of knowledge transfer to determine how they may have an impact.

Keywords: Decision making, Heuristic decision and cognitive biases, Education, Case study

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1 INTRODUCTION

Engineers have to make a variety of judgments, from daily activities to those that are essential to the company. The availability of information, the level of decisions made, the responsibilities of the decision-makers, the decision-makers experiences, and the length of time all have an impact on how complicated a decision-making scenario is. A heuristic choice is occasionally automatically adapted in decision-making based on limited time and information, even if a systematic decision is often made by evaluating information or using mathematical models and procedures. A mental shortcut called a heuristic choice is used to reach a hasty conclusion when solving complicated situations. Sometimes, adopting this decision leads to better results than using a systematic one, but it can also result in cognitive bias, which refers to a decision bias and error.

Heuristic and cognitive biases come in many different varieties. However, representativeness, availability, and anchoring are three basic heuristics that Kahnemann and Tversky (Kahneman, 2011) provided. when a choice is made under the false assumption that two comparable objects or occurrences are more tightly connected than they are. The representativeness heuristic, which is confused by an object's likeness, causes decision-makers to believe erroneously about the probability of a particular result. Decision-makers use the first piece of information or the first, most straightforward example that comes to mind when making judgments, which is known as the reliability heuristic. The anchoring heuristic describes a tendency in humans to accept and depend on the first bit of knowledge or the first thing they are presented with before making a choice. The tone for everything that follows is therefore set by this knowledge, which serves as the anchor. In the study of behavioral economics, the role of heuristics and cognitive biases in influencing consumer behavior is extensively discussed and shown (Samson, 2014).

Raising an individual's awareness of heuristics and cognitive biases through training and education is one possible method to counter them (Heath et al., 1998). Decision-making should be more effective with an understanding of heuristics and cognitive biases. However, there is little proof that understanding heuristics and cognitive biases will decrease their influence on judgment. Thus, this is an intriguing area that warrants greater study by scholars, particularly those working in the engineering discipline. We seek to present foundational knowledge about heuristics, cognitive biases, and our reason to use them in this part. In part 2, publications on heuristics and cognitive biases in the field of engineering and general knowledge are evaluated and summarized, along with possible solutions. Then, depending on the research deficit, section 3 suggests our goals. Sections 4 and 5 of this essay provide detailed explanations of the research methodology and findings, respectively. After that, in Section 6, the findings are examined and debated. All of the findings in this paper are summarized in Section 7, which also offers some recommendations for further research.

2 LITERATURE REVIEW

2.1 Heuristic decisions and cognitive biases

Fast thinking and slow thinking are the two components of a dual-system theoretical framework for decision-making, according to Kahneman (Kahneman, 2011). When a cognitive load is high or time is limited, quick thinking, or system 1, is chosen. This system relies on decision-making that is intuitive, automatic, based on experience, and largely unconscious. Contrarily, System 2 is used when the person is unable to rely on experience or regard for the future. This method is more analytical, regulated, reflective, and reflective. When system 2 is worn out and ignored when processing decisions, heuristics, and cognitive biases typically emerge. System 1, therefore, operates automatically and can occasionally result in a poor choice.

The introduction described three essential heuristics. Following that, a large number of them are discussed and illustrated with various examples. For instance, the effect of the decoy effect on an online subscription decision (Kahneman, 2011). When the third choice, which is asymmetrically dominated, is provided, the decision-makers preferences between the first two possibilities change specifically. Another illustration given in the context of entrepreneurs is the impact of status-quo bias (Burmeister and Schade, 2007). Entrepreneurs are likely to stick with their existing course of action unless there is a compelling reason to do otherwise. Decision-makers prefer to take no action rather than later regret their choice. This tendency relates to prospect theory's concept of loss aversion (Kahneman and Tversky, 2013). Decision-makers regret unfavorable outcomes more when they are

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the result of new actions taken than when they are the result of inaction (Samson, 2014). Numerous applications from various domains, including psychology (Ukpong et al., 2011), management (AlKhars et al., 2019), and politics (Blumenthal-Barby and Krieger, 2015), use more than 100 heuristics and cognitive biases (Lau and Redlawsk, 2001).

2.2 Heuristic decisions and cognitive biases in the engineering field

Different engineering activities are affected by heuristics and cognitive biases. The collection and explanation of 37 cognitive biases in software engineering. Developers of software that rely on current solutions often seem to add extra functionality. The management, design, and development of products also provide excellent examples of numerous heuristics and cognitive biases. Before significant investments have been made in new product development projects, gatekeepers in product development frequently increase a commitment to the early end of new product development (Sleesman et al., 2012). The IKEA effect is a different type of cognitive bias where owning a product makes it more valuable to people (Norton et al., 2012). Consumers place a disproportionately high value on products they partially created. This effect gives the shift from mass production to increase customization and co-production of value. Decision-makers have positive feelings that come with the successful completion of a task, a focus on the product's positive attributes, and the relationship between effort and liking (Kruger et al., 2004). The planning fallacy is a bias that project managers underestimate the length of time to complete a task and ignore experience (Buehler et al., 1994). Bendul and Zahner (Bendul and Zahner, 2019) proposed 6 main categories of cognitive biases in production planning and control, which are memory biases, statistical biases, confidence biases, adjustment biases, presentation biases, and situation biases. The influence of the decoy effect and representativeness heuristic in the decision-making in product development was explained when decision-makers select a concept idea of product profile for the next generation of apple peelers using experiments between a control group and a study group. These studies showed that decision-makers have different behavior based on the structure of alternatives and presented information (Bursac et al., 2018). The research from Tanaiutchawoot is another research that different from others. Twenty-two heuristic decision situations that can be appeared in product development processes are presented. However, types of cognitive bias are not referred to in this paper (Tanaiutchawoot et al., 2018).

2.3 De-biasing technique

Two essential ways to deal with heuristics and cognitive biases proposed by Brest and Milkman (Brest, 2013; Milkman et al., 2009), are de-biasing and counter-biasing. De-biasing involves complex strategies for active System 2 (slow thinking) which is rationality and analytical processing. An example of this technique is raising decision awareness of where traps of biases are likely to appear and trying to minimize the negative impact is a better approach than trying to avoid psychological traps (Kihlander and Ritzén, 2012). Counter-biasing is on the other hand playing on the system 1 bias against another as in the classical simple "nudges" proposed by Thaler and Sunstein (Sunstein and Thaler, 2014). The concept idea of "nudges" is to alter people's behavior predictably without prohibiting any options using the choice architecture. Heath also suggested motivation repairs and cognitive repairs for repairing cognitive biases (Heath et al., 1998). Motivation repairs are the methods to increase the energy and enthusiasm with which individuals pursue a task. Cognitive repairs are in contrast to the methods to improve the mental procedures of individual users to decide which task to pursue and how to pursue it. These repairs usually also focus on raising the decision-makers' awareness by increasing procedures of decision-making and adding reminders. However, these repairs should be trained to avoid cognitive bias.

3 RESEARCH OBJECTIVES

Heuristics and cognitive biases may manifest in a variety of engineering decision-making processes, including product design, product development, and project management, as demonstrated in the literature. A strategy from the literature is to increase the decision-makers awareness by teaching and training them. Before increasing their knowledge about heuristics and cognitive biases by teaching them, engineers' fundamental knowledge should first be examined. An important factor that can affect engineers' decision-making is maturity and experience. The researchers then have a question that whether engineering students and graduated students (junior engineers) can be influenced by heuristics and cognitive bias at the same level or not. Can experiences from working reduce the influences of heuristics and cognitive biases on decision-making despite no knowledge of them? As a result, researchers created a study to look at engineering students' and junior engineers' awareness of heuristics and cognitive biases for a case study. The goal of this study may be divided into the following two steps:

1. Investigate engineering students' and junior engineers' knowledge of heuristics and cognitive biases.
2. Investigate the relationship between the knowledge of heuristics and cognitive biases and how they influence decision-making.

4 RESEARCH METHODOLOGY

Four participant groups—engineering students from KIT (Karlsruhe Institute of Technology), engineering students from SUT (Suranaree University of Technology), junior German engineers, and junior Thai engineers—were chosen for the case study. Different degrees of decision-making competence were represented by the choice of students and junior engineers. However, different participant sites were not necessary for this investigation. The mechanical engineering students from KIT who participated in this study enrolled in the product development course offered by the IPEK Institute of Product Development. In contrast, SUT students who registered for the decision analysis course were industrial engineering (IE) students. Students in these lectures were requested to take part in the experiment since researchers were in charge of these two courses. Thirty engineers from SUT and thirty engineers from KIT were present. Before the lectures began, they took part in the experiment by responding within five minutes to questions on a paper-based questionnaire. Some of them were then questioned about their responses to the questionnaire. Alumni of KIT University and SUT University who graduated in less than four years were known as junior engineers. They have mechanical engineering and industrial engineering backgrounds. Before the survey went live, they were requested to take part in the study. The questionnaire would only be sent to participants in the study through email. Two weeks after the email was sent, the deadline for a response was set. Sixteen participants from the German companies and fifteen participants from the Thai companies replied. However, one participant from the German company did not complete the questionnaire. This respondent was then discarded. Figure 1 depicts the experiment's procedures.

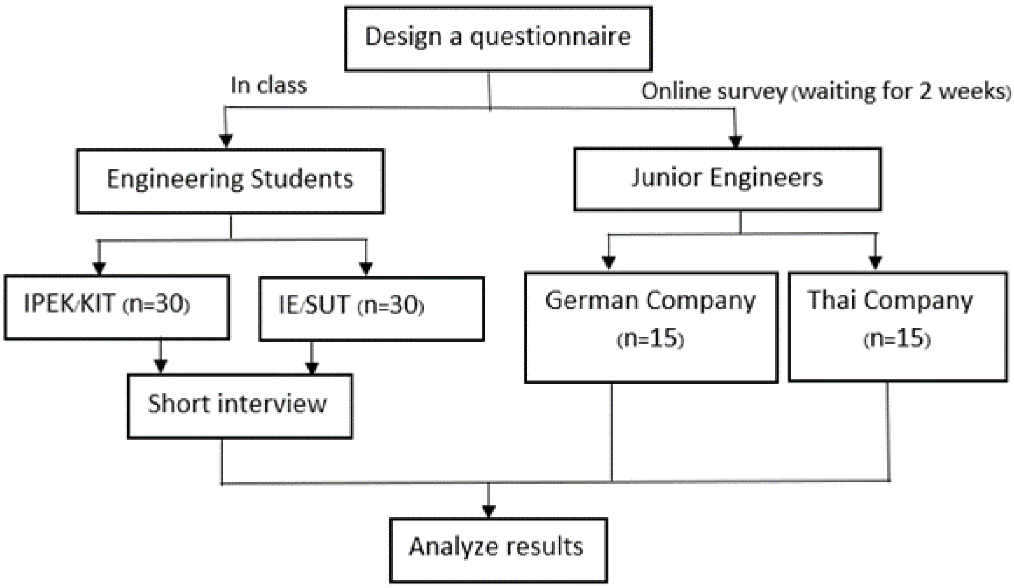

Figure 1. Processes of experiments to complete the questionnaire

The questionnaire was divided into two sections. The first part of the research attempted to assess participants' understanding of heuristics and cognitive biases. The second part of the research used a choice structure to assess the impact of heuristics and cognitive biases on decision-making. The first section included two questions (Questions 1 and 2), while the second section included one question (Question 3). Question 1 was a direct question, "Do you understand heuristics and cognitive biases?"

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Question 2 would display if the participants picked "yes." This topic asks participants to identify several forms of heuristics and cognitive biases. If participants choose "no," Question 3 would be displayed directly. Question 3 was an indirect or implied question. In this experiment, the status-quo bias (decision makers prefer to retain the present condition) was used to study its impact on decision-making. This impact is commonly observed when decision-makers oversee a project, as demonstrated in several articles. As a result, the budget choice for the new project was depicted in Question 3. Figure 2 depicts the flow of questions and answers in the questionnaire.

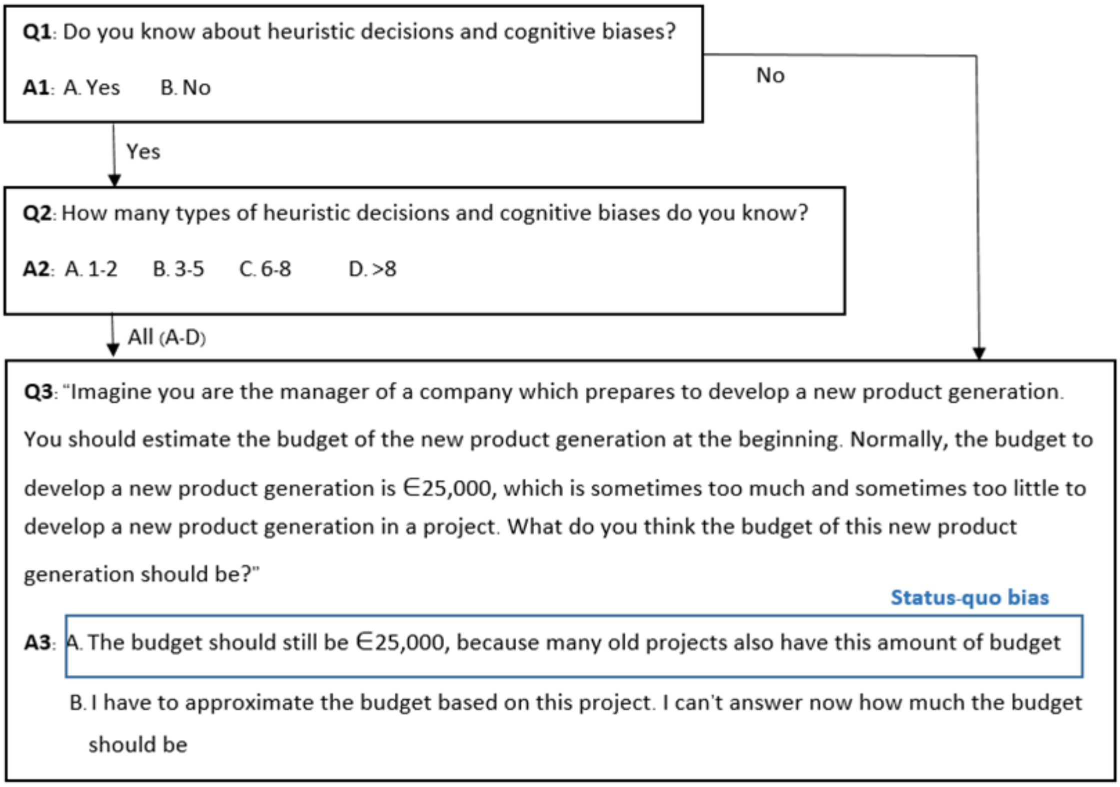

Figure 2. The flow of questions and answers in the questionnaire

In Question 3, there were two possible answers. The first response demonstrated the impact of status-quo bias in decision-making by picking the same number as provided by the researchers without considering additional information or analysis. The second option assumed that there was no impact of status-quo bias in decision-making or that the alternative was unbiased. In this response, decision-makers attempt to employ System 2 in decision-making by gathering additional information to prevent making mistakes.

5 RESULT

Figure 3 shows the results of the first question in the questionnaire, which demonstrate the participants' prior knowledge of heuristics and cognitive biases.

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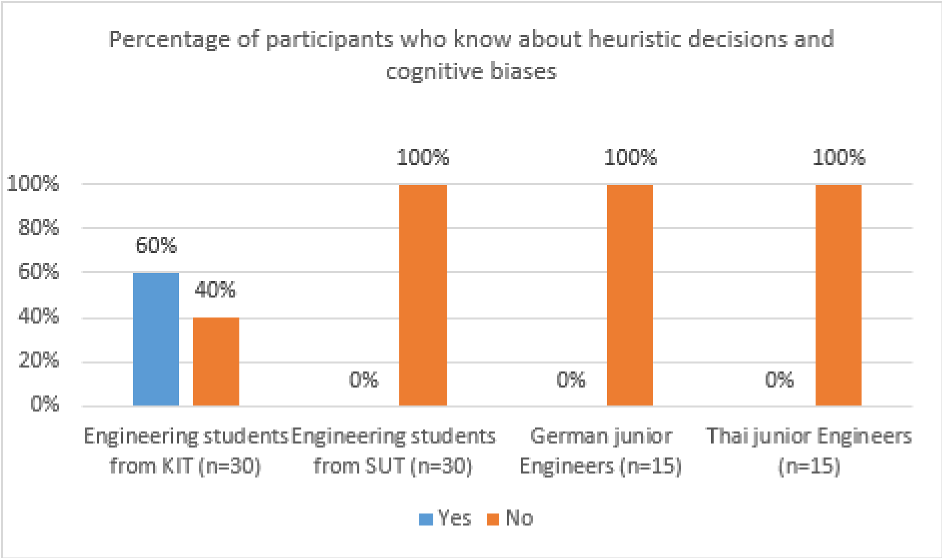

Figure 3. Percentages of participants who know about heuristics and cognitive biases

According to the results in Figure 3, sixty percent of KIT engineering students were aware of heuristics and cognitive biases. The answer to the second question in this group indicates that they are familiar with 1-2 kinds. Other people, on the other hand, are unaware of heuristics and cognitive biases. Students who are familiar with heuristic decisions and cognitive biases explain at the conclusion of the survey that they attended one lecture at the institution that addressed the impact of heuristic decisions in product development. They cannot, however, recall specifics about them. This is distinct from the other participants; they have never heard of them. As a result, these contents were new to them. Figure 4 summarizes the results of Question 3 of the questionnaire. The responses are divided into two categories: picking bias alternative and not selecting bias alternative.

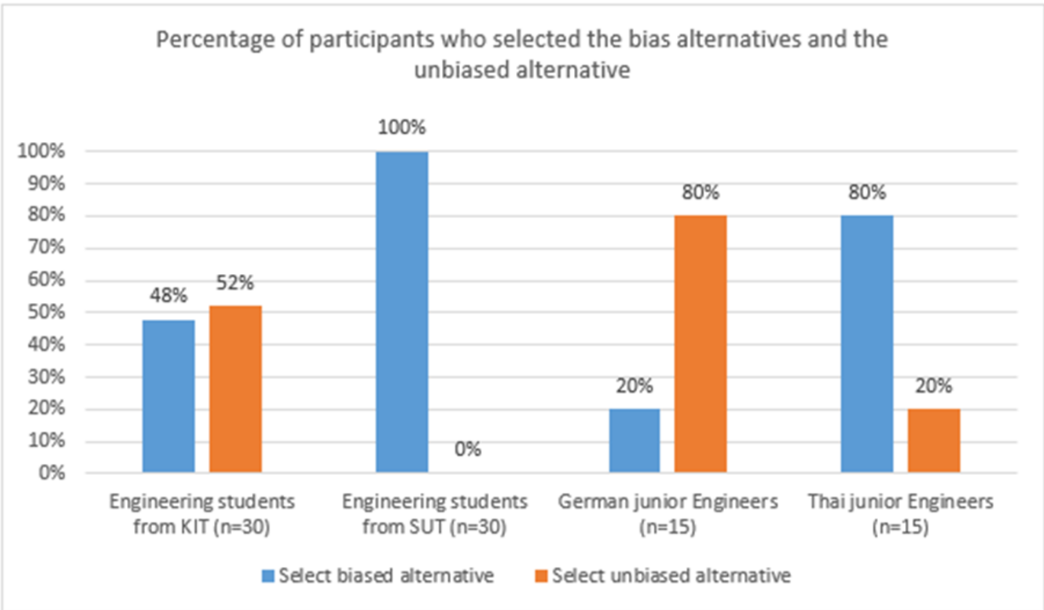

Figure 4. Percentages of participants who were influenced by heuristics and cognitive biases in decision making

Figure 4 illustrates that 52% of IPEK engineering students and 80% of German junior engineers select a reasonable alternative by deferring a decision and requesting further information. However, several of them chose the biased option. These findings were fundamentally opposed to those of Thai participants. The biased options were chosen by 100% of the students and 80% of the engineers. Thai students cited reasons for their replies such as the number appears to be appropriate, they need to make a quick choice, and we can adjust the budget later. Thai engineers emphasized similarly that we have a

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limited amount of time to decide, that it is common to retain the same budget for safety, and that we may alter the budget afterward.

6 DISCUSSION AND CONCLUSION

Although heuristics and cognitive biases arise in many engineering applications such as product development, product design, and management, engineering students and young engineers have little expertise in them. Some engineering students learned about them in a brief lecture, but they were not thoroughly discussed. This knowledge is novel to them and is rarely applied in traditional courses or lectures. This finding suggests that most engineers are unaware of the impact of heuristics and cognitive biases while making a choice. The answer to Question 3 explains the effect of information on the role of heuristics and cognitive biases in decision-making. Some KIT engineering students and German junior engineers might choose the impartial option. Even though German junior engineers are unaware of heuristics and cognitive biases, the percentage of German junior engineers who chose unbiased options is greater than that of KIT engineering students. When comparing these two groups, understanding heuristics and cognitive biases may not be the most important aspect in dealing with their impacts on decision-making. One possible component to cope with them is the decision-makers' expertise in decision-making. When comparing the results of engineering students from SUT with Thai junior engineers, this assumption is validated. The percentage of Thai junior engineers who selected the unbiased alternative is greater than the proportion of SUT engineering students. Although neither group's participants had any basic knowledge of heuristics or cognitive biases, some Thai junior engineers were not impacted by heuristics or cognitive biases when making a judgment. The results of the participant explanations correspond to the availability heuristic. Decision-makers base their decisions on their prior experience and behavior.

Although understanding heuristics and cognitive biases is not the primary element preventing the effect of decisions between engineering students from KIT and German junior engineers, various degrees of knowledge influence engineering students' decision-making. The percentage of KIT engineering students that chose the impartial alternative is higher than the percentage of SUT engineering students. This parallel shows that understanding heuristics and cognitive biases might be viewed as a safety strategy for preventing the effect of heuristics and cognitive biases when decision-makers lack expertise. Furthermore, before drawing conclusions regarding debiasing strategies based on an increased understanding of them, levels of knowledge should be categorized (aware, recognize, understand, detect, and apply). Furthermore, the amount of effectiveness in using the information to prevent heuristics and cognitive biases should be thoroughly investigated. This factor should be investigated more.

Although knowledge does not appear to be a necessary tool for reducing the effect of heuristics and cognitive biases on the experiential decision-makers in this study, being aware of it should raise the likelihood of choosing an unbiased choice. According to the researchers, transmitting knowledge of heuristics and cognitive biases is a technique to boost the efficiency of decision-making in engineers by making them aware of the effect of heuristics and cognitive biases regardless of their level of expertise in decision-making.

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