Validation of a design thinking mindset questionnaire with Thai elementary teachers

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Abstract. Due to a recent educational reform in Thailand, elementary teachers are challenged to use an engineering design process as an instructional approach to STEM education. This would require them to have a design thinking mindset (DTM) as a basic requirement. However, it has been argued that it is difficult to measure DTM using a questionnaire. Therefore, there has been little information if Thai elementary teachers possess DTM. This study aimed to develop and validate a Thai version of DTM questionnaire with two groups of Thai elementary teachers (N=138). Successively determining Cronbach’s alpha values with each group of the teachers, six components of DTM were suggested. These components included (1) Being comfortable with problems, (2) User empathy, (3) Mindfulness of the process, (4) Collaborative working with diversity, (5) Orientation to learning, and (6) Creative confidence. While this result may need to be confirmed with a larger population of teachers, a Thai version of the questionnaire can be potentially used to explore Thai elementary teachers’ DTM in other contexts.

1. Introduction
Since workforce in science, mathematics, engineering, and technology is conceptualized as a key component for sustainable economic and social development in Thailand’s 20-Year (2018-2037) National Strategy [11]. STEM education has taken its part in the latest reform of Thailand’s Basic Education Curriculum B.E. 2561 [3]. This reform encourages teachers at all educational levels to use an engineering design process as an instructional approach to teaching science, mathematics, and technology in an integrated manner. This requirement indeed is challenging for many teachers, especially those teaching at elementary levels, because they are not familiar with STEM education and engineering design process [8].
It is argued that design thinking requires a mindset necessary for individuals engaging in design activities. Therefore, teachers should have and exhibit design thinking mindset (DTM) when facilitating students’ design-based learning. However, there is little, if any, information about Thai teachers’ mindset associated design thinking. This shortcoming may partly result from the lack of a clear agreement about what design thinking mindset actually means and how to measure it. As a consequence, it seems difficult to gain information to facilitate Thai teachers’ DTM. This study aims to develop and validate a Thai version of DTM questionnaire, which can be used as an instrument for research and practice in the field of teacher professional development.

2. Theoretical Background
As an engineering design process is complex [5], it can be defined differently. However, it is argued that design thinking is necessary in any design process [10]. However, there is no clear agreement of what this term actually means. For example, design thinking can be defined as “an analytic and creative process that engages a person in opportunities to experiment, create and prototype models, gather feedback, and redesign” [13]. Design thinking may also refer to an ability to combine empathy, creativity, and rationality to analyse and fit solutions to particular problems [15] as designers aim to solve problems of others, not their own. Moreover, design thinking can be illustrated as a process of (1) empathizing users, (2) defining the problem, (3) ideating ideas, (4) creating prototypes, and (5) testing the prototypes [6].

Given the complexity of design thinking, there have been attempts to identify characteristics of those who have and exhibit design thinking. Such characteristics can be labels using different terms such as traits [1], attributes [14], and mindset [4]. However, the term “mindset” seems to be most appropriate [2] as it refers to “the set of opinions, beliefs and behaviors that characterized an individual” [12] when engaging in design activities. Regardless of the terms used, it appears that design thinking is a multifaceted concept. As shown in Table 1, DTM can be described with a different yet similar set of characteristics. This difference is understandable given the fact that DTM can be applied into various contexts (e.g., engineering and business) and scopes (e.g., individual and organization).

| Table 1. Characteristics of design thinking mindset. |
|-----------------------------------------------------|
| Bilzzard et al. [1] | Schweitzer et al. [14] | Dosi et al. [4] |
| 1. Collaboration | 1. Empathetic towards people’s needs and context | 1. Tolerance for ambiguity |
| 2. Experimentation | 2. Collaboratively geared and embracing diversity | 2. Embracing risk |
| 3. Optimism | 3. Inquisitive and open to new perspectives and learning | 3. Human centeredness |
| 4. Feedback-seeking | 4. Mindful of process and thinking modes | 4. Empathy |
| 5. Integrative thinking | 5. Experiential intelligence | 5. Mindfulness of process |
| | 6. Taking action deliberately and overtly | 6. Holistic view |
| | 7. Consciously creative | 7. Problem framing |
| | 8. Accepting of uncertainty and open to risk | 8. Team working |
| | 9. Modelling behaviour | 9. Multi-disciplinary collaboration |
| | 10. Desire and determination to make a difference | 10. Open to different perspectives |
| | 11. Critically questioning | 11. Learning oriented |
| | | 12. Experimentation |
| | | 13. Bias toward action |
| | | 14. Critical questioning |
| | | 15. Abductive thinking |
| | | 16. Envisioning new things |
Based on the shared characteristics of DTM in Table 1, it can be summarized that DTM is the mindset that characterizes a designer to empathize people’s problems, desire to take actions, and learn in the process of problem solving in order to have an impact on their life and societies. In doing so, they wish to communicate ideas and collaborate with others, be open to diverse perspectives, be mindful to the process of problem solving, be aware of his or her own thinking modes (e.g., divergent and convergent thinking), be comfortable with ambiguity and uncertainty, be confident in creativity, embrace risks when trying different approaches or testing new ideas, and be resilient to not back down from the challenging problems as they are in the process of creating innovations that help solve the people’s problems.

As many of the DTM characteristics are interrelated [12], it is suggested that they must be validated for parsimony to develop a precise set of scales of an instrument to adequately measure DTM [1]. Many scholars provided a set of self-assessing questionnaire scales associated with their DTM characteristics [4]. They also validated those scales with innovation managers [14], design thinking experts [12], or college students [1]. However, as far as we know, there is no study that aims to developing and validating a DTM instrument in elementary education contexts, especially in Thailand. Therefore, the existing instruments may not be directly utilized with Thai elementary teachers without modification. This study is the first step to develop a DTM questionnaire for Thai elementary teachers.

3. Methods
We began with the list of Dosi et al.’s [4] items as it presents a widest range of the DTM characteristics. Then, we did a vibatim translation of all 71 items of their DTM questionnaire from English into Thai. We collaboratively checked the meaning of each item to ensure that it corresponds with its relevant characteristic. Once we agreed upon the translated items, we validated the questionnaire with the first group of Thai elementary teachers (N=70) who attended a workshop about design-based learning activities [7] where they were challenged to design a layout and a structure of an energy-saving and house based users’ requirements (e.g., living and garden area) and scientific data (e.g., solar paths and wind direction). They completed the questionnaire just after finishing the design activities.

We then determined a Cronbach’s reliability coefficient for all the items as well as for each DTM characteristic. It was found that, while the Cronbach’s alpha values for the whole questionnaire as well as for many DTM characteristics were acceptable (> 0.7), some were not [9] as shown in Table 2. This suggested for modification. As a consequence, we reconsidered the meaning of each item and this led us to realize that some items had changed their meanings as a result of translation. For example, item D33 (I am comfortable to share my knowledge with my team mates), which originally corresponds to the “Team working,” seemed to change its meaning towards the “Learning oriented” as the term “share with” was translated to a Thai word that seemed to mean “learn from.”

| DTM characteristics (Number of items) | Cronbach’s alpha values |
|---------------------------------------|-------------------------|
| 1. Tolerance for ambiguity (5)        | 0.772                   |
| 2. Embracing risk (2)                 | 0.455                   |
| 3. Human centeredness (3)             | 0.475                   |
| 4. Empathy (4)                        | 0.813                   |

Table 1. Characteristics of design thinking mindset.

| Bilzzard et al. [1] | Schweitzer et al. [14] | Dosi et al. [4] |
|---------------------|------------------------|-----------------|
| 17. Creative confidence | 18. Desire to make a difference | 19. Optimism to have an impact |
Table 2. Cronbach’s alpha value for each DTM characteristics (first round).

| DTM characteristics (Number of items) | Cronbach’s alpha values |
|---------------------------------------|-------------------------|
| 5. Mindfulness of process (3)          | 0.655                   |
| 6. Holistic view (3)                  | 0.582                   |
| 7. Problem framing (3)                | 0.772                   |
| 8. Team working (4)                   | 0.874                   |
| 9. Multi-disciplinary collaboration (4)| 0.818                   |
| 10. Open to different perspectives (4)| 0.874                   |
| 11. Learning oriented (6)             | 0.916                   |
| 12. Experimentation (6)               | 0.881                   |
| 13. Bias toward action (4)            | 0.796                   |
| 14. Critical questioning (3)          | 0.781                   |
| 15. Abductive thinking (4)            | 0.782                   |
| 16. Envisioning new things (3)        | 0.792                   |
| 17. Creative confidence (4)           | 0.819                   |
| 18. Desire to make a difference (3)   | 0.578                   |
| 19. Optimism to have an impact (3)    | 0.854                   |
| Overall (71)                          | 0.957                   |

Since an exploratory factor analysis “should never be used if the number of items is greater than the number of participants” [9, p. 118], we decided to qualitatively analyze the items based on Thai meanings in order to regroup them into a smaller number of the key characteristics. In doing so, we were guided by some scholars that the items can be merged into 5-8 key characteristics [1, 12]. For example, the items belonging to the “Human centeredness” and those belonging to the “Empathy” can be merged into the same group as they both focus on understanding users’ problems, needs, and feelings. Moreover, some items that seemed to be vague or unclear for the teachers were excluded based on the result of reliability analysis.

As a result, we ended up with only 27 items belonging to seven key characteristics, which can be labeled as (1) Being comfortable with problems, (2) User empathy, (3) Mindfulness of the process, (4) Collaborative working with diversity, (5) Optimism, (6) Orientation to learning, and (7) Creative confidence. Then, we used the same data set to repeat the process of determining Cronbach’s reliability coefficients of the remaining items, which resulted in acceptable values (0.792 for Being comfortable with problems, 0.858 for User empathy, 0.707 for Mindfulness of the process, 0.851 for Collaborative working with diversity, 0.808 for Optimism, 0.922 for Orientation to learning, and 0.807 for Creative confidence). The reliability for the all items is 0.890.

In order to validate the modified questionnaire, we asked the second group of Thai elementary teachers (N=68), who attended the same workshop, to complete the questionnaire just after finishing the design activities. We then analyzed this set of data to determine a Cronbach’s reliability coefficient for all the items as well as for each DTM characteristic. It was found that all the Cronbach’s alpha values were acceptable except that for Optimism as shown in Table 3. The result of reliability analysis suggested that even deleted some of the items in this characteristic did not improve the Cronbach’s alpha value. Moreover, merging these items into those of other characteristics did not do so as well. Eventually, we decided to exclude this characteristics from the questionnaire.
Table 3. Cronbach’s alpha value for each DTM characteristics (second round).

| DTM characteristics (Number of items) | Cronbach’s alpha values |
|--------------------------------------|-------------------------|
| 1. Being comfortable with problems (3) | 0.900                   |
| 2. User empathy (3)                   | 0.811                   |
| 3. Mindfulness of the process (3)     | 0.809                   |
| 4. Collaborative working with diversity (3) | 0.760                  |
| 5. Optimism (3)                       | 0.685                   |
| 6. Orientation to learning (7)        | 0.920                   |
| 7. Creative confidence (5)            | 0.898                   |
| Overall (27)                          | 0.958                   |

4. Results
Based on a succession of the process of validating and modifying the original scales measuring DTM characteristics with two group of Thai elementary teachers, we ended up with a Thai version of DTM questionnaires with 24 items belonging to six DTM characteristics, which include (1) Being comfortable with problems, (2) User empathy, (3) Mindfulness of the process, (4) Collaborative working with diversity, (5) Orientation to learning, and (6) Creative confidence. Table 4 shows the items for each DTM characteristic as we translated back from Thai to English. For those who are interested in the Thai version of this questionnaire, it is available upon a request to the corresponding author of this article via email.

Table 4. The final version of the DTM questionnair.

| DTM characteristics            | Items                                                                 | Cronbach’s alpha values |
|--------------------------------|-----------------------------------------------------------------------|-------------------------|
| 1. Being comfortable with problems | 1.1 I am comfortable even in dealing with unsolved problems.          | 0.900                   |
|                                | 1.2 I enjoy when the result of problem solving is unexpected.         |                         |
|                                | 1.3 I don’t worry even when solving a problem that I don’t know if it is successful. |             |
| 2. User empathy                | 2.1 During the design process, I try to understand uses’ needs.       | 0.811                   |
|                                | 2.2 During the design process, I often see the problem from users’ perspectives. |           |
|                                | 2.3 During the design process, I often put myself in users’ shoes.    |                         |
| 3. Mindfulness of the process  | 3.1 I am aware when I have to be mind-open and when I have to focus on a thing. | 0.809                  |
|                                | 3.2 I believe in discovering new things rather than worrying about failed results. |               |
|                                | 3.3 I am aware when I necessarily have to redefine the problem more clearly. |            |
| 4. Collaborative working with diversity | 4.1 I like working in group rather than working alone.            | 0.760                   |
**Table 4.** The final version of the DTM questionniare.

| DTM characteristics | Items                                                                 | Cronbach’s alpha values |
|---------------------|-----------------------------------------------------------------------|-------------------------|
| 4.2 I like working with those coming from different institutes. | 0.920                                                                |
| 4.3 I accept the group’s decisions even I do not agree with them. |                                                                       |
| 5. Orientation to learning                                    | 5.1 I often apply new things that I have learned.                      | 0.920                                                                |
| 5.2 I like learning from experiences, observations, and actions. |                                                                       |
| 5.3 I like learning with colleges within and across groups.    |                                                                       |
| 5.4 I like learning from those who have diverse and different perspectives. |                                                                       |
| 5.5 I like to get feedback and learn from it.                  |                                                                       |
| 5.6 I try to get information that I have not ever known.        |                                                                       |
| 5.7 I can discuss, share, and learn from mistakes.              |                                                                       |
| 6. Creative confidence                                        | 6.1 I can make inferences and propose ideas based on incomplete information. | 0.898                                                                |
| 6.2 I like to use creative thinking to solve complex problems.  |                                                                       |
| 6.3 I like to think of new things that are different from what exits. |                                                                       |
| 6.4 I like to create a model to represent a new idea.           |                                                                       |
| 6.5 I like to create new conditions to test other possibilities. |                                                                       |
| Overall                                                        |                                                                       | 0.953                                                                |

**5. Discussion**

In an attempt to develop a reliable instrument measuring DTM, we obtained a questionnaire with 24 items corresponding to 6 characteristics. Some of these characteristics are consistent with the result of Paparo et al.’s study [12] that those who have DTM tend to be comfortable with or tolerant of unsolved problems, empathize users, be mindfull of the process and their own thinking, prefer to collaborate with other people who might have different perspectives, eager to learn from experiences, actions, or even mistakes, and be confident in the use of creativity. However, some characteristic (e.g., optimism) in Blizzard et al.’s study [1] might not be explicitly measured by our questionniare. Future research should be conducted with a larger population using more advanced methods (e.g., a factor analysis).

**6. Implications**

As Thai teachers at all educational levels are challenged to teach science, mathematics, and technology through an engineering design process [3], they should have and exhibit DTM when facilitating design-based learning activities. However, there is no or little work having been done in developing a reliable instrument measuring DTM in Thailand’s educational contexts, resulting in the lack of Thai teachers’ DTM. The questionniare developed in this study can serve as an instrument to gain basic information about Thai teachers’ DTM, which can be useful for educational researchers and those who are
responsible to teacher professional development related to STEM education in Thailand and perhaps elsewhere.

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