

Research on Joint Application of Digital Media Interaction Technology and Points-Based Reward System in Digital Game-based Learning

——Take Shanghai Eagle Children's Museum as an Example

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Abstract: Digital Game-oriented Learning (DGBL) is a learning method that integrates educational content with games, which has been an innovative approach to motivate children to learn. As an informal educational institution, children's museums are the perfect application places of DGBL. DGBL contains four main features, namely objectives, participation, rules and feedbacks. Digital media interaction technology provides interesting and interactive game environment for DGBL. Points-based reward system is the feedback mechanism of DGBL, including making game rules, measuring learning outcomes and rewards. The joint application is conducive to realize the learning objectives of DGBL. Research in digital media interaction technology in museums is a relatively young field, but growing rapidly. However, there is little research on its application in children's museums, moreover, there is a lack of research on the application of DGBL and points-based reward system in children's museum. This paper firstly studies the interaction types, application practices and educational function of digital media interaction technology. Secondly, it analyzes the role of points-based reward system in stimulating children's internal learning motivation, and builds the joint application mode of digital media interaction technology and points-based reward system. Finally, it takes Shanghai Eagle Children's Museum as an example to practice the joint application mode of digital media interaction technology and points-based reward system by organizing children's experience tests and in-depth interviews. It is hoped that the theoretical and practical research of this paper can be used for reference to other children's museums, especially the children's museums to be built in future.

Keywords: Digital game-based learning; digital media interaction technology; points-based reward system; Shanghai Eagle Children's Museum.

1. Introduction

Children easily accomplish their knowledge construction in an environment filled with entertainment and games. Today's children are "digital natives", who are more and more involved in digital learning environment. DGBL, as one of the methods in game-based learning, has been an innovative approach to motivate children to learn, especially in digital age. The game-based learning is distinguished by

rules, competition, educational goals, learning objectives, learning outcomes, feedbacks, conflicts, interactions and typical stories [1]. There are four main features in a game, namely rules, objectives, voluntary participation and feedback system related to aspects in the world of education [2]. Objectives is the educational goals, including learning knowledge, improving learning abilities and physical skills. Engaging in game is an essential part of children's learning, however, children must also be willing to participate in learning process. Digital media interaction technology has become effective to encourage children to participate in DGBL because of its fun, interaction and immersion; Children more easily gain self-confidence and personal achievement through making efforts to accomplish some challenges or tasks, especially when they are rewarded after accomplishing learning targets. Points-based reward system is the game rules and feedbacks of DGBL, by setting challenging learning tasks and assigning corresponding points, making game rules on how to gain points, measuring learning outcomes and rewarding by points. The joint application of digital media interaction technology and points-based reward system is conducive to realize the learning objectives of DGBL.

The children's museum originated in the United States. According to the definition of Association of Children's Museums(ACM), the children's museum aims at education, stimulates children's curiosity and learning motivation by providing interactive exhibitions and educational projects, turning visiting museums from simple "fun" to "interesting learning experience"[3]. It can be seen that the children's museum first takes educational function as the core, and takes stimulating children's thirst for knowledge and learning motivation as the goal; Secondly, based on children's nature of learning in games, a large number of enjoyable and interactive projects are used to motivate children's learning. In fact, children's museum is the best place to practice DGBL. Digital media interaction technology can greatly improve children's participation through diversified and innovative interactive experience projects. Points-based reward system is effective to stimulate children's internal learning motivation and increase children's self-confidence and sense of achievement. There are more than 300 children's museums all over the world, however, most of them were built earlier, while the application of digital media interaction technology is just emerging, therefore, the application in children museums is still in the stage of exploration and experiment. In the developing countries represented by China, the constructions of children's museums have just started, there is a huge demand for new constructions and a wide range of digital media interaction technology application. The joint application of digital media interaction technology and points-based reward system is necessary for existing children's museums or new children's museums in the future.

Firstly, this paper studies the types, application practice and educational function of digital media interaction technology. Secondly, it analyzes the role of points-based reward system in stimulating children's internal learning motivation, and builds the joint application mode of digital media interaction technology and points-based reward system to realize the learning objectives of DGBL. Thirdly, it takes Shanghai Eagle Children's Museum as an example to practice the joint application mode.

2. Types and Educational Function of Digital Media Interaction Technology

2.1. Types and Characteristics of Digital Media Interaction Technology

Digital media interaction technology is realized by "human-computer interaction" and "virtual reality", and has timely feedbacks by capturing human's various actions and feelings [4]. It mainly includes interactive projection technology, motion sensing technology, AR technology and so on. Digital media interaction technology provides interesting and interactive game environment and has become the technology of DGBL to stimulate children's participation.

Interactive projection technology is to project a specific virtual scene on the curtain, wall or ground, so as to bring dynamic and interactive real fun experience to the plain animation. When the user's body parts (such as hands and feet, or even the whole body) enter the projection area, the system tracks and captures the occluded area of the user's body through the infrared camera, and transmits the location data of the occluded area to the system. The tracking target position information is converted into control signal to realize the interactive action feedback of the control virtual reality screen [5].

Motion sensing technology uses humans' body as the controller of human-computer interaction, including haptics technology and perception technology. Haptics interaction refers to the interaction using touchable entity input devices such as touch screens, handles or buttons; Perception technology refers to the interaction using body languages, such as visual, audio and gesture, to obtain game experience without touching any auxiliary devices [6].

AR technology is unique in that it can impose layers of virtual content including 3D digital models and 2D graphics, text, audio, and video on top of real-world objects and artefacts, providing access to normally hidden data that individuals can use to develop deeper knowledge about a content area (Tesoriero, Gullard, and Lozano 2014). Users scan the codes with mobile phone, iPads or AR glasses (e.g Google Glasses) , installed AR application, to explore hidden information.

2.2. Application Practices and Educational Function of Digital Media Interaction Technology

The development of digital media interaction technology has been a powerful tool for learning. Institutions of informal education, such as museums, especially the children's museums, are in better position to make use of different digital media interaction technology to improve educational function. For example, interactive projection technology is used in San Francisco Children's Creativity Museum. Dynamic and virtual town is projected on the wall, children can touch and interact with the virtual town, and even draw a painting and scan it, then see the painting showing in the screen. It is simple for children to participate in without wearing any devices, and cultivates their artistic imagination and practical creative ability.

Indianapolis Children's Museum has the "Take me to Greece" exhibition, which makes use of motion sensing technology. For example, children participate in the Greek Olympics running contest with virtual runners who are in the screen. Motion sensing technology enables children to interact in a simple and natural way by directing using languages or gestures, meanwhile, in some running or moving game, it greatly improves children's physical skills while they are learning knowledge.

Natasha Moorhouse, M. Claudia tom Dieck(ect) evaluates the effectiveness of the AR application as an experiential learning tool for schoolchildren in a museum of the UK. Children can see 2D and 3D avatars, text, images and audio come up after scanning the codes with iPads. AR enables them to learn the hidden knowledge and improves their imagination. From the experimental result, integrating AR could further enhance knowledge acquisition. School children are motivated to continue learning with AR in museum [7]. However, iPads are not convenient for children to bring everywhere especially for young aged children. AR glasses may be more suitable for mobile visiting, but now AR glasses on the market are too large for small heads and too fragile. They should be customized according to children's physical characters if widely used in children's museums.

According to the characteristics and application practices, interactive projection technology and motion sensing technology apply to the children museums. AR is also a strong tool for learning if AR glasses are customized for children. However, all of these are just interactive technological tools to motivate children's participation of DGBL, the core and key elements are their contents, including

learning objectives, rules and feedbacks, especially whether the contents are matches for children's learning and development.

3. Points-based Reward System and Joint Application with Digital Media Interaction Technology

3.1. Points-Based Reward System

A challenge in digital learning games is assessing children's learning outcomes and mastered abilities. In-game formative assessment can be a powerful complementary tool for capturing students' learning progress [8]. Points or levels are widely used to motivate learning and physical exercise. Sun Joo Ahn, Kyle Johnsen(ect) experimented the points-based reward systems in gamification, results suggested that it promoted children's physical activities and psychological needs in the gamified intervention [9].

Meanwhile, it is popular to use points-based reward system in digital sporty game parks. Each interactive game is assigned points, which is earned through completing the sporty game games. Each interactive equipment is installed inductor. The visitors wear Radio Frequency Identification (RFI) bracelet to recognize the inductor and start playing the sporty game games. They will earn points in the end of the games. Points-based reward system records points and shows the rank automatically through computer software. Points motivate the visitors to engage in the games and improve physical skills. To some extent, learning outcomes could be measured with points in children museum because points reveal children's knowledge gains, learning abilities and even physical skills. Points-based reward system makes rules of earning points and measures learning outcomes with points.

Efforts to increase program visibility also play an important role in delivering information and may also help boost participation [10]. Good games constantly require input from the learner and provide feedback [11]. Children more easily gain self-confidence and achievement through making efforts to accomplish the game's targeted skills, especially when they are rewarded after completing learning targets in the end of the game. Therefore, immediate reward is attractive to children, such as exclusive cultural and creative goods of the museum or other rewards.

Learning outcome measurements and rewards are the feedback of DGBL. Points-based reward system is the game rules and feedback of DGBL, by setting challenging learning tasks and assigning corresponding points, making game rules on how to gain points, measuring learning outcomes and rewarding by points.

3.2. Joint Application of Digital Media Interaction Technology and Points-based Reward System in DGBL

DGBL mainly includes learning objectives, participation, rules and feedbacks. There are four parts in the joint application of digital media interaction technology and points-based reward system in DGBL. On Figure 1, firstly, making sure what's learning objectives, which are parts of the initial design of the games so as to make children have a sense of purpose, including learning knowledges, learning abilities (e.g. observation, concentration, imagination, memory) and physical skills. Secondly, choosing digital media interaction technology (e.g. interactive projection technology, motion sensing technology, AR technology) to motivate children's participation. Each interactive game is assigned tasks and points. Children earn points through accomplishing different game tasks. Thirdly, making game rules on how to gain points, such as answering in-game questions or accomplishing tasks or doing sporty games (e.g. running, jumping, moving or other sporty games). Lastly, making the feedbacks about how to measure learning outcomes and what're rewards. In points-based reward system, learning outcome measurements and rewards both depend on points, which can also

determine and exchange gifts (e.g. exclusive cultural and creative goods of the museum) or other rewards .

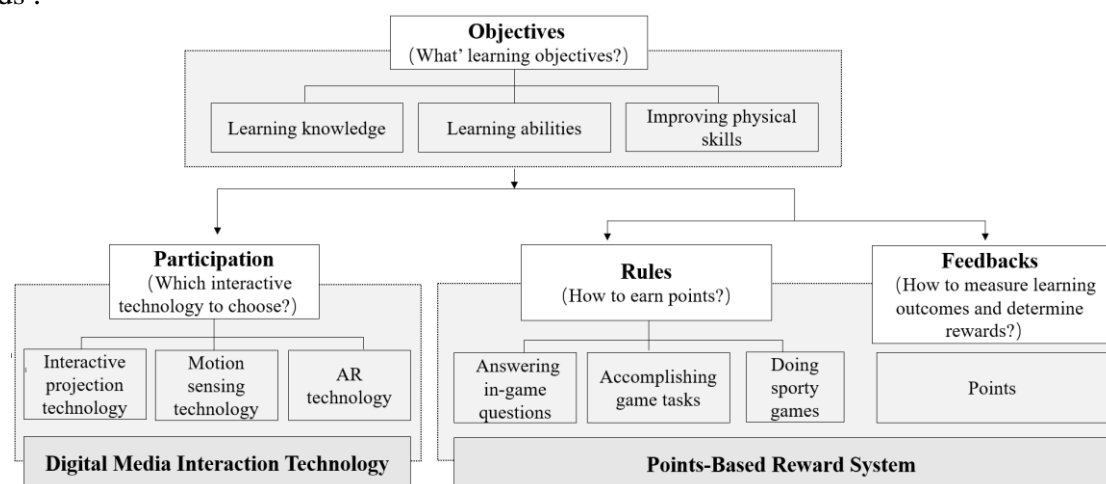


Figure 1: The joint application of digital media interaction technology and points-based reward system in DGBL.

4. Taking Shanghai Eagle Children' Museum as an Example

4.1. The Application of Digital Media Interaction Technology in Shanghai Eagle Children's Museum

Shanghai Eagle Children's Museum is under construction, including four theme halls that are astronomy hall, nature hall, science and engineering hall and life and health hall. At present, the construction of the astronomy hall has been completed. Shanghai Eagle Children's Museum takes children's education as the leading function and aligns the game with the curriculum and mainly receives primary school students. Moreover, as a private children's museum, in order to increase continued attractiveness and more revisit, Shanghai Eagle Children's Museum was guided by DGBL at the beginning of construction. It composed a R & D team of educational experts, school teachers, technical experts, game planners and took three years to design game contents and develop equipment. Digital media interaction technology and points-based reward system are joint applied to achieve educational goals and continuous operation.

The astronomy hall has 5 interactive projection games, 3 motion sensing games and 5 AR interactive games. Each game has defined learning objectives and game rules in the initial design period. Meanwhile in order to improve children's cooperation ability and competitive consciousness, and also reduce queue time, each game has at least two equipment. Then children can both play "single-game" or "multiple-game". The representative games are expressed as follows.

In the "Constellation Connecting Game", children learn different constellation shapes and train observation, concentration, imagination and memory. The game makes use of interactive projection technology. On Figure 2, children firstly carefully observe the constellation shape in the screen on the wall and remember it, then connect the stars on the ground projection area and make sure the ground constellation shape the same as the screen constellation shape. They need to connect correctly to earn the points.

In the "Eight Planets Jumping Game", children learn that different planets have different gravity and train observation, concentration, imagination, memory and practical skills. The game makes use of motion sensing technology. On Figure 3, the screen on the wall appears eight planets jumping

games in turn, children jump on the equipment and then the virtual 3D cartoon astronaut jumps synchronously and the jump height value is always shown in the screen. Children should complete the eight games to earn points. Within the games, children jump the same height on different virtual planets, they have different jump height values in the screen. Therefore, children immediately learn that different planets have different gravity and also improve physical skills through jumping.



Figure 2: Children play "Constellation Connecting Game".

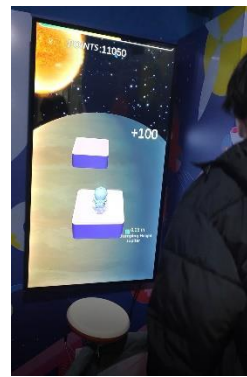


Figure 3: Children play "Eight Planets Jumping Game".

In the "Manned Rocket Factory Game", children learn the assembly process and launch process of manned rocket and train observation, concentration, imagination and memory. On Figure 4, there is a cartoon rocket factory display board on the wall, there are 5 codes on the wall which will appear corresponding 3D animation of the rocket knowledge after being scanned. For example, children wear the AR glasses and scan the code on the spacecraft illustration of the display board, On Figure 5, they will see the 3D animation of spacecraft knowledge. Children need to answer the question after watching the animation correctly to gain points. Moreover, Shanghai Eagle Children's Museum requires the AR glasses supplier to custom AR glasses according to children's physical characters in order to facilitate children's mobile visiting and wearing comfort.



Figure 4: Children wear AR glasses to play "Manned Rocket Factory Game".



Figure 5: The virtual 3D animation of spacecraft knowledge.

4.2. The Joint Application of Points-Based Reward System and Points-based Reward System in Shanghai Eagle Children's Museum

In Shanghai Eagle Children's Museum, each game is assigned points and installed inductor in order to record and accumulate points automatically. The digital media interactive equipment software is networked with the background points-based reward system. Each child member will be equipped with a watch before playing the game. There is a IC Card (Integrated Circuit Card) with unique membership number and built-in identification sensor in the watch. Children touch the inductor with the watch and then points-based reward system recognizes the membership number and then starts

the equipment. The digital media interactive equipment software records the points and unloads the points to points-based reward system in the end of the game. Points-based reward system assigns the earned points to the corresponding membership number and accumulates automatically. Within the game, children earn points through answering in-game questions or accomplishing game tasks or doing sport.

In the rewards and feedbacks of Shanghai Eagle Children's Museum, there are a lot of gift machines, where children can exchange points for blind box gifts, which are mainly exclusive cultural and creative goods of the museum.

The joint application mode of digital media interaction technology and points-based reward system in Shanghai Eagle Children's Museum, on the one hand, encourages children to participate DGBL, especially when children exchange rewards immediately. It improves children's self-confidence, sense of achievement sense of achievement and intrinsic learning motivation, and also increases the museums attraction and revisit; On the other hand, children are able to choose favorite games. Points-based reward system also records the total points of each equipment, to some extent, the total points reflect the popularity of each equipment. Therefore, the managers can use points as a basis to decide which equipment needs to be optimized or replaced in order to maximize the continued attractiveness and space utilization. Meanwhile, the renewed equipment will encourage children to visit the museum again, which is conducive to sustainable and stable operation (Figure 6).

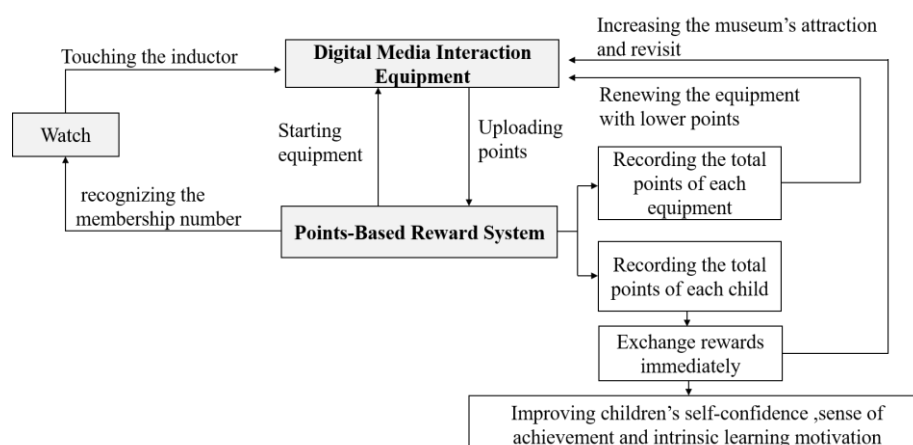


Figure 6: The joint application mode of digital media interaction technology and points-based reward system in Shanghai Eagle Children's Museum.

4.3. Experience Tests on the Effectiveness of DGBL

Affected by the epidemic situation of COVID-19 and not yet fully opened, Shanghai Eagle Children's Museum just invited 60 children aged 6-12 years (mainly primary school students) in three times to test the effectiveness in facilitating children's learning. There are 20 children each time. The children were coded from A1 to A60. There was reflective observation on the children's emotions while they were playing games and in-depth interviews in the end of the game. From the observation, the children were enjoyable to engage in the games. The majority of them even played again, because each game was just 3-5 minutes in order to improve turnover in the in actual operation.

In the in-depth interviews, questions were mapped to the four dimensions of DGBL, including learning objectives, participation, rules, feedbacks. There are four following questions included, as shown in Table 1.

Table 1: The questions of in-depth interview.

Dimensions of DGBL	Introductory questions
Learning Objectives	1.Have you learned new knowledge and improved your learning ability?
Participation	2.Do you enjoy the interactivity with the learning environment?
Rules	3.Do you like the game rules on earning points?
Feedbacks	4.Do you like the exchanged gifts?

When asked "Have you learned new knowledge and improved your learning ability?", fifty of them answered "Yes". They thoroughly enjoyed answering the questions in the games because they were able to assess the level of knowledge acquired and learning abilities. They need observation, concentration, memory and even physical skills to win the game. A10 stated "I preferred the AR games because I can learn the hidden spacecraft knowledge from the display board."

When asked "Do you enjoy the interactivity with the learning environment?", all of them said that they are motivated to explore the museum and participate the games. A3 stated "I enjoyed jumping on the virtual planets". A6 stated "It is fun to connect the stars on the ground".

When asked "Do you like the game rules on earning points?", fifty-five of them confirmed that they preferred points-based reward system, because they could gain immediate feedback through points, which can motivate them to compete with classmates. A8 stated "I want to earn more points than my classmates and get a good rank, it makes me feel a sense of achievement".

When asked "Do you like the exchanged gifts?", fifty-six of them stated that they like the gifts because they are exchanged with points through their efforts. A12 said that "I think the gift is unique and valuable for me and reveals my efforts". A9 stated that "I want to experience again so as to exchange another blind box gifts".

In summary, from the tests, the joint application of digital media interaction technology and points-based reward system in DGBL greatly improve children's participation and revisit. It is effective in facilitating children's learning and measuring learning outcomes.

5. Conclusions

DGBL is an innovative approach to motivate children to learn. Digital media interaction technology provides interesting and interactive game environment for DGBL. Points-based reward system is the rules and feedback mechanism of DGBL, including making game rules, measuring learning outcomes and determining rewards. The joint application of digital media interaction technology and points-based reward system is conducive to realize the learning objectives of DGBL. On the one hand, this paper theoretically builds the joint application mode of digital media interaction technology and points-based reward system. On the other hand, it takes Shanghai Eagle Children's Museum as an example to practice the joint application mode, which provides an interesting opportunity to capture interest, enhance motivation to learn, measure learning outcomes and provide a reason to revisit. However, there is relatively little research on the application of digital media interaction technology and points-based reward system in children's museums. With the development of digital technology and more updated or newly built of children's museums in the future, the joint application mode of digital media interaction technology and points-based reward system in children's museum is worthy of academic discussion and research. However, this study has the limitations that need to be considered in the future. Firstly, the limitation relates to a single case study approach, just taking Shanghai Eagle Children's Museum as an example; Secondly, in the experience tests of the effectiveness of DGBL, given that this study uses a limited sample (just 60 children), future studies

using a diverse sample would strengthen the research surrounding the effectiveness of DGBL in children's museums.

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