Exploring Thai seventh Grade students' understandings of design thinking

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Abstract. This study explores 35 Thai seventh grade students’ understandings of design thinking. As design thinking is a process by which designers empathize human needs, define problems, create ideas, make prototypes, and test the prototypes, its important aspects are focused in this study. These aspects include (1) human-centerness, (2) problem defining, (3) use of creativity, (4) collaborative work, (5) design constraints, (6) prototype testing, and (7) iterative process. The students’ understandings regarding these seven aspects are examined using an open-ended questionnaire in corroboration with individual semi-structured interviews. The data are analysed using content analysis. The result reveals that most of students had proper understandings of four aspects, which are human-centerness, use of creativity, design constraints, and collaborative work. However, their understandings of the other three aspects (i.e., problem defining, prototype testing, and iterative process) are inadequate. This result provides insights into development of STEM design-based activities to enhance the students’ better understandings of design thinking.

1. Introduction
STEM education has been promoted as a national strategy in Thailand in order to enhance a workforce in science, technology, engineering, and mathematics [6]. In response to this policy, engineering design process has been recommended as an instructional approach to STEM education [1]. This requires students to learn science, technology, and mathematics in an integrated way through engineering design process.

It is argued that design thinking is necessary for those who engage in design-based activities [5]. Thus, it seems important if not necessary that students have an adequate understanding of what engineers think and do when they designing things or products. However, as STEM education and design-based activities are rather new in Thailand [4], little is known about what Thai students understand about design thinking. It is the aim of this study to contribute to literature in this regard.

2. Theoretical Background
According to Institute of Design at Stanford [3], design thinking can be illustrated as a five-stage process of (1) empathizing users, (2) defining the problem, (3) ideating ideas of possible solutions, (4) creating prototypes, and (5) testing the prototypes. There are some important aspects regarding design thinking that are embedded in this five-stage process. Such aspects will be discussed as follows.

The first stage suggests that design thinking requires designers to focus on human’s needs, problems, and feelings. Thus, it is human-centered. As the problem that designers are to solve are not their own, designers need to clearly understand and define the problem. It is also that designers create
as many as ideas that can help solve the problem. Thus, it requires creativity, which can be enhanced by collaboration among designers or even users.

However, solving the problems always involves constraints in a given circumstance. Thus, it is necessary that designers transform their creative ideas into concrete prototypes in order for them to be able to test whether such ideas work and solve the problem under the given constraints. This can be done through prototype testing. It is often that this process is iterative until designers archive a solution of the defined problem.

Based on these, design thinking can be operationally defined as seven aspects, which include (1), human-centerness, (2) problem defining, (3) use of creativity, (4), collaborative work, (5) design constraints, (6), prototype testing, and (7) iterative processes. It is important to note that, while these aspects are not exclusive [2], they are useful to serve as a theoretical framework that guides the present study.

3. Methods
Thirty five Thai seventh-grade students (16 males and 19 females) participate in this study. They are purposively selected based on a convenient criteria as they are students in one of the first author’s classes. These students are asked to complete a questionnaire aiming to explore understandings of the seven aspects of design thinking. The questionnaire consists of seven open ended questions that ask each student to suppose themselves as an engineer who works at a toy company and design a toy for children at the age of 10-15 years old. Here are the questions.

(1) What is the first thing that you will do after being assigned to design a toy by the company?
(2) What do you need to consider when designing a toy? Will you use creativity to design and build a toy? And how?
(3) How would the process look like when you are designing a toy? Please, describe in details.
(4) What will you do with the toy’s target group who are children at the age of 10-15 years old?
(5) When designing a toy, which one are you comfortable to do between choosing a specific type of toys and then creating it accordingly OR creating as many as ideas of toy designs and then selecting the best one? Please provide the reason that supports your choice.
(6) What kind of methods will you use to determine if your designed toy is good enough to be produced for a commercial purpose?
(7) In designing of a toy car, do you prefer to work alone or collaborate with others? Please provide the reason that supports your choice.

In doing so, the students spend about 30 minutes to complete the questionnaire. After the completion of the questionnaire, each student is individually interviwed by the first author for five minutes in order for them to clarify and elaborate their written answers in the questionnaire. Both written and oral answers are then analyzed using content analysis regarding each aspect of design thinking.

4. Result and Discussion
Based on the data analysis, a majority of the students have proper understandings of four aspects of design thinking, which are human-centered, use of creativity, collaborative work, and design constraints. However, they do not well understand about the remaining three aspects of design thinking. Their understandings of each aspect can be discussed as follows. In this, either M or F stands for male or female respectively, which will be followed by an identification number.

Regarding the human-centerness, the students state that products of the designing process must serve needs of people who are targets of the designed products. They mention marketing reasons for the designed products to make profit for the company. However, the students do not elaborate how designers can empathize and have access to what the target people need as well as how designers will use such information in the process of designing products. Examples of some students’ answers addressing to the first question are shown below.
“I have to use the target group information in creating the product (toy) because my product will be of interest and I can sell a lot.” (M13)

“Use it (the target group information). If kids like it (the toy), it could be sold easily and will make more money than others (toys).” (F12)

However, while most of the students focus on human-centerness of designing thinking process due to marketing reasons, they are not aware that human’s needs must be translated into a problem definition. Rather, most of them state that designers can immediately design a product when they know human’s needs. They are not aware that defining a problem helps designers create ideas of possible solutions to the problem. Therefore, when asking the third question, some students answer as follows.

“(I will) design the car toy immediately because all kids like it.” (M8)

“I have to … think of designs that are balanced and appropriate.” (F5)

In spite of the inadequate understanding of defining problems as part of the designing process, most of the students are aware that creativity is important if not necessary for designers to design products. They argue that designers have to create as many as ideas that a problem can be solved. Then designers are able to choose the best one among the possible solutions.

Nonetheless, the students tend to ignore a combination of two or more possible ideas in order for designers to reach the best solution. The following are examples of some students’ answers addressing to the fifth question.

“I shall design a number of toys and then choose the most suitable model. It is creating more novelty and variety. There are many options.” (M15)

“I will select the second choice because it has a variety from which I can choose. It makes an innovative and interesting toy.” (F17)

In order to have as many as possible ideas, most of the students state that collaboration among a group of designers is important. Moreover, they state that collaboration can help designers work more efficiently as they can allocate tasks and share expertise within the group.

Additionally, working as a team can help designers prevent mistakes as a result of working individually. The following are examples of some students’ answers addressing to the seventh question.

“No, it's not a good idea to work alone because all work can't be done by one person. Therefore, work must be allocated to people according to their personal skills.” (F10)

“It's not appropriate to work alone because it may cause an error and the work may be delayed. If many people do it together, it will make the work proceed faster and have more new ideas as well.” (F17)

While most of the students understand about serving human’s needs in the designing process, they recognize that there must always be some constraints in the process of designing products. They are aware of cases that designers may not design products as creative as they can imagine because of the constraints such as costs and properties of materials. The awareness of these constraints may result from their marketing reasons that the designed products must make profits. Examples of some students’ answers are shown below.

“No. I can't design using only my own ideas. I have to consider what children are interested in. I must also consider cost, safety, and price of the product.” (M3)

“They can’t (use only creativity). Children aged 10-15 years may not like what I think solely. I must also consider price, softness, and durability.” (F4)

Most of the students argue that, before a final product will enter into the market for users to buy, the product must be tested or tried whether it works properly. In this, some properties of the prototype are mentioned by the students such as strengthness and endurance. However, while focusing on the final product, they tend to ignore creating and testing a prototype before a final product will be made. Moreover, only a few students suggest that the prototype must be qualified by a field test in that users or experts are asked to use or check if it satisfies them.
Below are examples of some students’ answers addressing to the sixth question.

“Products should be open for trials. Then, let users try out the product and tell their own opinions about the product. Use feedback for improving the product.” (M15)

“Try the product yourself. If the product is defective, improve it.” (F1)

“Try to use it by yourself for a period of time and then let children at the age of 10-15 years try it out.” (F4)

As most of the students ignore the process of testing prototypes, they are not aware of the iterative nature of designing process. None of the students do mention about improvement of the prototypes as a result of the testing process. They tend to perceive the designing process as a linear one by which designers empathize human’s needs, create ideas of possible solutions, choose the best one of them, build the real product, and finally sell the product in the market. Below are examples of some students’ answers about the designing process.

“Planning ➔ Designing ➔ Producing ➔ Testing ➔ Selling.” (F5)

“Design toys for children aged 10-15 years old and then consult with colleagues and build it.” (F12)

5. Implications

The result of this study provides some insights into development of design-based activities as an instructional approach to STEM education. As this study shows that students have some basic understandings of some aspects regarding design thinking (i.e., human-centerness, use of creativity, collaborative work, and design constraints) and that they tend to ignore the other aspects of design thinking (i.e., problem definition, prototype testing, and iterative nature of designing process), it is necessary that the poorly understood aspects need to be facilitated among these students.

In doing so, during design-based activities, teachers can explicitly discuss with the students on some questions such as how designers can ensure that a final product will serve its users’ needs without repeatedly testing it, how designers can test the product without making a prototype, and how designers can test a prototype without a clear definition of the problem and criteria. With explicit questions like these, we hope students will develop better understandings of design thinking, which will enhance their STEM learning via design-based activities.

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