Learning Effect for Students with Game-based Learning on Meta-Analysis

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***Abstract*— This meta-analysis employs a theoretical framework in quantitatively synthesizing empirical studies that investigate the effects of game-based learning versus classroom instruction on the student learning effect. Analyses of 14 journal papers with 21 studies on 946 students were conducted according to how media were used to support game-based learning. The results indicate that the effect sizes for synchronous game-based learning for the students' study were consistent and significantly different from zero. The highest effect size is the learning performance (case 1), and the lowest effect size the learning outcome (case 1), although all the studies were the significance. Follow-up analysis of game-based learning findings was framed in terms of some patterns of interaction with the learning effect including learning performance, learning outcome, and knowledge test and so on.**

***Keywords*— meta-analysis, effect size, learning effect, game-based learning**

I. INTRODUCTION

A. The Importance of Digital Game for the Knowledge and Education Development

Federation of American Scientists proposed that human get the new knowledge or complex skills to strengthen the education system according to the game process and employment market in the 21st century is the country's most urgent needs [1]。Because of these potential benefits, more and more educators and instructional designers are developing and using digital games in schools, higher education, and commercial to promote the diversity of learning achievement. Modern digital games have been identified can be used as an effective teaching tools because (a)Games need to take actions to make people feel, not only static paraphrase; (b) Games can create a personal motivation and satisfaction; (c) Games can make people adapt to a variety of learning styles and methods of leadership; (d) Strengthen the skills; and (e) interact and decision-make situations [1, 2, 3]. Digital games often compete or cooperate with fellow. In the process of the competition or cooperation, it can learn how to interact with people in addition to learning to play the game skill and knowledge. Therefore, digital games can not only assisted learning knowledge and skills, but social skills are also helpful in learning.

B. Game-based Learning

Bramucci [4]stressed not because of computer games is the most popular toys, computer games should be used to learn, but computer games have become an effective learning tool. That is, the game-based learning context for students to learn in the game. As learners easily active learning and problem solving in the game's competition, it can be to improve the willingness to learn through the teaching situation. On the motivation for learning, Prensky [5] believed that caused the game to the spirit of competition and cooperation, and is fun, can be reached with the challenging. Through a digital educational games to assist teaching, it can provide students with challenging environment, and enhance imagination and fantasy of the world [7]。In creative learning, Piaget [6] supported the process of playing the game can make the children know their environment, and create a world of the imagination. In addition to entertainment, the process of playing games can also help students develop the thinking skills [8]. In the construction of the knowledge cultivation, Kafai [9] believed the game can make students to construct their own knowledge in the process of playing the game.

Above all, the study of game-based learning has a positive effect of the positive results, but some studies have a different view. Curtis [10] used a commercial game farm operator of senior secondary and adult students of teaching. The results showed on the measure of the courses and decision-making capacity, and the test results revealed that high school teaching was no significant difference between the methods. Dando & Brown [11] found that white-collar employees and non-white collar employees in the stores by the game management skills after learning there was no difference for the teaching game development and assessment in the industry. Cohen & Bradley [12] found that simulation games are no significant effect for children to learn the concept development of capacity. Darley & Katz [13] supported that children groups of the teaching children with games and free games teaching did not differ for the heart rate in the pretest and posttest. We can see the effectiveness of game-based learning is significant or not on both sides from the above literature. Analysis of the same issues tends the significant or not significant. It should summarize and clarify from the existing literature, as follow-up researchers to explore the basis of the relevant issues.

C. The Purpose

Games are a product of the multimedia and interaction. According to other various features, such as fun, competition and cooperation, the game-based learning can be applied in the course of study, and make the physical development, the

promotion of psychological, personality development and knowledge development and so on for learners. However, it also not significant learning effect of the some promotion for the game. In order to clarify these results, the research support exported by an existing game-based learning in the literature of these studies(a) What types of games should be used in teaching; (b) What subjects, courses or skills should be explored as game-based learning; (c) What factors affect the effectiveness of game-based learning and the effectiveness of the significant. In order to explore and summarize these issues, this project will extract the meta-analysis method based on the literature review, and explore the relationship between the variables. Major research project has three purposes:

- Survey of the papers, journals and research reports of empirical research of "game-based learning" in the relative education research. Analyze the cumulative cases of variables with meta-analysis method including publication years, published status, number of samples, sample status, dependent variables, the related research topics and the main results of the studies, and so on to understand the whole picture over the years, and to make this project preparation of a meta-analysis.
- For the domestic "game-based learning" research, the "game-based learning course on the game type and implementation" and all of the correlation between variables or differences proceed the meta-analysis such as the relationship between the independent and dependent variable in all the contained quantitative research with "game-based learning" in the past
- According to the results of meta-analysis, it will propose the meta-analysis model with the related factors of "game-based learning" which integrated the quantitative research in the past.

II. LITERATURE REVIEW

A. Divide the Types of Digital Games with Games Content

TABLE I. THE RELATED RESEARCH ON THE TYPES OF COMPUTER GAMES

Author	Type
Alessi & Trollip [7]	Adventure game, board, cards or gambling, logic, hands and brain, role-playing, war games
Dempsey [14]	Adventure games, playground games, board, card, diversity games, puzzle, simulation, word games
Jackson & Kalai [15]	Action, war, sports, race, flight simulation, adventure, role-playing, puzzle, concept modeling, integrated game
Gamespot [16]	Action, adventure, driving, puzzle, role playing, simulation, sports, strategy
Prensky [5]	Action, adventure, role playing, simulation, sports, strategy, puzzle and war games
Computer Gaming World	Action, adventure, role playing, simulation, sports, strategy, puzzle and war games

B. The relationship between subjects, courses, learning skills and game-based learning

The project initially found that the game-based learning has been used in a variety of disciplines in the game-based learning literature including Sociology [17], Linguistics [18], Management [19], Decision Sciences [20, 21], Ecology [20], Psychology [20], Finance and Insurance [20], Mechanical [21], Geography [22] and so on.

C. Meta-analysis and Concept of the Effect size

Meta-analysis is a method of measurement of the literature review. The aim is to present a field of study, giving further analysis. And the integration of the specific variables determines a single variable on the importance of other variables and summarizes the objective conclusions with measurement methods [23]. In this study, the meta-analysis results will be made the subject in the past to study. After synthesizing the research object, research variables, sample size, it can estimate the effectiveness with the Meta-analysis. From the literature review process, the results found that many of the past results of the study is not consistent (or consistent), some even contradictory. So, it adopts the meta-analysis to understand and clarify further, makes in depth.

Effect size means that to explore the phenomenon exists in the parent group level, or the null hypothesis is wrong [12]. In the course of the hypotheses, the null hypothesis always represents a zero effect. Even if a null hypothesis is a statement of values to a phenomenon, it still represents a zero, which is the result equals zero. When the null hypothesis is the bias, its error will be different extent which has the relationship with the degree of the effect size. Thus, the effect size represents the value of a non-zero in the parent group. The larger the effect size is the phenomenon in the research the more easy to be manifested.

III. METHOD

This project will be game-based learning literature review with Meta-analysis method. This project implements the procedures to the meta-analysis with three goal of meta-analysis Rosenthal [24]. (a) Summary the overall relationship between the two variables. It usually estimated the average between the two variables in this group of researchers. (b) Establish what associated factors is the relationship and strength between two variables. That is why the moderators are. (c) Provides a cluster for each variable data or average data in each study. These clusters or an average of data is related to each other or with other research-related features. It can test assumptions or suggest a particular hypothesis can be tested for the future design.

A. Data Sources and Inclusion / Exclusion Criteria

This project adopted the electronic database and searched as the database by the following: ABI/Inform, Compendex, Cambridge Scientific Abstracts, Canadian Research Index, Communication Abstracts, Digital Dissertations onProQuest, Dissertation Abstracts, Education Abstracts, ERIC, PsycInfo, Social SciSearch and Google Scholar。 The webs research as Google, Microsoft Academic Search, Allthe Web, and Teoma an so on. Manual search is a game-based learning from a number of journals published including British Journal of Educational Technology, Computers and Education, Computers in Entertainment, International Journal ofLearning Technology, Journal of Computer Assisted Learning, Simulation & Gaming, Simulationand Games ; the conferences

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including ACM SIGCHI, ACM SIGCOMM, ACM SIGGRAPH,ACIE, ACE, DIMEA, FDG, GDCSE, GRD, DiGRA。In addition, some early comment may also be included for the plan check on the contents of the reference list. For the key document included in the meta-analysis, each literature has been based on the following inclusion / exclusion criteria:

- Each study had to have been conducted with game-based learning which is defined on Mata analysis.
- Each study had to involve an empirical comparison of game-based learning as defined in this meta-analysis (including satellite/TV/radio broadcast + telephone/e-mail, e-mail-based correspondence, text-based correspondence + telephone, Web/audio/video-based two-way telecommunication) with face-to-face classroom instruction (including lectures, seminars, tutorials, and laboratory sessions).
- Game-based learning with some face-to-face meetings (less than 50%) was included. However, studies where electronic media were used to supplement regular face-to-face classes with the instructor physically present were excluded.
- Each study had to report measured achievement outcomes for both experimental and control groups.
- Studies with insufficient data for effect size calculations (e.g., with means but no standard deviations or no inferential statistics or no sample size) were excluded. All studies had to be publicly available or archived.
- The study had to be published or presented no earlier than 1950 and no later than 2009.
- Studies comparing students' achievement results with national standards or norms rather than using experimental or quasi-experimental designs were excluded on game-based learning.
- Outcome measures had to be the same or comparable. If the study explicitly stated that different exams were used for the experimental and control groups, the study was excluded.
- The outcome measures had to reflect individual courses rather than whole programs. Thus, programs composed of many different courses, where no opportunity existed to analyze conditions and the corresponding outcomes for individual treatments, were excluded.
- When data about a particular study were available from different sources (e.g., journal article and dissertation), although only the published source is referenced, additional data from the other source was used to make coding study features more detailed and accurate.

B. *Extract the Effect Size*

In the estimation of the effect size, this project adopts effect size [25]. When the effect size (Cohen's d) is greater than or equal to .2 as the lower value, greater than or equal to 0.5 as the medial value, greater than equal to the effect of .8 as high value. In the Mata analysis, this project also is used to carry out effective analysis of the value when exploring the difference between the two variables. Effect size is related to the effect of the degree value. The basic index for the effect size calculation is the mean of the experimental group minus the mean of the control group (traditional face-to-face instruction) divided by the pooled standard deviation:

$$d_i = \frac{\overline{Y}_{Experimental} - \overline{Y}_{Control}}{S_{pooled}} \quad (1)$$

Cohen's d was converted to Hedges' g (i.e., unbiased estimate) using Equation 2 (Hedges & Olkin, p. 81) [26]:

$$g_i \cong (1 - \frac{3}{4N - 9})d_i \quad (2)$$

IV. DATA ANALYSIS AND RESULTS

A. *Overall Effects*

In total, 14 independent findings from 21 studies representing 946 students were analyzed in this meta-analysis. On average, the students achieved similarly, whether they learned in game courses or in the traditional classrooms (g+ = 0.580; 95% CI=0.03/1.13). While there are no universally accepted standards for describing values of d in words, many researchers use Cohen's suggestions [25]: (1) a value of d of about 0.20 (one-fifth of a standard deviation) is "small," (2) a value of 0.50 (one-half of a standard deviation) is "medium," and (3) a value of 0.80 (eight-tenths of a standard deviation) is "large." Figure 1 presents the distribution of the 17 effect sizes. While CI confirms that there are no outliers in the findings, it shows a huge range of about three standard deviations from the lowest negative effect size of -0.49 favoring classroom instruction to the highest positive effect size of +2.36 favoring game-based learning instruction. The distribution also indicates that about half of the effect sizes demonstrating small to large positive effect sizes favoring game-based learning and about half showing small to large negative effect sizes favoring classroom instruction.

B. *Data Analysis*

This study summaries 17 learning effects including learning performance, knowledge test, learning outcome, Karma scores, post-test, knowledge specified, Iowa tests of basic skills, concept development test, positive affect, mission success, accuracy and posttest CMKT. According to the age of students, the experience is divided into two groups. One is the game-based learning, and other is the traditional learning in the classroom courses. The highest effect size is revealed on learning performance in case 1 ($d = 1.46$); the lowest effect size is showed on knowledge test in case 1 as Figure 1. According to Cohen's suggestions (1988)[25], the effect sizes of knowledge test (case 1), learning outcome (case 1), post-test (case 2), and concept development test are small (under 0.2); learning performance (case 2), Karma scores (case 1), post-test (case 4), and Iowa tests of basic skills are medium between 0.2 to 0.5; learning outcome (case 2), learning outcome (case 3), post-test (case 1), post-test (case 5), knowledge specified, positive affect, accuracy, and posttest CMKT are the effect sizes between 0.5 to 0.8; learning performance (case 1), knowledge test (case 2), Karma scores (case 1), post-test (case 3), and mission success are large (over 0.8). The result shows that the most of all effect sizes are over 0.2 [25]. That means the learning performance on game-based learning and traditional learning reveals the significance.

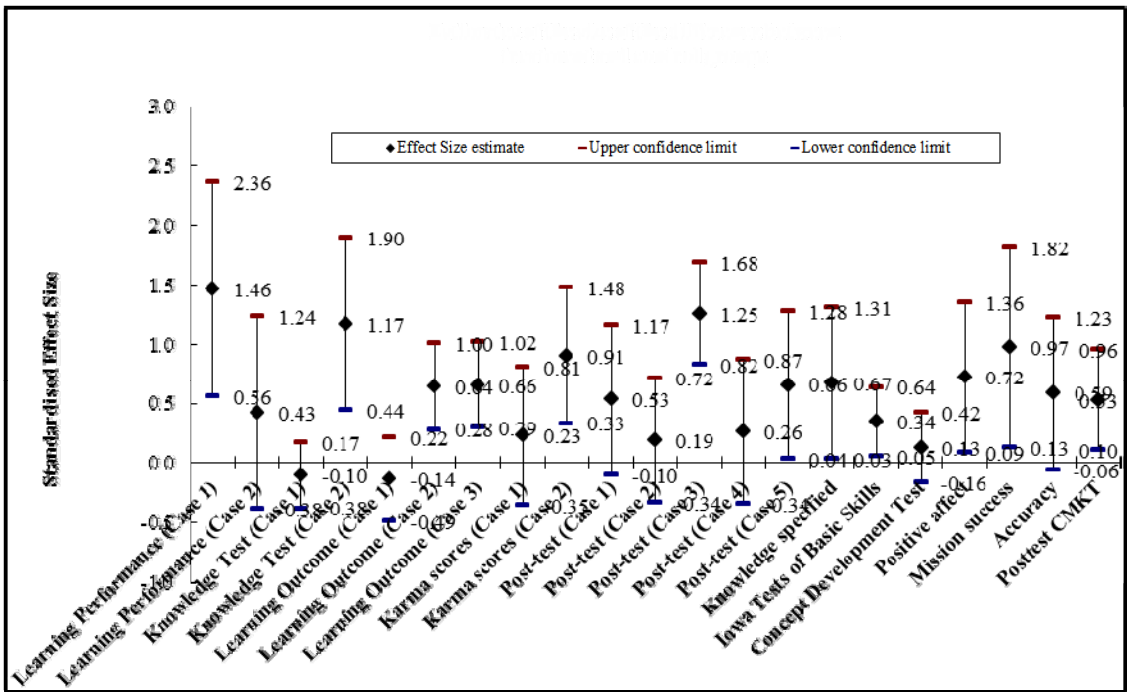

Figure 1. Estimates of the size of the difference between treatment and control groups

V. CONCLUSION

Our synthesis characterized game-based learning intervention research within the field of learning effect over the last 20 years. We identified treatments that yielded high effect sizes for the domains of learning effect. Learning difference between game-based learning and traditional learning (No game-based learning) was verified. In spite of the limitations in participant descriptions, we were also able to identify that most of all effect sizes exceed 0.5 or one-half of a standard deviation. That means students who learning with game play can obtain better learning effect than those who learning without game play. Based on the above recognitions, this article proposes future research orientations on game-based learning effect. More literatures collected and analysis will be coped with to facilitate future research.

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