Develop and Analysis of Educational Board Game <The Golden Silk Road> on Cultural Cognition

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Abstract: This study investigated the impact of digital game-based learning on cultural cognition among upper-grade primary school students by developing a tabletop game combining augmented reality (AR) based on the theme of the Silk Road. The game aimed to enhance learning outcomes through multiple media and interdisciplinary integration, promoting multiculturalism, aesthetics education, and technological information. AR technology is used as an assisted learning tool to design game activities that enabled learners to role-play, trade, construct, and experience historical events along the Silk Road, reducing learning pressure while learning in a fun and interactive way. Results showed that <The Golden Silk Road> game activity significantly improved participants' understanding of Silk Road culture and related knowledge. The overall survey indicated that <The Golden Silk Road> could arouse students' interest, stimulate their internal motivation to learn and encourage active participation, with positive feedback from participants.

Keywords: Digital Game-Based Learning, Cultural Cognition, Augmented Reality, Tabletop Games.

1. Introduction

The 21st century emphasizes diverse learning and technology's role in transforming education. Philosopher Dewey promoted "learning by doing," advocating practical, hands-on problem-solving (Williams, 2017). Integrating education into physical board games helps students grow in knowledge, social skills, and emotions. Combining tabletop games with digital tech is a recent trend, providing information, social interaction, competition, and sensory stimulation, bridging gaps in traditional education. Augmented Reality (AR) breaks down barriers, offering a richer learning experience. This study explores "Cultural Cognition" changes in elementary students using the educational board game <The Golden Silk Road> and assesses satisfaction and feedback on incorporating AR into cultural aesthetics education board games.

2. Related work

2.1 DGBL tabletop game with AR integration

Digital game-based learning (DGBL) combines technology and games with educational learning to assist individuals in achieving ideal learning outcomes. It utilizes a reward system, visual imagery, auditory or interesting elements to attract students and immerse them in the learning process, which is a trend in modern education (Deubel, 2006). Tabletop games, combined with diverse learning fields, not only enhance learning outcomes but also help students to develop a spirit of self-initiation, independent thinking, and mutual growth (Dyson et al., 2016). With the increasing number of cases utilizing technology-assisted game-based learning, smart mobile devices, tablets, or multi-touch screens are commonly used as media. Compared to the traditional desktop computers, smart mobile devices are more lightweight, flexible, and cost-effective (Behnamnia et al., 2022). These new learning

methods deviate from traditional classroom teaching methods. Firstly, students are easily attracted to novel technologies, which arouses their interest. Secondly, the rendering power among peers and the classroom atmosphere can infect everyone's emotions, becoming a driving force. When students immerse themselves in games, their concentration naturally increases, which can improve their absorption of knowledge. These factors are considered in this study.

2.2 Silk Road Cultural Cognition

The Silk Road served as a vital transportation route connecting the East and the West, stretching from Xi'an, China to the Mediterranean coast of Europe. The diverse terrain along the route, including deserts, oases, desolate regions, and towering mountains, enriched the multiculturalism of the Silk Road. Early on, missionaries used the Silk Road to spread their faith, while in the 19th century, explorers, geographers, and archaeologists conducted a series of investigations along the Silk Road (Wood, 2002). Human commerce and business transactions were accompanied by the transmission of knowledge, ideas, religions, languages, and customs (Andrea, 2014).

Cognitive psychologist Neisser (1967) defined "cognition" as a series of processes that occur internally, including transformation, deletion, modification, addition, storage, regeneration, and application of sensory input, even in the absence of external stimuli. The result of participating in a way of life that has been passed down by a particular ethnic group or region is species-unique cultural cognition (Tomasello, 2005). Cultural cognition refers to the cognitive behaviors in two forms, external forms such as architecture, daily utensils, artistic creations, entertainment, and internal forms such as social civilization, language, norms, religion, and class, which have been formed by various ethnic groups.

The impact of the Silk Road on historical culture was profound, with trades and resources exchanges serving as mediums. This study allows players to act as the representative of a nation with the goal of promoting national prosperity and experiencing the beauty of the Silk Road.

3. Game design

3.1 Game Object

Taking into consideration the literacy and reading capabilities of upper-grade elementary students and adjusting for an appropriate level, the visual and interface design of the game <The Golden Silk Road> primarily focuses on graphics, with text serving as a supplementary element to ensure intuitive and easy differentiation. Throughout gameplay, players engage in role-playing, enabling them to witness the historical traces of cultural exchanges, fusion, and coexistence along the Silk Road. <The Golden Silk Road> features four types of game objects: (1) the Silk Road Map, (2) Civilization Map Cards, (3) Tokens, and (4) Mobile Devices.

3.1.1 Silk Road Map

Game map of <The Golden Silk Road> (as shown in Figure 1) is modeled after the ancient Silk Road, with Chang'an in the east end and Constantinople in the west end as the main representative cities. Three kinds of geological features are simulated: a) high mountains (brown), which will take two steps pre move; plains (green), which takes one step per move; and deserts (yellow), which takes one step per move and require a camel mount card. The map also lists the major cities (dark red) and small cities (blue) and sacred places (orange) that the Silk Road passed through. The four nations are represented by different colors and are divided into four territorial areas by colored lines: Chang'an area as red outline for Tang Dynasty, Dunhuang area as blue outline for Gupta, Samarkand area as yellow outline for Arab Empire, and Constantinople area as purple outline for Byzantine Empire.

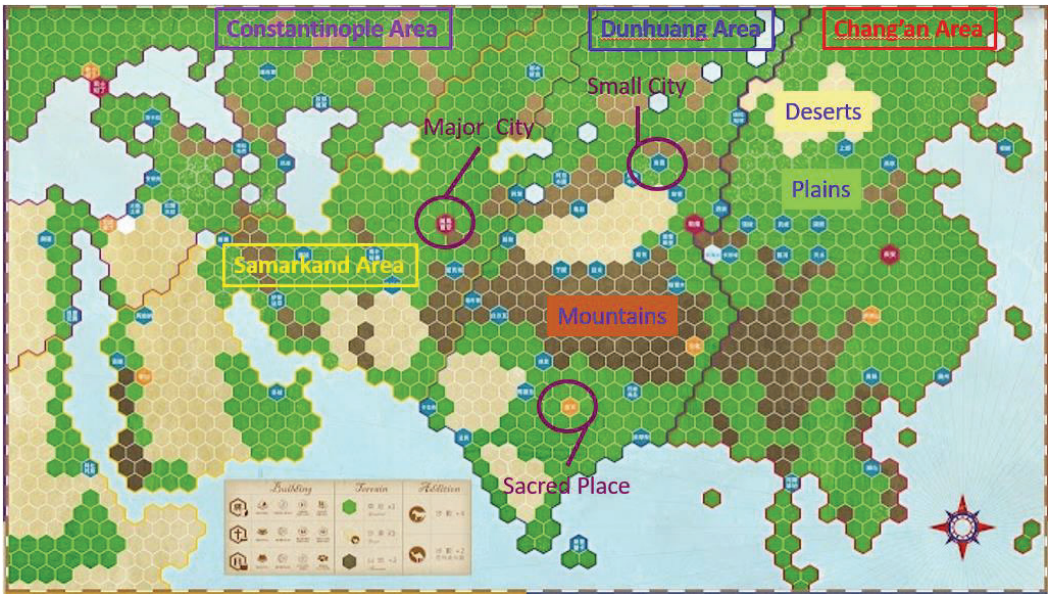

Figure 1. Map of <The Golden Silk Road>

3.1.2 Civilization Map Cards

Each nation has its own civilization card (as shown in Figure 2), which describes the country's background, mission details, and abilities, divided into three stages from left to right. After completing the missions as instructed, players can upgrade to the next dynasty and gain special abilities. Missions are divided into three categories: politics, economy, and religion. The second mission of each categories involve exchanging the obtained cultural relics from mission one with the designated nation. Once all three categories are completed, players can use the special abilities listed in the third stage of the civilization card in the next round to help them become the winner of the game.

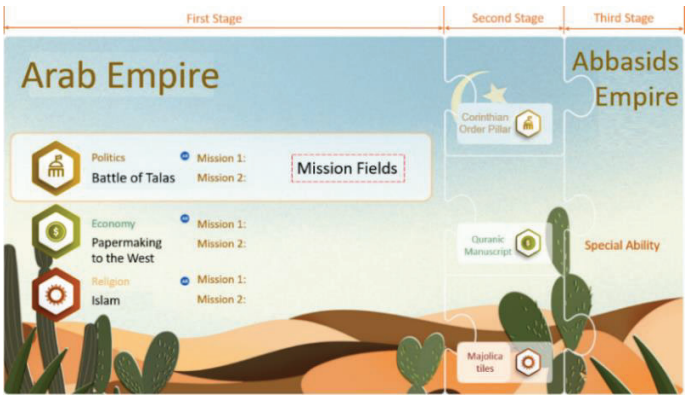

Figure 2. The Civilization Card for Arab Empire

3.1.3 Tokens

There are four types of tokens: a) pawns, b) mounts, c) local treasures, and d) buildings. a) Each nation has a pawn for Silk Road navigation. b) Mount cards are available in major cities, limited to one per nation. c) Each nation has unique regional products, distributed as local treasures at round's end, increasing in value with distance. d) Players can build Waystations, Fortresses, and Temples for their nation each round.

3.1.4 Mobile Device

<The Golden Silk Road> has incorporated augmented reality (AR) app technology to add human-computer interaction to game-based learning using the Artivive application. Artivive is

an augmented reality tool designed by a Viennese team in Austria (www.artivive.com), which can display dynamic or static information in a tablet device when scanning key surfaces, explaining which unique artifacts were produced in the local area at the moment of time and space. Players can view ancient artifacts and stories with the mobile device. The visual imagery is segmented into puzzle pieces, requiring players to adjust the tablet's angle to piece together the appearance of the artifacts, thereby increasing the fun and impact of the gameplay. When players move to a city, they can open the Artivive app and point the camera towards the city to display the corresponding information. The scanning reward (as shown in **錯誤! 找不到參照來源。**) can also be found in the displayed image, with a total of 32 scanning points included in the entire map.

3.2 Game Flow

In <The Golden Silk Road>, four to eight players represent the Tang Dynasty, the Arab Empire, the Byzantine Empire, and the Kingdom of Gupta, guided by a game master. Sessions last 60 to 90 minutes. Players collect coins through AR-aided relic exploration and missions. They choose a nation, receiving nation-specific items. Each turn, players can navigate, trade, build, or raid. Scanning cities with tablets reveals historical events, offering rewards for comprehension, combining learning with gameplay. At round's end, the game master disperses treasure tokens and coins. Participants journey along the Silk Road map, fulfilling tasks at waypoints. The game concludes after two rounds following all players' dynasty advancements. Victory is determined by total coins.

4. Research Design

This study involved 50 sixth-grade students (aged 11-12) from a Taiwanese primary school, comprising 24 males and 26 females. Data collection included pre- and post-tests, questionnaires, and interviews. The pre- and post-tests consisted of 10 questions on cultural cognition. Results were analyzed quantitatively and qualitatively. Interviews were coded as country-question number-student (e.g., AR-01-S1 for an Arab Empire student answering question 1). The test assessed Silk Road cultural knowledge with 9 multiple-choice questions and 1 matching question (split into 5 sub-questions). It covered geography, history, cultural integration, and artifact identification to evaluate learning from <The Golden Silk Road> board game. Students completed the pre-test, followed by game rules explanation and gameplay. (as shown in Figure 3).

Figure 3. Game Master leads the students to play <The Golden Silk Road>.

After the conclusion of the game, students are required to complete the post-test and the questionnaire. The questionnaire examines five factors: "Game Motivation", "Visual Interface", "Learning Knowledge", "Game Mechanism Design", and "AR design". Finally, interviews were conducted to support and explained the results of the questionnaires. Research Process is as shown in Figure 4.

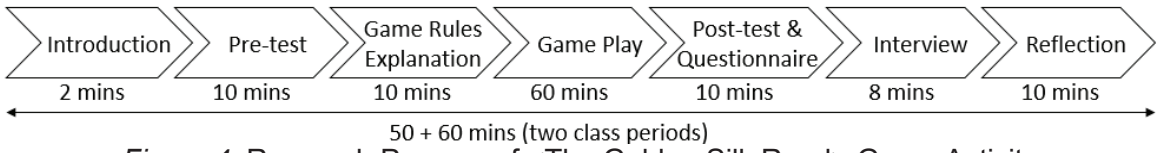

Figure 4. Research Process of <The Golden Silk Road> Game Activity

5. Result

This study investigates the effects of digital game-based learning on cultural cognition, and analyzes the differences in "Cultural Cognition" for elementary school students before and after using the educational board game <The Golden Silk Road>. A satisfaction questionnaire and group interviews were conducted after the tests to understand the students' opinions and suggestions on game design. The effective number of students is 50.

5.1 Cultural Cognition

The paired-sample t-test results of pre- and post-tests for cultural cognition were examined. Table 1 shows the overall paired t-test results of the pre-test and post-test scores of cultural cognition for 50 participants. The post-test scores were higher than the pre-test scores in average, and has a significant improvement in culture cognition. During the game process, participants would decide where buildings should be constructed for the most favorable outcome or for completing the mission, thus recognizing the geographical location relationship between different cities. The cultural integration was presented in visual images, and the use of AR technology to read artifact descriptions with artifact imaging in the game process was helpful. Participants acquired historical knowledge in the process of using AR technology and game activities, indicating their familiarity and engagement with board games. They could see artifacts and their details in the game but also experience the Silk Road's methods, and learn about the history of "Cultural Integrations". The participants stated, "Through <The Golden Silk Road>, I can learn more about the culture on the Silk Road and navigate for trading (*GU-04-S3*)." It proved that participants could learn knowledge through peer cooperation and competition in the game, simulate the situation of the Silk Road by playing roles, and enhance their learning effectiveness and motivation.

Table 1 Results of Players' Cultural Cognition of Playing <The Golden Silk Road> (QN=Numbers of Questions)

Cultural Cognition	N	Means	SD	t	p
Pre-test	50	29.08	18.121	-6.356***	.000
Post-test	50	47.92	19.111		

****p<.001*

5.2 Overall Satisfactions

According to Table 2, the overall satisfaction of the participants from both classes towards the board game <The Golden Silk Road> was reasonably high. The participants were able to learn cultural knowledge and aesthetic literacy through the game activity. The overall satisfaction of the participants were 3.99 points. This could be due to the fact that the participants are engaged with the game mechanics (M=3.58) and the integration of AR technology (M=3.99) is novelty for six grade elementary students. They also responded positively to the game: "Need to use strategy and have discussions during the game (*TA-06-S2*)" and "Using AR technology can have more interactivity (*TA-06-S2*)". Participants believed that the game had clear mission instructions and that the interface design and configuration were beautiful and attractive, which could help enhance learning motivation and interest in participating in the game (M=4.14). They also believed that the game materials were clearly and reasonably presented and could deepen their understanding of

the Silk Road culture (M=4.11). Participants stated that they would recommend it to their friends, but they thought that the game mechanism and rules were slightly complicated to understand (M=3.58).

Table 2 Overall Results of Players' Satisfactions

Aspects	Numbers of Questions	Means
Game Motivation	3	4.15
Visual Interface	3	4.14
Learning Knowledge	2	4.11
Game Mechanism Design	6	3.58
AR design	6	3.99
Overall Satisfaction	20	3.99

6. Conclusion

This study developed a physical board game infused with AR technology to enhance history, geography, and humanities education. The game featured visually appealing elements, including vibrant colors, cultural themes, and regional landscapes, making learning interactive and engaging. "The Golden Silk Road" board game was used to assess the impact on elementary students' "Cultural Cognition" and their satisfaction. The results demonstrated a significant enhancement in cultural cognition, highlighting the effectiveness of well-designed educational games in stimulating learning. Both classes averaged 14 AR interactions, indicating user-friendliness and encouraging exploration of Silk Road culture. The integration of AR with game-based learning immersed students in historical and geographical knowledge. For future game-based learning, simplifying game mechanics and rules explanations for elementary students could enhance their participation and learning experience. This study showcases the potential of combining AR technology with educational games to foster immersive learning.

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