Educational Computer Games for Instructional Purposes: Current Status and Evaluative Indicators

ERIC ZHI FENG LIU and CHUN HUNG LIN
Graduate Institute of Learning & Instruction
National Central University
No. 300 Jung-da Road, Chung-Li City, Taoyuan
TAIWAN

Abstract: Although educational computer games are popular in current educational settings, few studies and policies in Taiwan have considered their evaluative indicators. Owing to this lack of evaluative indicators, teachers do not have suitable references to choose good educational computer games. This study aims to summarize educational indicators for evaluating educational computer games. We analyzed the content of educational computer games and used the Delphi method to collect expert opinion. From the results obtained, we developed a set of forty three evaluative indicators sorted into five categories.

Key-Words: Evaluative indicator, Educational computer game, Digital learning, E-learning, Human-computer interface, Delphi method

1 Introduction

In Taiwan, e-learning is being applied increasingly; this together with the Taiwanese government encouraging the integration of technology into teaching has resulted in teachers using many types of instructional media to assist learning.

The growing gaming market has accelerated the combination of different professional areas such as information technology, visual art, and education. From the discussions that are conducted on gaming bulletin boards, it is evident how much gaming is enjoyed. In addition, in recent years, more teachers have been trying to integrate educational computer games into their teaching methods to motivate learning. However, given the vast number of educational computer games available, the question is whether every one of them can improve student learning. If the answer is no, the next question is whether there exist any evaluative indicators that can help teachers or parents select games that are suitable for their students or children, respectively. Past research indicates that because there is feedback and interaction in computer-aided instruction software, students are willing to spend more time on doing tasks using these systems; they are also showing improved learning efficiency [1]. The question is what kind of feedback and interaction should be provided in an educational computer game.

Based on this background, the authors ascertained that the indicators for evaluating educational computer games are indeed very important. These evaluative indicators can not only help teachers select suitable educational computer games but also serve as a guide for game designers to design suitable educational computer games.

2 Literature Review

The elements of educational computer games include graphics, sound, human-computer interfaces, game-play, and stories [2-5]. Graphics include still images or picture effects such as 3D objects, textures, and full-motion video. Here, it is necessary to consider the match between size and style. Sounds include music and sound effects. Sounds in an educational computer game could be background music or reminders of certain consequences. Human-computer interfaces include an object and a menu system that users can click on and utilize for giving instructions. Some human-computer interface systems employ artificial intelligence technology. The main principle in designing a human-computer interface system is user-friendliness. Game-play includes providing entertainment and interactivity in an educational computer game. The main objectives of game-play are to create interesting interactions and challenges. Stories are sequences of scenarios or all the information a user can receive from an educational computer game. The purpose of designing a story is to set sequences and goals that users can experience and achieve.

2.1 Gaming and Education

Fileni [6] believed that games can help children enter a professional field and that gaming enables skill

development and learning improvement. Duffield [7] showed that educational computer games provide greater chances for students to practice and motivate them to learn. Dempsey [3, 8] pointed out that games entertain, instruct, change attitudes, and enable skill development. By designing educational computer games appropriately, efficacy in student learning can be improved.

According to Lepper and Malone [9], two strategies are available to improve student motivation when games are integrated into instructional activities. One provides intrinsic motivation, wherein instructional motivation is incorporated into games. In general, games with instructional functions usually have interesting learning environments. The other strategy provides extrinsic motivation, wherein games are used as prizes for achieving a goal. The content of extrinsically motivating games may not be related to instructional activities.

Roblyer [10] proposed that the common characteristics of educational computer games are game rules, elements of competition or challenge, and amusing or entertaining formats. These characteristics generate a set of mental and emotional expectations in students that make game-based teaching activities different from non-game ones. When designed appropriately, games can provide intrinsic motivation. Besides, students obtain added values from games, such as knowledge acquirement and entertainment. Moreover, games have an advantage over learning. For example, games can encourage students to learn a topic that they do not like initially. Moreover, when games are employed, students become willing to spend more time in solving problems. For different kinds of games, especially adventure games, different stages are helpful in the integration of knowledge and skills [2-6]. Many people would consider games to be more suitable for young students to learn new things. However, educational computer games have two types of users. One kind is the elementary school student or junior high school student. Such students can practice many skills through games. The other kind of user is the college student. In business curricula, simulation games are used for users to experience competitive business situations [2, 5].

2.2 ARCS Model

It is difficult to inspire motivation in students if games are merely enforced extrinsically. Here, the ARCS model can be applied as a strategy to consider how educational computer games can attract students. The ARCS model was proposed by Keller [11] in 1983. The letters in the acronym ARCS can be explained as follows: “A” means attention gaining; “R,” relevance; “C,” confidence building; and “S,” satisfaction. An educational computer game can be arranged according to this model to gain the attention of the student, show relations in learning materials, build student confidence toward subjects, and provide satisfaction through learning results and the learning environment.

3 Research Methodology

3.1 Content Analysis

Content analysis is also called informational analysis or documentary analysis. Content analysis developed from researches on mass communication. Initially, researchers analyzed newspapers subsequently, they began analyzing movies, TV programs, radio programs, books, and so on [12].

In this research, content analysis was used to analyze educational computer game searching on the three most famous search engines in Taiwan (Yahoo!, http://tw.yahoo.com/; Google, http://www.google.com/; Yam, http://www.yam.com/) and from computer game stores. A total of 196 educational computer games were analyzed in this research.

3.2 Delphi Method

The Delphi method is a systematic interactive forecasting method for obtain forecasts from a panel of independent experts. Carefully selected experts answer questionnaires in two or more rounds. Through specific procedures and steps, the Delphi method can be used to integrate expert opinions and finally, an agreement can be arrived at [13].

In this study, the people who were invited to serve as experts in the Delphi survey were as follows: six educational technology experts, six educational psychology experts, six game design experts, six elementary school students with at least a year’s experience in using educational computer games for learning, six junior high school students with at least a year’s experiences in using educational computer games for learning, six senior high school students with at least a year’s experience in using educational computer games for learning, and six school teachers with at least a year’s experience in using educational computer games for teaching. In the first round, the experts wrote down what evaluative indicators were

required according to them and on the basis of results and information on the content analysis of the 196 games. These opinions were analyzed and based on the analysis questionnaires for the second round were produced. In the second round, after analyzing the opinions obtained in the first round, five categories and a total of 60 items were included in the final results. In the third round, after integrating the results for the second round, five categories and 43 items were arrived at. In the fourth round, after analyzing the results for the third round, the opinions of experts were found to be consistent, and the Delphi survey was stopped.

4 Research Findings

4.1 Characteristics

In this study, 196 educational computer games were analyzed. The results showed that there are many different genres of educational computer games, puzzle games being the most common ones (Table 1). Further, pictures are the multimedia materials used most often (Table 2). Software and hardware requirements are most strongly documented for games. However, descriptions of a suitable user are not documented in some educational computer games (Table 3). Most educational computer games can provide suitable feedback (Table 4), and most of them were designed to be used in language learning (Table 5).

Table 1. Genres of educational computer games.

Genre	Amount	Order
Role-playing	17	6
Puzzle	60	1
Simulation	40	2
Action adventure	21	4
Shooting	20	5
Sports	24	3
Strategy	14	7

Table 2. Multimedia used in educational computer games.

Type	Amount	Order
Picture	196	1
Animation	120	3
Sound	168	2

Table 3. Descriptive information on educational computer games.

Type	Amount	Order
Software and hardware requirements	143	1
Description of suitable user	120	3
Information on content	168	2

Table 4. Feedback and interaction in educational computer games.

Type	Amount	Order
Providing suitable feedback	188	1
Providing status of main character	110	2
Recording user profile	60	3

Table 5. Subjects learned by users in educational computer games.

Subject	Amount	Order
Language	84	1
History	22	4
Geography	15	5
Math	35	3
Science	40	2

4.2 Evaluative Indicators

From the results of the Delphi method and content analysis, we summarized 43 indicators under five categories for evaluating educational computer games: game information, multimedia, interface design and structure, content, and feedback.

Table 6. Game information.

#	Evaluative indicator
1	Are software and hardware requirements documented?
2	Are there any descriptions of a suitable user?
3	Is related information documented in the game?
4	Is the learning subject documented in the game?

Table 7. Multimedia.

#	Evaluative indicator
1	Are pictures and animations in the game related to learning content?
2	Do multimedia materials and learning goals match well?
3	Is the game attractive?
4	Are animations used to increase user interest?
5	Are pictures, sounds, and animation arranged suitably?
6	Are pictures clear?
7	Are pictures used to increase user interest?
8	Are sound effects used to increase user interest?

Table 8. Interface design and structure.

#	Evaluative indicator
1	Is the order of the content reasonable?
2	Can a learner obtain a record for the game-play?
3	Does the game provide individual learning?
4	Does the game closely interact with the user?
5	Is the game screen clear and easy to understand?
6	Is the operation of the game easy to learn?
7	Are there any quick keys?
8	Is the design of the game screen attractive?
9	Is important information presented clearly?
10	Can a user find help in the game menu?

Table 9. Content.

#	Evaluative indicator
1	Does the story of the game match the activities of the learning content?
2	Are descriptions in the game short and easy to understand?
3	Is the content presented in a conceptual order?
4	Is any help required with difficult learning materials?
5	Are challenges in the game related to learning materials?
6	Are learning goals documented in the game?
7	Does the game context match the learning context?
8	Is the information in the game correct?
9	Is the content of the game interesting?
10	Does the game use rich media?
11	Do game resources match the game story?
12	Are pictures, animations, sounds, and language used in the game suitable for the user?

Table 10. Feedback.

#	Evaluative indicator
1	Is the feedback given timely?
2	Are hints in the game clear?
3	Is the speed of the game controlled by the user?
4	Does the game provide proper assessment?
5	Can the game report a user's current status?
6	Can the learning process be saved in the game?
7	During game-play, is there any information that shows the current situation?
8	Can a user browse the feedback history at any time?
9	Does the game allow a teacher to edit the feedback or design of the game?

5 Conclusions and Discussion

Literature reviews showed that there are some advantages of applying educational computer games in teaching and learning. Some of the advantages are attractive multimedia, interactive systems, and various contexts. Therefore, it is predicted that games will be widely applied to teaching and learning. In this research, we considered that the focus of

multimedia in educational computer games should not only be on attractive animation, sound effects, and photographs, but also on matching multimedia materials with the learning content. In addition, the interface must be user-friendly. In order to develop a more suitable educational computer game, it is necessary to arrange learning materials correctly and to have a clear goal. Recording the learning process can help track the learning profiles for teachers or students, but many educational computer games (136/196) do not support this function.

The development of educational computer games has shown a shift in focus to learning and teaching. Educational computer games create different learning styles, combining knowledge, information, and entertainment. In this study, we used content analysis to determine the characteristics of educational computer games. There are many different kinds of educational computer games with attractive visuals and sound effects. In this study, 43 evaluative indicators for educational computer games categorized into five groups were proposed. The results revealed that these evaluative indicators will provide enough information to parents or teachers for them to make a choice. The results also showed that the multimedia used in educational computer games should be arranged suitably to provide increased motivation to the student, and the content and information in the games should be accurate. The principles of instructional design and elements (e.g., the arrangement of learning content, record of learning process, and suitable feedback) should be appropriately included in educational computer games.

In the future, it will be important for game designers to develop educational computer games that are both entertaining and educational. Currently, several computer games are available. However, not all of them are suitable for learners. Teachers or schools should select good and suitable educational computer games. In this study, through content analysis and by using the Delphi method, indicators for evaluating educational computer games were developed. In order to obtain different opinions from different user groups, we recommend that more user groups be interviewed. This will promote the development of educational computer games, and provide a more complete idea of the evaluative indicators necessary for educational computer games.

Acknowledgments

The authors would like to thank the National Science Council of the Republic of China for financially supporting this research under Contract No. NSC 94-2520-S-008-007.

References

[1] D. Buttler and P. H. Winne, Feedback and self-regulated learning: A theoretical synthesis, *Review of Educational Research*, Vol.65, 1995, pp.245-281.

[2] S. M. Alessi and S. R. Trollip, *Multimedia for learning: Methods and development* (3rd ed.), Boston: Allyn and Bacon, 2001.

[3] J. V. Dempsey, B. Lucassen, L. Haynes, and M. Casey, *Instructional applications of computer games*, 1996. (ED394500)

[4] G. Howland, *Game design: The essence of computer games*, Retrieved April 2, 2003, from http://www.lupinegames.com/articles/essgames.htm, 1998.

[5] M. Prensky, *Digital game-based learning*, New York: McGraw-Hill, 2001.

[6] F. Fileni, Educational and cognitive aspects of video games, In D.Crookall, et al. (ed.), *Simulation gaming in education and training*. Oxford, England: Pengamin, 1988.

[7] J. A. Duffield, Designing computer software for problem-solving instruction, *Educational Technology Research & Development*, Vol.39, No.1, 1990, pp.52-60.

[8] J. V. Dempsey, K. Rasmusse, and B. Lucassen, *Instructional gaming: Implications for instructional technology*, 1994. (ED368345)

[9] M. R. Lepper and T. W. Malone, Intrinsic motivation and instructional effectiveness in computer-based education, In R. E. Snow, & M. J. Farr (ed.), *Aptitude, learning, and instruction: III: Cognition and affective process analysis*, NJ: Lawrence Erlbaum, 1987.

[10] M. D. Roblyer, *Integrating educational technology into teaching* (4th ed.), Merrill Prentice Hall, Columbus, Oh, 2006.

[11] J. M. Keller, Motivation design of instruction, In C. Reigeluth (ed.), Instructional design theories and models, NJ: Lawrence Erlbaum, 1983.

[12] B. Barelson, Content analysis in communication research, Glencoe, Ill: The Free Press, 1971.

[13] G. Rowe and G. Wright, The Delphi technique as a forecasting tool: Issues and analysis, *International Journal of Forecasting*, Vol.15, No.4, 1999, pp.353-375.