

*Content Design of Virtual Game for Elementary School Students:  
Using Circle and Compound Graphics of Circle as an Example*

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**Abstract**

Recently how to take advantage of digital games to enhance learning has become a hot issue in the area of learning technologies and attracted much attention. If being well designed, we cannot only help students immerse themselves in the learning activities, but also promote students' motivation. Hopefully, we can improve students' learning outcomes. Thus in this study, we, through the design of the scenario-based learning content, aimed to transform students into leading roles in the virtual game. In this designed environment, students could play as a warrior to save the victims via problem solving in the critical situations and, meanwhile, could learn about the knowledge of circle and compound graphics of circle. Moreover, to achieve this end, we have implemented the situated mathematics digital game system used on the tablets, based on situated-learning theory, Van Hiele geometric thinking level theory and ARCS teaching mode. In order to make sure that the content design and learning process of virtual game are suitable for the study and the needs of the target users. Researcher adopted the questionnaire survey, including the feeling of using a situated digital game and views on the use of situated digital games to learn mathematics. This study is in stage of system development. We hope we can build a better content design of virtual game by the result of questionnaire to enhance students' knowledge and learning motivation of mathematics.

Keywords: Digital Game-Based Learning, Situated-Learning, Van Hiele Geometric Thinking Level, Compound Graphics of Circle

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## **Introduction**

Today, for the “Digital Natives” elementary school students who live in the internet generations, their growing processes are often accompanied by 3C. Furthermore, visual stimulation floods video websites and digital games, so they become one of the main activities for children to use internet (Taiwan Child Welfare League Foundation, 2015). Successful game experience is from the accumulation of continuous practice. Learn is also like this. If the students have enough practice and interesting situations immerse them in it, I think it will provide positive support to learning motivation and learning outcomes.

The evolvement of students’ geometry abilities will influence each other with different grade. When students face graphic area problems, they will ignore the situation and how to extract and apply relevant mathematical knowledge. Then, this mistake may cause students to be computer robots. It’s difficult to build a solid mathematical concept for students and they will gradually lose motivation to learn (Confrey, 2012). As a result, circle and compound graphics of circle is hard to learn for elementary school students, they may use formulas directly without the understanding of compound shapes’ composing (Chen, & Wu, 2016). Hoffer (1977) thinks learning geometry concept will influence each other with improving the ability of visual consciousness. If we can improve students’ visual consciousness, they will learn better in geometry. ZHANG (2009) also proposes if students operate geometry activities (translation, rotation, superposition, decomposition and recombination), they will get basic geometric concept better and calculate the area of compound graphics successfully.

In order to solve students’ problems in circle and compound graphics of circle, this research plan to interview the present teachers in elementary school first, then discussing with research group and expert teachers, then literature review for proper teaching material design and teaching method application. At last, this research aims to develop a scenario-based learning with digital game. Specially, the scenario is adapted from “Taiwanese folk tales - Aunty Tigress”. We expect students can not only increase learning motivations and achievements in mathematics, but also understanding local culture by the scenario-based learning with digital game.

This study will discuss related literature sequentially, then, presenting the teaching content design of the situated mathematics digital game and the outcome of requirement analysis. At last, we will discuss the future usability of situated mathematics digital game teaching mode.

## **Current Study**

Digital game-based learning is a combination of “learning content” and “digital game”. Prensky (2001) expected to combine learning contents with digital games to make the same or better learning outcomes than traditional teaching. In recent years, Game-based learning has become an important research topic in learning (Cheng et al, 2013; Hsu, Tsai, & Wang, 2012). Liang, Chen, Young, & Yang (2008) indicate that we can live up to educate children while having fun with them at the same time and increase their learning achievement by game-based learning. Some related researches show many benefits in learning with game, for example, Chen (2009) had used the

game on teaching of addition and subtraction. She found that the experimental group had reached a significant level in mathematics learning; the traditional group didn't seriously answer questions. YE(2017) considers games can stimulate students' intrinsic motivation, and overcome the difficulties to open the books to find the answers.

Brown, Collins and Duguid(1989) considers knowledge is produced by the interaction with learner and situation. For the sake of this, the best way to learn is in the specific situation (Lave & Wenger , 1991). Chan, & Lee (2005) think situated mathematics teaching is an important teaching approach. They advocate provide meaningful situational questions, let students explore various types of math problems in the situation. The more mathematics questions close to students' real live, the better students can achieve effective mathematics learning. Furthermore, situated teaching through the text, actual or simulation let students entering math problems and get the mathematics concept by interaction and experience. Scott (1985) thinks storytelling in the classroom can promote a relaxed and intimate atmosphere. The students in the atmosphere, their mind will up and downs with the characters. At the same time, it will initiate students' learning interest and generalization concept.

Netherlands mathematics educator Van Hiele (1986) proposed the geometric thinking level theory, divided into five levels. It follows as visualization, analysis, informal deduction, formal deduction and rigor. These levels are sequential and Van Hiele (1986) thinks learner should be taught from a level to the next level. Then, their geometric thinking level will be already from the basic level "visualization" to the top level "rigor". Wu (1995)'s research illustrated most of the elementary school students in lower grades are belong to level 1 "visualization", the middle grade students almost can be level2 "analysis", and the high grade students are approximately between level 2 "analysis" and level 3 "informal deduction". Therefore, this research will apply Van Hiele geometry development theory in the game design and follow the geometric concept to arrange operational activity sequentially. We hope students can upgrade their geometric ability by this game.

The curriculum policy of primary and junior high schools in Taiwan, geometric unit is considered very much. According to the curriculum's synopses of Ministry of Education, the five topics in the mathematics learning of Nine-Year Curriculum include "Number and Quantity", "Geometry", "Algebra", "Statistics" and "Connection" (Ministry of Education, 2009). Under this structure, there are three teaching objectives of students' geometric curriculum in the elementary school as follow: 1) Level 1 (The first and second grade): students can grasp the preliminary concept of Number, Quantity and Shape, 2) Level 2 (The third and fourth grade) students gradually acquire the abilities of knowing the geometric property by operating, 3) Level 3 (The fifth and sixth grade) students can know the geometric property of plane and stereo figures and understand about calculating area or volume. For students, conservation of area is the basis of area learning. However, when the fifth and sixth grade students solve the problems of area, they are still effected by visual sensation. In other words, only the figures slightly rotate, it will effect students' conservation concept (Tan, 1998). Tan (1998) indicated that, area instruction should be divided into three parts: Form the concept in conservation of area, establishment of the area measurement concept and training of area estimation ability. When students solve the problems of the area of compound graphics, teachers should stimulate them

to think about the strategy of “split, combine, shift and fill”. Thus, students will learn the geometric concept more complete (Confrey, 2012). Wu (2016) also figures that if students use the strategy of “split, combine, shift and fill”, they can round-off the compound graphics of circle. By the strategy, the compound graphics of circle will be easier figures. At the same time, the process will improve students' confidence and accuracy.

## Method

This research aims to develop a scenario-based learning with digital game, which is based on situated-learning theory and Van Hiele geometry development theory, taking the sixth grade math “Circle and Compound graphics of Circle” unit as an example to research and discussion. Specially, the scenario is adapted from “Taiwanese folk tales - Aunty Tigress”. We expect students can not only increase learning motivations and achievements in mathematics, but also understanding local culture by the scenario-based learning with digital game.

In order to make sure that scenario-based learning content design and learning process of virtual game are suitable for the study and the needs of the target users. This study adopted the questionnaire survey (5-point Likert scale), including two parts the feeling of using a situated digital game and views on the use of situated digital games to learn mathematics for a total of 30 questions. The 5-point Likert scale questionnaire ranges from 1 (strongly disagree) to 5 (strongly agree). Each part of the questionnaire has 13 positive questions and 2 reverse questions. Researcher invited 24 students in northern Taiwan who are the same grade with target students to interview by questionnaire. As showed in Figure 1, there are 14 males (58%) and 10 females (42%) included. All of participants are between eleven to thirteen years old.

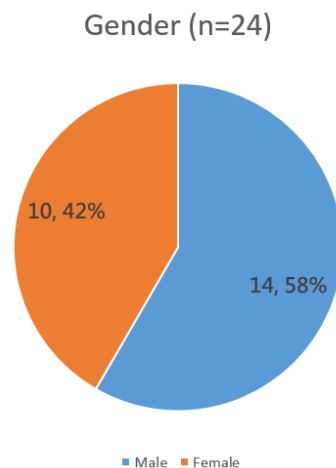


Figure 1: Gender Distribution

## Results

In the research stage of system development, we expect to design a digital game teaching that meets current student needs and preferences. we have conducted questionnaires from one elementary school in Hsinchu, Taiwan. For the following were on the questionnaire of views on the use of situated digital games to learn mathematics and the feeling of using a situated digital game to analysis. The results of this formative evaluation questionnaire will be described as follows. The overall

positive question of this questionnaire is on average 4. This shows that the students' feeling about this situational digital game and view of applying it to learn mathematics are both satisfied. In the feeling of using a situated digital game part, a total of 15 questions, including 13 positive questions and 2 reverse questions. The average of the positive questions is 3.5~4.3, and the average of the reverse questions is 1.5~2. This shows that the student is satisfied with this situated digital game, but there are still some parts that need to be adjusted. Among them, "Overall, I think it is very helpful for me to learn circle and compound graphics of circle through this situated digital game." get the highest score (4.3) of this part. In the views on the use of situated digital games to learn mathematics, a total of 15 questions, including 13 positive questions and 2 reverse questions. The average of the positive questions is 3.7~4.5, and the average of the reverse questions is 1.7~2.1. It indicates that students are positive about using this situated digital game to learn mathematics. "I feel that I can use the tablet to learn math, which makes me feel very novel" get the highest score of 4.5 in this section.

### **Conclusion and Future Study**

This research explores the impact of integrating virtual games into situated mathematics teaching, on the learning outcomes, attitudes, and analytical problem-based skills of the sixth grade students in the circle and compound graphics of circle. In order to design a digital game teaching that meets current student needs and preferences and integrates situated-learning theory, Van Hiele geometric thinking level theory and ARCS teaching mode, we conducted this survey. According to the results of this formative evaluation questionnaire, students are quite satisfied with the integration of virtual games into situated math classes. Among them, they are even more novel about the teacher's use of stories and tablets to take math classes. The game design of this study incorporates Van Hiele Geometric Thinking Level and Taiwanese folk tales - Aunty Tigress, Students focus on the learning and challenges of circle and compound graphics of circle units in a step-by-step level arrangement and interesting story scenarios. Most students agree that this situated digital game system is fun and helpful for their learning.

This research is in the stage of system development now. However, the research team will follow the result to improve the game based on students' learning requirement and preferences as well as feedback and discuss with the expert team to help students improve their learning. Looking forward to the future, this situated digital game teaching can be applied to more units or other subjects, so that technology is no longer just the object of student play, but also the best assistant for growth.

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