A Preliminary Study of the Influence of Game Types on the Learning Interests of Primary School Students in Digital Games

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Abstract: Learning is mainly based on the students' mental activities. If they can learn spontaneously, it will help increase their interest and the effectiveness of the learning. Learning through playing will make it easier for students to learn spontaneously. The balance between gameplay and education in educational games is a key issue in designing such games. Designing educational games to be less complex and more casual makes it easier to balance education and entertainment. For courses with practical operational characteristics, combining a game with a virtual and real integration experience can increase both student interest and learning effectiveness. This research develops an augmented reality app, named "Mobile Plant", which is an app developed for the primary school plant curriculum, combining games and augmented reality to enhance students' interest in learning. A questionnaire shows that the game has positive results in terms of game difficulty and absorption of content.

1. Introduction

In the context of mobile and ubiquitous learning, digital multimedia technology is also maturing. Education is no longer confined to classrooms and textbooks. Using technology to give learners timely and appropriate personal learning and understanding how to apply what they have learned will help them effectively learn and acquire knowledge [1,2].

The use of technology to assist teaching can enhance learning, both inside and outside the classroom; technology usage can increase students' interest, motivation, and participation, and can bridge the gap between learning spaces [3]. Blended learning, which combines traditional face-to-face lessons and teaching technology, gives learners the flexibility to learn based on their time and learning speed, however there are some challenges associated with this method [4]. Blended learning injected with new technology will distract students while they are learning due to the technology being overly complex [5], and it is necessary to train students on how to use online teaching materials and effectively learn autonomously [6]. These factors must be considered when developing suitable educational games in this study.

Game technology has been applied to teaching, with some studies using it to teach mathematics. Improving mathematics learning through a digital game-based learning (DGBL) system [7] with a diagnostic mechanism strategy can motivate students, effectively increase students' interest in learning mathematics, and can also reduce anxiety. In mathematics courses for lower grades, the use of competitive, adaptive, and collaborative gamified learning activities has been shown to help improve students' performance in math learning [8]. Although senior children are more exposed to games, the

learning effects of daily exposure to educational games have also been studied [9]. In a large-scale experiment, children were allowed to use a game machine for 20 minutes a day for "brain training" games. Both accuracy and calculation speed were significantly improved. For more complex arithmetic problem-solving, using the number navigation game (NNG) [10] to enrich conventional mathematics teaching can effectively improve the different types of arithmetic skills and knowledge.

In addition to applying games to math learning, in the stroke order learning of Chinese characters, computer games [11] use different colors (e.g., red) to evoke learners' memory and cognitive processes, which can help students learn the correct stroke order. In [12], a computer game was developed for primary school students to learn geography. Analysis of tests pre- and post-achievement showed that students obtained considerable learning results by participating in game-based learning environments. Using game-assisted learning in different environments will also have different effects [13]. When comparing three different learning modes, which involve playing at school integrated into a lesson, playing at home without attention at school, and playing at home with a debriefing at school, the third way of learning is the most effective, while the other two situations may not have significant effects. Games with scaffolding tools will help learners solve problems in the game and prevent them from feeling stuck and frustrated [14]. These games significantly improve academic performance and satisfaction; however, students tend to rely too much on scaffolding tools during gameplay. On the whole, the use of games in learning has a positive impact on learners' motivation and enthusiasm.

Finding the right balance between gameplay and education in educational games is an elusive problem, so a conceptual model was proposed in [15], which organized the game functions in a modular manner with different design perspectives. The model includes features from the literature that are often considered essential to produce an engaging, fun, and educational gaming experience to help educational game designers. This view is accepted in this research, whereby different games are designed based on the teaching content to assist learners, whilst analyzing the difficulty and learning effects of the games. The results can be used as a reference for educational game design.

Augmented reality (AR) can display virtual content in the real world on mobile devices (smartphones or tablets). Its applications have covered various fields, such as entertainment, exhibitions, education, and health care. AR and games can provide rich support for learning [16]. The use of AR technology in the education field provides a safe environment for dangerous hands-on learning through the use of three-dimensional technology. For abstract conceptual learning (such as chemical reactions), using AR can give students a continuous positive attitude [17] and can increase learning attention [18]. In mathematics courses, learning with AR can improve learning performance, whereby high-anxiety learners perform well in algebra and geometry, have higher self-confidence and satisfaction, and have lower anxiety [19].

There are many types of digital games, which can be classified as follows [20,21]:

1. Strategy games: Players manage or build certain units (such as cities or countries), and they can also build or destroy the facilities in the units. Players have fun by experiencing the game's operation and intended thought process. Strategy war games are also thinking games, owing to the march layout of board games. This type of game can be said to be a computer board game with interactive multimedia.
2. Adventure games: Through the plot of the story, the player explores and makes choices, interacting with the story. The process of adventure could be a journey or a task, as if the player has entered the adventure journey and interacted with the story. This type of game has a long process and requires high artistic effects.
3. Role-playing games: In these games, players play a certain role to play the game, encounter various challenges in the story or task of the game, increase their skills, and experience or change their profession as the role experience grows. These games let players feel the fun of improving their ability, which is one of the most important aspects of role-playing games (RPGs).
4. Action games: The main gameplay is character controlled, and these games can be divided into combat and non-combat games. Combat games include fighting games, shooting games, and

others. In addition to seeing other opponents and fighting, such games can also be played in cooperation or opposition if you use multiplayer games. In non-combat games, there are many platform games (such as the ones featuring the famous Super Mario), which challenge the player's immediate response and control the character through different designed scene environments to achieve the goal.

5. Sports game: This type of game is based on action as the main axis, and it is a game that develops in the direction of simulating real events or physical sensations. Its technical development direction is mainly in pursuit of realism. There is also another type of management game that allows players to control the team like a team manager.

6. Driving game: In addition to typical flying and racing games, there are other types of vehicles such as tanks and ships. There are games that develop towards authenticity, and there are also casual games that are mainly fun. In terms of the development technology of this type of game, there are different control methods for different types of vehicles which are quite different.

7. Puzzle game: Puzzle games are popular and mainstream casual games. The game process is easy, but it can provide a lot of fun for players. There are four main elements in the design of a puzzle game: panel (such as drawing), object (such as pattern), action (such as player's behavior), and victory condition.

Casual games that are easier for learners to learn, as the rules of the game are simpler, and they do not need the use of a lot of brainpower, so learners will be less distracted during study, and will not need to be trained to use teaching materials.

Therefore, in this research, less complex casual games will be used to design educational games. These games are mainly designed to be easy to learn and use, so that learners can use them without training. This game also incorporates Augmented Reality, so that learners can learn in actual fields to improve learning effectiveness.

The use of digital multimedia technology combined with modern education concepts, in a way which facilitates learning in games, raises learners' interest in learning, and lets learners have a sense of reality.

The teaching content of the educational game app developed by this research allows students to know the relevant knowledge extended by the textbook. At the end of the app, there are corresponding AR cameras and 2D animations. The app provides various 3D objects as rewards to students to encourage them to play and learn.

This app is designed in accordance with the elementary school's botanical curriculum, and different games are used to assist learners according to the teaching content. This study analyzes the effects of different game types on learners, and we also compare the effects of games and animation on learning.

2. App Architecture

This app << Mobile Plant >> is a mobile application used on smart phones. It was developed with Unity and Vuforia. The augmented reality part uses the fiducial marker as the tracking target. The content is divided into three chapters (Figure 1). The first and second chapters have different game levels. Easy-to-use gameplay can increase the student's willingness to learn. The third chapter uses animation for teaching. Along with using observation and learning to find the correct answer and get rewards, there is also a video summary and AR camera after the game, which can help learners review different plant characteristics and deepen their impressions. The function of the AR camera is to simulate the plants, fruits, and life-related objects mentioned in the app, so that students can quickly understand its structure and appearance.

Figure 1. Start menu.

2.1. Casual Games

This part of the game is designed according to different course content, using different types of casual games such as guide instruction, quiz question, detective question, and jigsaw puzzle (Figure 3, Figure 4, Figure 5, Figure 9), so that learners can learn the course content in a more interesting way.

2.2. Augmented Reality

Place the fiducial marker in the actual scene and scan the fiducial marker with the app to enable the learner to observe the 3D model of the plant in the actual scene, with animations and related data (Figure 6, Figure 7, Figure 10, Figure 11). Students can also observe the plants related to life and the leaves, flowers and fruits of different plants according to the content of the teaching materials.

3. Plant's Root, Stem, and Leaf (Chapter 1)

At the beginning, the learner selects the plant that he wants to learn (Figure 2). Take the linden tree on the textbook as an example: after entering the game level, it will guide the user to understand the plant before starting the game (Figure 3). The method of play of the root is a quiz question (Figure 4), and the method of play of the stem is a detective question (Figure 5). In the summary, on the left side there will be the appearance of the plants, and on the right side, there are extra knowledge of the plants, a summary animation (Figure 6), and an AR camera (Figure 7) for learners to use freely. The summary animation will appear in the corresponding roots, stems, and leaves to help learners review the plants they have learned about.

Figure 2. <<Mobile Plant>>Main menu of chapter 1.

Figure 3. Guide instructions.

Figure 4. Quiz question.

Figure 5. Detective question.

Figure 6. Summary animation.

Figure 7. AR camera.

4. Plant's Flower, Fruit and Seed (Chapter 2)

There are 5 kinds of fruits in this chapter in total (Figure 8). Using the black outline in the puzzle and the pieces of puzzles below, the learner can complete the puzzle and can enter the summary section (Figure 9). In the summary section, there will be a complete flower on the left. Corresponding fruits, animations (Figure 10), and AR cameras (Figure 11) on the right are available for learners to use freely. The flower structure will appear in the summary's animation to help learners review the plants they have learned. By scanning the fiducial marker, the learner can observe the fruits corresponding to each flower with a 3D model of the fruit.

Figure 8. <<Mobile Plant>>Main menu of chapter 2.

Figure 9. Jigsaw puzzle.

Figure 10. Animation.

Figure 11. AR Camera.

5. Plants and Life (Chapter 3)

This chapter provides animations for learning without games, and is divided into four parts: food, housing, education, and entertainment (Figure 12). The animations allow students to understand the relationship between plants and life from daily life, and uses augmented reality to enhance the learning experience in the actual field.

Figure 12. <<Mobile Plant>>Main menu of chapter 3.

Food: Through the process of collecting crops to making salads, learners understand that plants are closely related to diet (Figure 13).

Figure 13. Food.

Housing: Use the house as a starting point, list all the furniture related to plants and wood in the home, and attach English words to allow learners to acquire diverse knowledge (Figure 14).

Figure 14. Housing.

Education: Take the textbooks used by learners as examples, teach them to understand where the process of papermaking begins, and let students know that whether books or magazines are produced through these procedures (Figure 15).
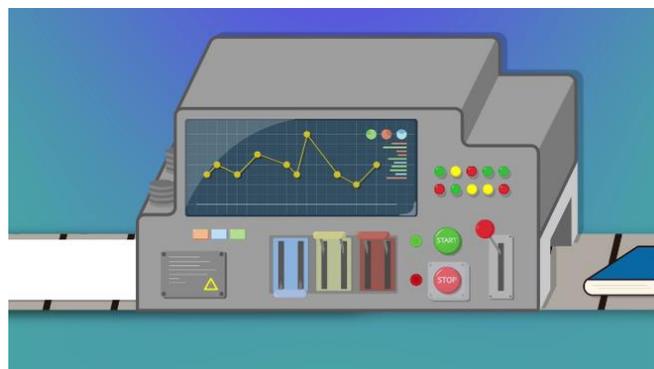

Figure 15. Education.

Entertainment: Taking early toys as examples, in addition to the current plastic and mechanical toys, plants can also be used to make a variety of toys in the past. This also teaches students forms of entertainment that were common in the past (Figure 16).
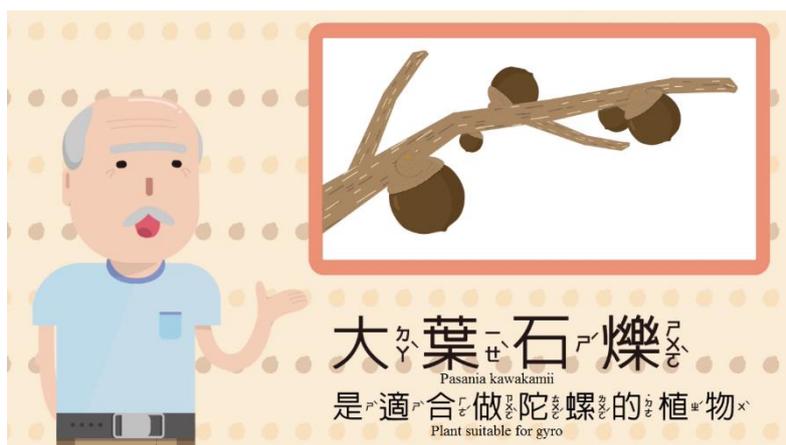
Figure 16. Entertainment.

6. Experimental Design

The experiment of this research was designed as a quasi-experiment. 129 third-grade students from three elementary schools in northern Taiwan tried this app. Before starting to use the app, the students received a brief explanation about the game's content. After playing the games in the app, a questionnaire was distributed to the students to complete, which they filled in again after watching the animation. Finally, after the app usage was over, the students were interviewed about their learning experiences.

Each chapter's feedback and analysis has been received. After the students played the games in the app, they completed a difficulty survey (Table 1) and a learning result questionnaire (Table 2). Then they watched the animation in the app and conducted a willingness survey (Table 3) and a summary survey (Table 4) to indicate the effectiveness of this app.

Table 1. Questionnaire survey results for the game difficulty.

No.	Questions	Easy	Fair	Difficult
1	How difficult was the game in Chapter 1 for you?	79%	21%	0%
2	How difficult was the game in Chapter 2 for you?	63%	37%	0%

Table 2. Questionnaire survey of the results of game learning in the app.

No.	Questions	Yes	No
1	Can you distinguish between different veins by learning from the game in Chapter 1?	91%	9%
2	Can you distinguish between different flower structures by learning from the game in Chapter 2?	81%	19%

Table 3. Questionnaire for the willingness to watch animation in the app.

No.	Questions	Yes	No
1	Do you want to see the animation in Chapter 1 again?	63%	37%
2	Do you want to see the animation in Chapter 2 again?	58%	42%
3	Do you want to see the animation in Chapter 3 again?	44%	56%

Table 4. Questionnaire survey of achievements in the app after animation learning.

No.	Questions	Yes	No
1	Does the animation in Chapter 1 let you understand the differences between different plants?	93%	7%
2	Does the animation in Chapter 2 let you know the structure of different flowers?	91%	9%
3	Learning from the animation in Chapter 3, have you learned that plants have more different uses?	95%	5%

7. Results and Discussion

In terms of the difficulty of games for students, different games have different levels of difficulties for students (Table 1), and learning outcomes are also different (Table 2). Most of the students (79%) thought the game content in Chapter 1 was simple and the learning results were good (91% students could distinguish different roots, stems, and leaves). For the jigsaw puzzle in Chapter 2, only 63% of the students felt that it was simple, and the number of students who could reach the learning goal was reduced to 81%.

Students' willingness to learn with animation can be seen from Table 3, which shows that 63% and 58% results for student willingness in Chapters 1 and 2 decreased to only 44% in Chapter 3. Because the content of Chapter 3 is relatively simple, the learning results are good, but student willingness to watch animations was found to be poor. From the field observation, because there is no game in this chapter, the willingness to watch animations was low.

When discussing the learning experience of students after playing this game, most students said that they have learned teaching content using this app, with comments such as: "Chapter 1 allows me to learn some plant knowledge, Chapter 2 allows me to learn about plant structures, and Chapter 3 taught me about the use of plants and I also learned English."," Let me know the functions of plants "," I think this app can let us know more about plants "," Learn more about the structure of plants"... and so on. A few students report that gameplay can also be improved and provided statements to this effect such as: "The games can be more fun", "I think it's just ok".

8. Conclusions

To negate the learners' feeling of boredom, in conjunction with textbooks, the additional use of mobile learning allows learners to have fun while learning, thereby increasing their willingness to learn independently.

When designing educational games, game designers need help in designing fun and educational game experience features [15]. This study examines the difficulty of different games for third grade primary school students to support early game design in game development.

In the casual games used in this research, different games have different levels of difficulty for learners, with different levels of effectiveness, and have an impact on student willingness to watch animations in this app. Guide instructions, quizzes, and detective questions in the game are easier for students to engage with and the learning effect is better, while puzzle questions are less easy for learners and less effective. In terms of watching animations, the learners' intentions are quite different, and their willingness to watch animations without games is relatively low.

These conclusions must be stated in the right context to avoid misunderstandings. It should be noted that we do not emphasize that designing educational games according to the difficulty of the game can guarantee the success of the educational games produced. The success of games also relates to factors such as content arrangement and art. Therefore, this research can help educational game designers because they can use it as a reference to consider the difficulty of their games when designing, in order to support their basic ideas in their early designs.

Designing educational games with less complicated casual games combined with augmented reality can impress learners more, and apps such as this one can help students to understand plants, flower structures, and the application of plants in life.

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