

The Effectiveness of Different Types of Digital Game-based Learning Contents on Children e-Learning - Empirical Study on The Digital Museum of Children Website

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Abstract

In recent years, many studies have proposed that the digital game based learning model can arouse learning intentions for learners, help them to retain memory longer and provide them with chances to practice and feedback to enhance learning effectiveness. Thus, this learning model is widely adopted in supported learning for K12 student groups. Many studies have also shown that the crucial key is that digital game based learning can successfully stimulate internal motives for learners and encourage them to voluntarily participate and actively engage themselves in learning. However, there are a lot of game models available to present various scenarios in diversified forms. How to effectively meet the requirements of digital learning contents for children and design games based on learning objectives is a topic worth further study. Furthermore, how children respond to different types of game-based learning contents is also very important for analyzing the effectiveness of implementing relevant learning models. Thus, based on the flow model, this study attempts to analyze previous literature pertaining to digital game-based learning; discuss three game based learning content types: video and animation, picture and text, and interactive game classified from the website of the Digital Museum of Children, National Museum of Natural Science. We further

defined consisting elements for the above three types and conduct empirical research accordingly. The study subjects are elementary school and junior high school students. The ANOVA is applied in this study to evaluate the effectiveness differences between these three types of game based learning contents. This result is then used to identify factors influencing relationships between different digital game based learning types and learning responses and effectiveness for future studies in the development of digital game based learning models.

Keywords: Game Based Learning, Type of Game Based Learning, E-Learning, Learning Satisfaction, Flow Theory

1. Introduction

As multimedia and online information have quickly developed in recent years, the concept digital learning model that incorporates game elements are emphasized and hence, various digital learning models such as edutainment, game-based learning, edumarket games and serious games are continuously introduced (Hsieh, 2009). The rationale behind such development are expectations that learning interests of learners can be stimulated via a combination of teaching activities and digital games to enhance their learning effectiveness. Among

other models, the game based learning model, based on the flow theory, will enable learners to become immersed in games and ignore all irrelevant external stimuli, acquire self-affirmation via challenges offered in the gaming process (Kiili, 2005a), and reinforce learning motives for learners to enhance their interests in learning and concentration. Some scholars also agree that the game-based learning model can help learners to change their learning style from reactive to active and proactively enrich their knowledge base in the learning process. This kind of learning model also confirms to modern learning theories – Constructivist. Therefore, since game based learning features a high level of interactivity, it should be able to enhance learning motives for children and their intention to learn and to break through their learning barriers. Its applications are more and more emphasized by researchers in the field of e-learning (Feinberg and Batson, 2006 ; Kickmeier-Rust et al., 2005). In terms of e-learning for K12 student groups, more vendors (such as Hikids and Yoyo schools) started to market products developed applying the game based learning concept. While game based learning is emphasized by scholars and product vendors, research regarding 1) influences that different types of contents exert on learners; and 2) children's responses to them are rather insufficient. Thus, this study applies the website of Digital Museum of Children, National Museum of Natural Science, Taiwan, as the study example; classifies the lessons offered in the website into three types of contents: video and animation, picture and text and interactive game to define consisting elements and control processes for each type; cross examines results from different researches to analyze whether different types of contents will lead to different responses from children. However, we hopes that the result of this study can provide directions and guidance for further studies on game-based learning.

2. Literature Review

2.1 Digital Game Based Learning

In Digital Game-based Learning, Prensky (2007) proposed that the 21st century is the century of digital game based learning and labeled children born after 1975 as Generation G (Game generation). The reason that Generation G prefers video games and the Internet is that they offer interactivity. Students today are largely different from their counterparts in previous Generations. They were born in the era of digital technologies and they speak digital languages pertaining to computer, video games and the Internet. Therefore, they are called digital natives and different from digital immigrants who were born in the non-digital era. With the emergence of Generation G and the PC, computer simulation games have become popular. Moreover, educators in the past have repeatedly emphasized the importance that gaming is a nature and necessary element in the learning process of a child and should be a part of the teaching agenda. Furthermore, gaming is able to eliminate boredom in a classroom learning process. (Prensky 2007). Many research studies have concluded that game-based learning is one of the diversified learning methods as gaming can bring enjoyment to players and deliver experiences of immersion and induced stimuli. This confirms the main element of an effective learning process and allows learners to enter a flow state, a term used in the field of psychology (Mihaly Csikszentmihalyi, 1975). For example, Prensky (2007) pointed out that most game players have this kind of experience - when they are facing challenges offered in the game and learning the process, they will have a sense of pleasure and the flow state will keep players focused on the learning process and missions assigned. Thus, a well-conceived game must include special strategies to keep players in the flow state and provide rewards when they accomplish assigned tasks. Rosas and fellow scholars have collected research related to digital game based learning and pointed out that the game-based learning is very helpful to

develop the following personal dimensions – learning and achievement, cognitive ability, study motive and learning and engagement (Rosas, Nussbaum, Cumsille, Marianov, Correa, & Flores et al., 2003). Hogle (1996) further added that game-based learning offers the following advantages:

- Stimulate intrinsic motives and interests: game characters including curiosity, expectation, control, interactivity and fantasy (story plots) will improve learning interests and internal motives for learners. To acquire a sense of accomplishment, learners are motivated to try different approaches when they face challenges and obstacles.
- Improved retention: comparing to tradition classes, simulation games offer better retention results
- Practice and feedback: many game based learning software programs provide practices that enable users to perform iterations and acquire instant feedbacks with which learners can evaluate learning effectiveness themselves to achieve learning objectives.
- Improving higher order skills: designs of computer games usually confirm to our cognitive structure. If the game design can integrate contents of learning materials and encourage learners to search for solutions in games and make their own decisions, they will be able to integrate their own learning process and find solutions in the process. The contents will be repeatedly stressed and deeply printed in the mind of learners, which is the best learning format.

2.2 Input-Process-Outcome Game Model

The flow theory, proposed by Csikszentmihalyi (1975), asserts that when people are deeply engaged in their task at hand, they will ignore irrelevant external stimuli and enter the flow state. This offers

learners the best learning experiences in the learning process and can be achieved with the game based learning model. Garris, Ahlers and Diskell (2002) claimed literature regarding educational games and proposed an Input-Process-Outcome game model to illustrate the internal transformation process of learners, when games are applied in the learning process. This model is primarily divided into three steps. The first step is the Input phase in which instructional contents and game-specific characteristics are included. In terms of learning contents, they should be designed around different topics, while relevant game characteristics (Fantasy, Rules/Goals, Sensory Stimuli, Challenge, Mystery, Control) should be considered to enrich and diversity the design to arouse the learning interests of learners. The second step is the process phase in which user judgments, system feedback and user behaviors should be considered. The third step is the outcome phase. When the game-based learning cycle ends, task reports should be debriefed and mistakes made during the gaming process should be reviewed to achieve desired learning outcomes. The game based learning model and game specific characteristics, proposed by Garris, have been empirically supported by reference design models adopted in the field of educational game design (Thomas, Schott & Kambouri, 2003).

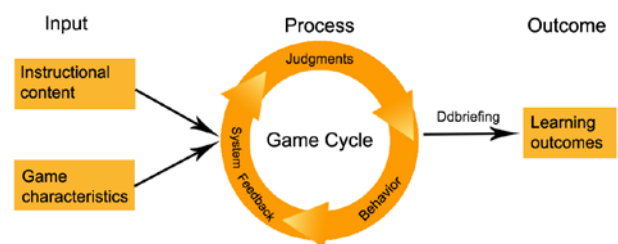


Fig. 1. Digital Game Based Learning Model (reference from Garis et al., 2002)

2.3 Relevant Research on Museum Deployment of Game Based Learning for Children

Since 1999, The Muse Awards, set up by the Media and Technology Committee,

American Association of Museums (AAM), is awarded to the winners of the digital media contest, hosted each year, to acknowledge museums featuring professional achievements and adopting revolutionary and innovative technology media. This award inspires museums to adopt new ideas and cater to new groups. The criteria include websites, podcasts, multimedia installations, interactive kiosks and cell phone audio tours. Types covered in the contest include media and function. Game is added under the function type as an evaluation criterion in 2007, and all contest participants need to present interactive games designed around four themes: education, entertainment, competition and role play. Frog Paradise from Digital Museum for Children has won the silver medal, Muse Award, in 2007. The judges indicated that this game adopts multiple forms to creatively illustrate the life of Taiwan frogs and can bring children enjoyment and cause their learning curiosity (<http://www.mediaandtechnology.org/>).

Additionally, museums in Taiwan and other countries have emphasized on children education and constructed instructional and learning web pages, as can be seen from their home pages. For example, the American Museum of Natural History has constructed Ology, (<http://www.amnh.org/ology/>) specially catered toward children, and have devised 12 major subjects: anthropology, archaeology, astronomy, biodiversity, climate change, earth, expeditions, genetics, marine biology, paleontology, water and zoology. The method Ology engages children in learning is to encourage them to gather cards that cover basic as well as advanced knowledge from experts and scientists. This card gathering activity will further lead children to identify topics they are truly interested in. The Green Trail from Boston Children's Museum (<http://www.ourgreentrail.org/>) offers various tasks. After completing them, children can accumulate points and decorate their personal lodges. Most tasks are related to environmental protection and energy conservation. Children can visit lodges that

belong to others and add them to their own favorites. The National Palace Museum has also constructed Kid's Garden (<http://www.npm.gov.tw/children/zh-tw/index.html>) and NPM e-learning (<http://elearning.npm.gov.tw/index.htm>) for children. Both sites lead children to enter the world of history and artifacts by encouraging children to navigate and discover in the interactive games and animations at both sites. As museums in Taiwan and other countries have focused a great deal on the children group, they have designed gaming and educational websites. Thus, the Digital Museum for Children was also designed along the same path to engage children. With tasks, discoveries and challenges, this site encourages children to discover common and advanced knowledge in the fields of nature science, arts and humanities.

3. Method

The website of the Digital Museum of Children, National Museum of Natural Science is chosen in this study to conduct empirical analysis on the learning performance of each type of learning content. The online content of the website is first classified into three types: interactive game, pictures and text, and video and animation, and this study utilizes one-way ANOVA to evaluate the effects that each type influences on the learning outcomes. Factors influencing the relationships between different digital game-based learning content and learning effectiveness are then identified for future studies in the field of digital game-based learning models.

3.1 Subject

The study subjects for this study are online members of the website. Through the online experience, this study conducts pretests, posttests, and questionnaires as research instruments on the study subjects over a period of four weeks. After unqualified subjects are eliminated for their missed questions and incomplete answers,

the effective sample size is 72 and their demographic profile is summarized in Table 1.

Table 1. Sample Demographics

Class Gender	Senior Class	Junior Class	Total
Male	16	24	40
Female	12	20	32
Total	28	44	72

3.2 Experimental Design

Definitions of important experimental materials and variables are described in this section.

3.2.1 Independent Variable

Content on the website of the Digital Museum of Children, National Museum of Natural Science, are categorized into three types: 1) interactive game; 2) picture and text, and 3) video and animation. These three types are independent variables in this study.

The game-based learning lessons are classified into the three types mentioned above and their design elements are elaborated below.

A. Interactive Game

In digital game-based learning, interactive games feature a stronger level of game engagement. This type is primarily based on storylines and provides learning content as feedback in the gaming process. Thus, there is no dedicated screen space to present learning content. The main design elements include: linkage between story-related games, level-based missions, and implicit learning-content or system feedback-based interactive games. Their explanations are provided below:

a. Linkage of story-related games

Composition of a series of plots and stories. They together will create an important game element – Fantasy (Prensky,

2001b). Different or related missions are interlinked along one unified story scenario.



Fig. 2. Starting with the missing mineral stones from the museum, the game is designed utilizing a series of interrelated missions including lectures on rock stratum, mineral exploration and return of mineral stones.

b. Level-based missions

The learning materials provide problems to learners on the basis of contests, challenges, obstacles and conflicts. Players need to accomplish game objectives under restrictions and rules and with provided game strategies. Learners are able to learn learning content delivered through games in the problem solving process (Prensky, 2001b).



Fig. 3. Entomic House: identify household insects from other common animals. Players can advance to other floors for challenges on other difficult insect types and their habitats after finishing the current floor.

c. Implicit learning-content or system feedback-based interactive games

Learning content is not explicitly shown onscreen but is presented in game results or system feedback. This shows the overall progress in the game that players have achieved and can solicit a high degree of emotional as well as self-content responses from learners, and the system feedback will provide instant message updates including player game status, rules, and objectives (Prensky, 2001b) .



Fig. 4. Frog Paradise: learning content is hidden inside the game. Knowledge about frogspawn and habitats is provided in the frogspawn-searching process.

B. Picture and Text

This type of learning content has onscreen space dedicated to displaying knowledge and learning content. They are presented in pure text or picture formats.

Thus, the core design element of this type is: dedicated onscreen space to present learning content and they are displayed in the form of text or picture.



Fig. 5. Lostland Mushroom Forest: present learning content within dedicated onscreen space in a task-oriented game.

C. Video and Animation

This type of learning content features not only a dedicated onscreen space for content presentation, but is also presented in the form of video and animation. Thus, the core design element of this type is: dedicated screen space and learning content are presented in the form of video and animation.

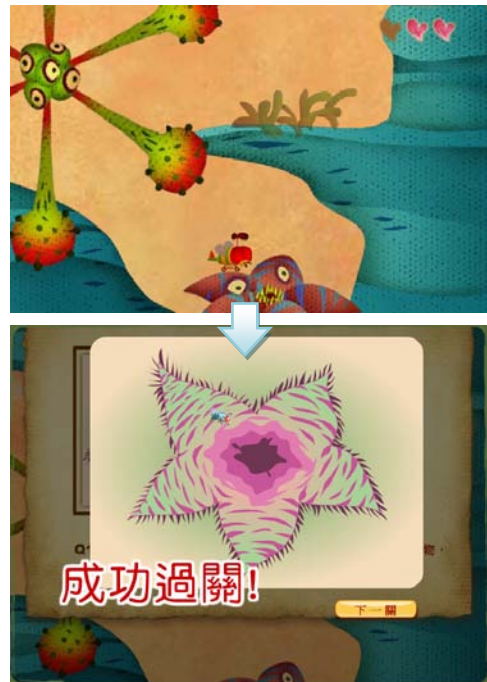


Fig. 7. Secret Garden Discovery: in this game, players will play a housefly to transfer Rafflesia pollens and the real pollination process is explained after the mission is complete.



Fig. 6. Bug Camp: learning content is presented in the form of picture and text and displayed in the middle of the interactive game.



Fig. 8. illustrate Eureptilia-related learning content with videos.

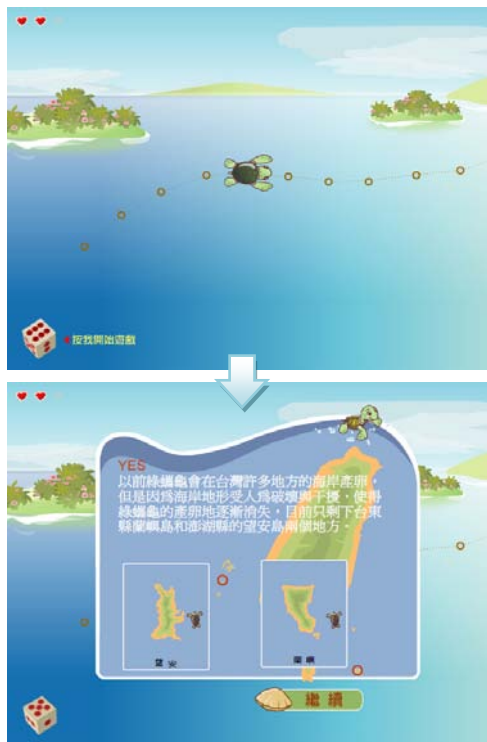


Fig. 9. the migratory routes of Green Turtles are demonstrated with videos in the gaming process.

3.2.2 Dependent Variable

There are two dependent variables in this study: learning performance and learning satisfaction.

A. Learning Performance

After online gaming experience at the Digital Museum of Children, the study subjects are tested utilizing the online challenge console. Questions offered in the console have been covered in learning content of the games and the correct answer rate will be calculated for all study subjects.

B. Learning Satisfaction

This variable measures the feelings or attitudes that the subjects measure the perceived usability about this learning exercise. The questionnaire for measuring variable is designed utilizing the five level Likert Scale and also adopts the dimensional design, proposed by Bohol Ma (2003), to measure two satisfaction dimensions – learning content and website usability. The questionnaire also collects user demographic information.

3.3 Experimental Procedure

The subjects are composed of middle class and senior class students from elementary schools, and an empirical study is conducted on them to evaluate the responses of the subjects toward these three types of learning content.

The experiment is conducted through online activities over a period of four weeks. After unqualified subjects are eliminated for missing questions and giving incomplete answers, a total of 72 students are remain as the effective sample size. The experiment procedures are described below:

Step1: first login to the website of Digital Museum of Children and freely selects desired learning topics.

Step2: utilizes the challenge console in the website to take the pretest and after which, the console will indicate which game-based

learning unit the subject should proceed to complete next.

Step3: utilizes the challenge console to take a posttest and after which, the subject will proceed to the next location pointed out by the console.

Step4: a treasure-hunting task will be assigned to the subject who can play a virtual character and will use special online tools such as free gate, unit entering point, or teleport point to move across different online scenes of the map.

Step5: after the subject arrives at the treasure chest hideout, the subject will be provided with a link inviting the subject to take the online questionnaire. After it is filled out by the subject, a souvenir certificate will be provided, as shown in Figure 10. The procedural flow of the experimental design is shown below:



Fig.10. Procedures of Experimental Design

3.4 Data Analysis

SPSS (for Windows) is adopted as the data analyzing tool in this study, and the statistical methods include descriptive statistics and one-way ANOVA. Details of each method are provided below:

3.4.1 Reliability Analysis

To assess the questionnaire reliability, Cronbach's α is utilized to evaluate all items and dimensions in the questionnaire and reliability of their internal consistency after statistics of the online questionnaire are collected.

3.4.2 Descriptive Statistic Analysis

Descriptive statistic is utilized to analyze the mean and standard deviation.

3.4.3 One-way ANOVA

Through one-way ANOVA, the significance test is conducted utilizing the pretest and posttest scores of the three groups to assess the validity. One-way ANOVA is conducted to assess the influence independent variables (interactive game, picture and text, video and animation) exert on learning performance.

4. Results and Discussion

Statistical analyses are performed on data collected after subjects complete online exercises at the website of the Digital Museum of Children. In this section, descriptive statistics, analyses of the pretest and posttest as well as the statistical results will be provided.

4.1 Descriptive Statistics

Descriptive statistics include reliability of the study sample, group divisions, online questions, and questionnaire and statistics of answers from the learning satisfactory questionnaire. They are discussed in the following sections:

4.1.1 Study Sample

72 members of the Digital Museum of

Children website are divided into three groups based on the categories of learning content – interactive game, picture and text, and video and animation. The group breakdown and size are listed in Table 2. Additionally, the satisfaction questionnaire is provided online for subjects.

Table 2. Sample Size and Group Classification

Type of Game-Based Learning Content	Group Size
Interactive Game	34
Picture and Text	16
Video and Animation	22
Total	72

4.1.2 Analysis of Questionnaire Reliability

Cronbach's α (or Confidence Coefficient) is adopted to test the internal consistency among dimensions. There are two dimensions included in the learning satisfaction questionnaire – learning content satisfaction and website usability satisfaction. Their Cronbach's α s are 0.882 and 0.930 respectively, and that statistic for the overall satisfaction questionnaire is 0.953. This shows that the levels of reliability for online questions and questionnaires are both very high.

4.1.3 Analysis of Learning Satisfaction

Adopting the five level Likert Scale, the learning satisfaction questionnaire measures the learning content and dimensions in the learning framework. The mean and standard deviation of the answers of the 72 subject s are listed in Table 3. For all items in Table 3, their means are above 4.347 and this shows the subject s are very satisfied with the learning materials offered on the Digital Museum of Children website.

As for learning content satisfaction, most subject s seem to agree that the online content from this digital game-based learning exercise is very interesting, suitable for self-learning, and successfully arouses learning interest and encourages active thinking and discovery.

As for website usability satisfaction, subjects feel the approach of role play to discover new knowledge and the use of a challenge console are very enjoyable. Moreover, the website design is very user-friendly and easy to use.

Table 3. Mean and Standard Deviation of Learning Satisfaction Dimensions

Dimension Questions	Mean	Std. Deviation
ID Learning Content Satisfaction		
1 I think the level of difficulty of learning content is about right and suitable for me to absorb new knowledge.	4.111	1.0948
2 I feel that game-based learning will make the learning process far more interesting and effective.	4.306	.9734
3 I feel the content offered at the site is related to what my school teacher has taught in class.	4.222	.9673
4 I feel knowledge offered at the website can help me to complete missions at games played.	4.347	.8746
5 I think the online content will arouse my learning interests and encourage me to actively think about and discover new knowledge.	4.208	.8296
Website Usability Satisfaction		
6 I feel the website is very easy to use and user-friendly.	4.208	1.0473
7 I feel that the challenge console can help me better understand key points taught at each learning unit .	4.264	.9493
8 I am satisfied with the layout of online pictures and texts.	4.194	.9137
9 I like the way I can play the virtual character at the website to discover the imaginary world at the six major islands.	4.291	.8950
10 The use of unit entering points and teleport points at the site will encourage me to continue my quest to the next scene.	4.291	.9991

4.2 Learning Performance

To assess the influence that these three types of digital game-based learning content

(interactive game, picture and text, and video and animation) exert on the learning outcome and identify possible factors mediating the learning process, this study utilizes the three learning content types as independent variables. Pretest and posttest scores are compared to determine if study subjects have made improvement as reflected in their scores. One-way ANOVA is adopted to confirm whether there are differences between outcomes of utilizing different learning content.

4.2.1 Statistical Analysis of Pretest and Posttest

One-way ANOVA is adopted to analyze the pretest score ($F=1.916$, $P=.155 > .05$), and the result shows that none of the three types passes the significance test, meaning that the pretest scores for each of the three groups have homogeneity.

Table 4. One-way ANOVA Analysis of Pretest Result

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3889.803	2	1834.901	1.916	.155
Within Groups	66089.183	69	957.814		
Total	69758.986	71			

Table 5 lists each of the independent variables (interactive game, picture and text, and video and animation), or the basis on which the samples are grouped, and the mean and standard deviation for pretest and posttest of each of the groups.

Table 5: Mean and Standard Deviation of Pretest and Posttest for Test Groups

Independent Variable	Pretest		Posttest		N
	Mean	Std. Deviation	Mean	Std. Deviation	
Interactive Game	60.56	30,848	69.53	29.989	34
Picture and Text	61.06	31.733	63.69	29.352	16
Video and Animation	45.23	30.536	64.09	24.882	22

4.2.2 Descriptive Statistic Analysis

One-way ANOVA is utilized in this study to test the influence that each type of digital game-based learning content exerts on the learning performance, to verify whether the sample has improved, and to assess how much they have improved. The gain scores variable is thus derived to answer the above questions. The result is shown in Table 6 – the mean of the video and animation learning content type is the highest among all three groups (mean =18.8636, or on average, 18.8636 points higher than the previous score), followed by the interactive game learning content type (mean = 8.9706, or on average, 8.9706 points higher than the previous score) and the picture and text learning content type (mean=2.6250, or on average, 2.625 points higher than the previous score).

Table 6. Analysis of Descriptive Statistics (Type1: Interactive Game; Type2: Picture and Text; Type3: Video and Animation)

Gain scores					
Type	N	Mean	Std. Deviation	Minimum	Maximum
1	34	8.9706	20.4990	-20.00	75.00
2	16	2.6250	10.7757	-25.00	25.00
3	22	18.863	20.3242	-17.00	80.00
Total	72	10.583	19.4623	-25.00	80.00

4.2.3 Test of Homogeneity Variances

The test result of homogeneity variance is shown in Table 7 ($p=.139>.05$) and it indicates that under 95% confidence interval in ANOVA, there is no homogeneity variance and hence, it is heterogeneous. Thus, the test result is statistically valid and the statistics are usable.

Table 7. Result of Homogeneity Variance Test

Gain scores			
Levene Statistic	df1	df2	Sig.
2.029	2	69	.139

4.2.4 Analyses of One-way ANOVA

Table 8 summarizes the result of one-way ANOVA analysis under 95% confidence interval for the three learning content types ($F=3.708$, $p=.030<.05$) and significant difference is observed, indicating that each of the three learning content types exerts a different level of influence on the learning outcome (score improvement).

Table 8: Result of One-way ANOVA Analysis

Gain scores					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2610.189	2	1305.094	3.708	.030
Within Groups	24283.311	69	351.932		
Total	26893.500	71			

4.2.5 Post Hoc

For post hoc, this study adopts the Scheffe's method, and the result: Type3 > Type2 (mean difference = 16.23864, $p=.037<.05$.) The mean difference passes the significance test, meaning that the video and animation learning content type is more effective than the picture and text learning content type (or the video and animation group has seen a larger score improvement; while the improvement of the picture and text group is smaller.)

Table 9. Summary of Post Hoc (Type1: Interactive Game; Type2: Picture and Text; Type3: Video and Animation)

Dependent Variable : Gain scores

Scheffe				
(I) Type	(J) Type	Mean Difference(I-J)	Std.Error	Sig.
1	2	6.34559	5.68742	.540
	3	-9.89305	5.13302	.164
2	1	-6.34559	5.68742	.540
	3	-16.23864	6.16382	.037
3	1	9.89305	5.13302	.164
	2	16.23864	6.16382	.037

*.The Mean difference is significant at the 0.05 level

5. Conclusion and Recommendation

In this empirical study, the digital game-based learning content is classified into three types: interactive game; picture and text; and video and animation. Their influence on the learning performance is examined. The result indicates that each of the types exerts a different level of influence, and among the three types, the video and animation-type learning content yields a higher level of influence on the learning performance, followed by interactive game, and then picture and text. As for the determining factors mediating the learning process, they are analyzed utilizing the four dimensions of the digital game-based learning advantages, proposed by Hogle (1996).

- The stimulate intrinsic motives and interests dimension: the interactive game type, or one that hides the learning content, and video and animation type, or one that presents learning content in a dynamic fashion, can better attract the attention of the audience and lead them into a flow state to attain the learning effect. However, the picture and text learning content type is less effective to gather attention and some audiences even directly close the window, causing disappointing learning performance.
- The improved retention dimension: the video and animation type, or one that emphasizes key points in the learning content, and the picture and text type, or one that provides details of learning content, can produce a better retention result than the interactive game type, or one that hides learning content in the game, and this type is harder for audiences to retain memories of learning content.
- The practice and feedback dimension: the interactive game type, or one that stresses repeat practice and features a highly interactive and feedback

mechanism, can better provide instant feedback in the gaming process and modify it accordingly to ensure that learning content is delivered in the game; as for the picture and text type and video and animation type, they both lack a mechanism to provide repeat practice and feedback and the audience may not effectively absorb learning content.

- The improving higher order skills dimension: all three types incorporate learning content in the gaming process and encourage the audience to solve problems and make decisions. In the process, the audience can organize their learning processes and find solutions themselves.

Based on the above analyses, this study provides the following recommendations for future studies: for the interactive game type in digital game-based learning, key points can be repeatedly stressed utilizing video or animation to retain memories; for the picture and text type, the elements of interactivity and system feedback should be included to increase the interest in learning; for the video and animation type, the options of repeat practice and interactive feedback should be considered in the game design to improve learning outcome and memory retention.

For the study limitations, this study only utilizes learning units offered on the website of the Digital Museum of Children, the National Museum of Natural Science for learning content type classification, and evaluation and effective sample size. The number of pretest and posttest questions is rather small, causing a larger gap between some statistics (ex. less number of questions to cause a larger standard deviation). In the future, the experimental design should be more complete to include such scenarios as collaborative learning when the study subjects are exposed to a gaming environment full of other online members and further emphasize the phenomenon of transfer of learning.

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