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The integration of design thinking into the process of developing a serious educational game and its influence on technological pedagogical content knowledge: Taking the case of a pre-service teacher as an example

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Abstract: This study aims to investigate how a pre-service teacher integrated design thinking into the development of an SEG (which elements of design thinking were needed) and what was the impact of the integration of design thinking into the process of making an SEG on her technological pedagogical content knowledge (TPACK) by using a self-study approach. The findings indicate that there were twelve elements of design thinking that are related to the whole process of making an SEG and the integration of design thinking into the development of an SEG affected the pre-service teacher's TPACK in three different aspects.

Keywords: SEGs, design thinking, TPACK

1. Introduction

The use of serious educational games (SEGs) in science learning has become an increasing trend in recent years (Connolly, Boyle, MacArthur, Hainey, & Boyle, 2012). However, making an SEG is never an easy task for both researchers and educators alike. The development of an SEG requires collaboration and communication between team members from multiple disciplines. It is really an effort- and time-consuming process in which game developers encounter different kinds of design problems often. On the one hand, researchers recently tend to agree that design thinking, a mindset considering design as an innovation process that focuses on human needs (Dunne, & Martin, 2006), should be taken into account while making an SEG. Through the iterations between divergent and convergent phases of the design process, design thinking allows designers to make mistakes and solve problems. But, how design thinking can be appropriately integrated into the development of an SEG is an issue that has not been clearly addressed. On the other hand, TPACK, knowledge about teaching with technology, is critical to today's teachers, because technology has been prevailingly integrated into educational settings. Therefore, it would also be of great interests to examine how the process of integrating design thinking into the development of an SEG affects teacher's TPACK. In this study, a self-study approach, taking the case of a pre-service teacher as an example, was used to preliminarily answer the two questions.

2. Methodology

In fall 2013, the first researcher and other four group partners took a course that requires them to work as a team to create their own an SEG for learning about biology. The self-study lasted about one year and the data collection consisted of audio recordings of each group discussion, researcher's reflection notes, game design profiles including game scripts, storyboards, planning proposals, etc.

The audio recordings were transcribed verbatim into transcriptions. Then, the researcher generated appropriate codes and created a coding scheme by repeatedly reading all the documents and transcriptions and reviewing the relative literatures regarding design thinking, SEGs, and TPACK. One another researcher was invited to analyze all the data by using the coding scheme again. The inter-rater reliability was 0.87 for the part of integrating design thinking into the process of making an SEG (Table 1) and 0.91 for the part regarding the impact of the process on teacher's TPACK (Table 2).

Table 1: Coding scheme of integrating design thinking into the process of making an SEG.

Category	Description
Questioning	• *Asking questions:* Raising questions about game design content
Empathy	• *Self-gaming experience:* Using personal previous gaming experience as a reference • *Simulating the view point of players:* Developing the game from players perspectives
Defining needs	• *Connecting goals:* Setting goals for designing the game or examining whether the game design meets these goals
Integration	• *Correlating elements:* Considering the relationships between the elements of the game design and whether they conflict each other or not • *Cross-domain connections:* Considering the integration of the game design with subject content knowledge
Documentation	• *Document recordings:* Recording ideas generated during team discussions
Divergent thinking	• *Brainstorming:* Brainstorming between team members to generate different ideas • *Superimposing creativities:* Expanding an existing idea to make it more complete
Convergent thinking	• *Logical thinking:* Logically hypothesizing, and/or inferring the effect of design • *Evaluating solutions:* Evaluating and selecting a better idea
Intuition	• *Intuition:* Pointing out inappropriate design according to personal intuition
Concretization	• *Drawing pictures:* Drawing pictures to describe a specific idea • *Giving analogical examples:* Giving analogical examples to concretize an idea
Seeking help	• *Seeking external assistance:* Asking for help from others for unsolvable problems
Making prototype	• *Executing ideas:* Transforming design concepts into a game product and testing it • *Accepting failures:* Facing frustrations and discussing about how to improve it
Positive attitudes	• *Positive thinking:* Having positive attitude to face challenges

Table 2: Coding scheme of impact of the process on teacher's TPACK.

Category	Description
Subject comprehension	• *Subject learning:* Integrating subject matter into the game to facilitate learning
Curriculum plan	• *Teaching goals:* Integrating teaching goals into the game design • *Impact factors:* Thinking factors having impact on the game-curriculum integration
Appropriate presentation	• *Subject presentation:* Considering a better design to appropriately present content • *Reducing loads:* Modifying the game design which might make learners confused • *Enhancing efficiency:* Considering appropriate design to increase learning efficiency

3. Results

3.1 The integration of design thinking into the process of making an SEG

The process of developing an SEG can be divided into three stages: pre- (the formulation of game scripts, storyboards, and planning proposals), mid- (the organization and expansion of game design), and post-development (the generation of game prototype). It is found that a total of twelve elements of design thinking were related to the three different development stages (Figure 1).

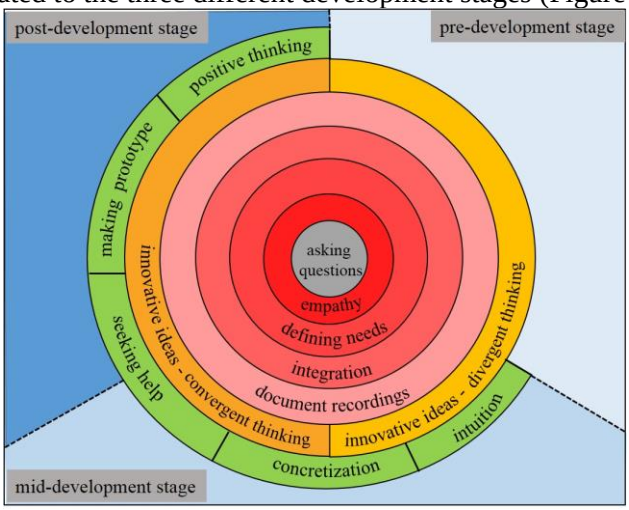

Figure 1. Three stages of the applying for design thinking elements.

3.2 Impact on the pre-service teacher's TPACK

Figure 2 shows the impact of integrating design thinking into the development of an SEG on pre-service teacher's TPACK. The impact included three different aspects, subject comprehension, curriculum plan, and appropriate presentation.

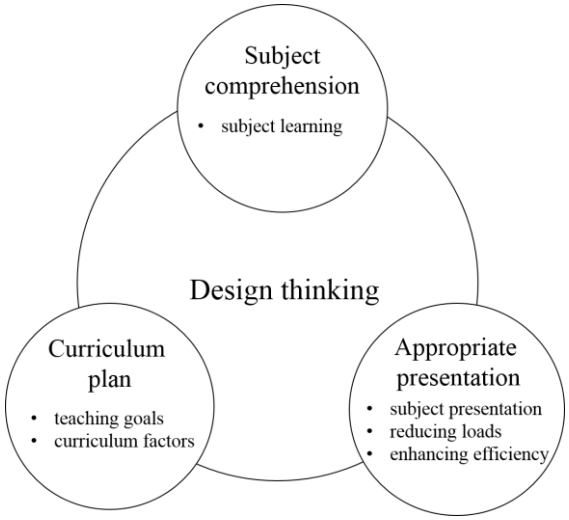

Figure 2. Design thinking impact on technological pedagogical content knowledge (TPACK).

4. Discussion and conclusion

According to the obtained results, we can find that asking questions is critical in terms of the integration of design thinking into the process of making an SEG. It is the initial of other elements; namely, other elements of design thinking all evolve from asking questions during the whole process of making an SEG. It is thought that the ways of integrating design thinking into the development of an SEG should be adjusted as the stages of development change. Moreover, it is worthy to note that these elements of design thinking actually interacted with and were interrelated to each other and the findings are in alignment with the previous research by Thoring, & Müller (2011). Finally, it is concluded in the present study that there were associations between the elements of integrating design thinking into the development of an SEG and the aspects of its impact on TPACK. Namely, different elements of design thinking may have different impacts on pre-service teacher's TPACK, and the impacts need to be explored in further studies.

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