

DELIVERING EFFECTIVE DIGITAL GAME-BASED LEARNING: A COMPARATIVE STUDY BETWEEN COMPUTER AND MOBILE AS THE LEARNING FRAMEWORK FOR PRESCHOOLERS

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ABSTRACT

Learning happens everywhere but where and how you learn make all the difference. With increasingly ubiquitous technology in schools, it is imperative that educational leaders must select the right device for teaching and learning. The right learning framework suitable for the student's grade level will activate their new pedagogical priorities and create their own artifacts of learning. This paper presents a comparative analysis between computer game-based learning and mobile game-based learning as the learning framework in Preschool Education in the Philippine setting when delivering effective digital game-based learning. A technical comparison was made to ascertain the implications of the selected learning medium in DGBL. The study was then evaluated based on the device assessment of the pupils covering various aspects such as availability, technical adequacy, usability, preference, enjoyment, and game repository. Another evaluation was made with regards to the learning criteria of the pupils when using a device based on the following criteria: learning objective, learning experience, learning engagement, skill scaffolding, and game storyline. Research data were collected within a city both in public and private schools using stratified random sampling. The researchers determined if there is a significant difference between computer and mobile as the learning medium of DGBL to provide a basis to educational leaders when choosing between CGBL and MGBL.

KEYWORDS

Digital Game-Based Learning (DGBL), Computer Game-Based Learning (CGBL), Mobile Game-Based Learning (MGBL), Flipped Classroom

1. INTRODUCTION

Technological tools can support a learner-centered and play-oriented early childhood curriculum and promote relationship building among children, families, and the wider community (National Association for the Education of Young Children [NAEYC], 2008). In fact, much research has been conducted throughout the world covering the effectiveness of technology integration in early childhood education particularly in supporting and encouraging the development and learning of preschool and primary age children. The use of technology opens up opportunities for kids to leverage deep learning and promote self-learning enough to warrant further exploration. Klopfer, Osterweil, Groff and Haas (2009) listed digital gaming an additional modality of teaching methods that “afford us the ability to convey concepts in new ways that would otherwise not be possible, efficient, or effective, with other instructional methods”.

In the digitized world, people expect everything to be instant and interactive. Since education is no different from the other sectors, it has its own need to adapt and modify to our transforming world in order to bridge the divide and leverage the emerging power of these new technologies and processes. Flipped classroom has been slowly replacing the traditional, lecture-formatted classroom as a mechanism of transmitting knowledge. The age of rapid e-Learning shows us that the challenges of conventional classroom-based learning faced by teachers can be stunned by games or game-based learning. The prevalence of game-based learning as a teaching approach by many educators and its entrance to the educational technology domain shaped a new, future-proof teaching technique: Digital Game-Based Learning (DGBL). Prensky (2007) dubs DGBL as “any learning on a computer or online”. Alternatively, Breuer and Bente’s (2010) own definition of DGBL is the section of serious games, which incorporates education/learning as the main or sole purpose, as can be seen in Figure 1.

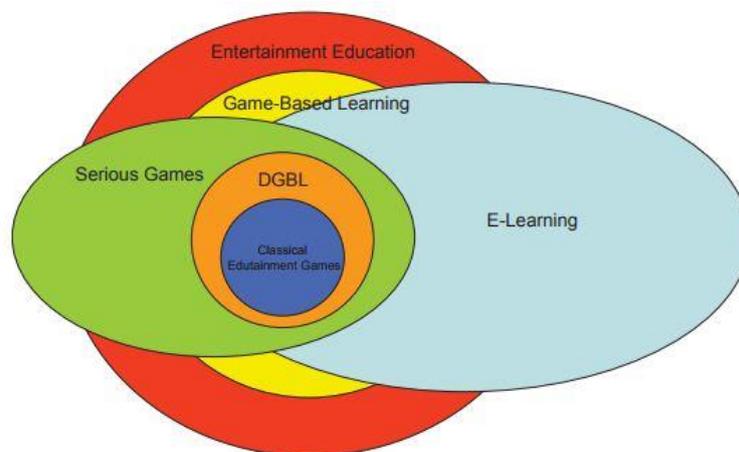


Figure 1. The Relations between DGBL and Other Educational Concepts. Reprinted from “Why So Serious? On the Relation of Serious Games and Learning” by Breuer & Bente, 2010.

Recent years have seen a marked growth in using Digital Game-Based Learning (DGBL) brought by the digital revolution which promotes digital classroom. In fact, various academic researchers published dozens of essays, mainstream books and article that documented the effect of using DGBL approach and its potent force in educational settings. The first comprehensive look at using digital games for learning was started by Prensky (2007) where he asserts that the promise of Digital Game-Based Learning is that motivation can finally be found for learning the subjects and content that are the most difficult to teach or train — either because they are extremely dull and dry or extremely complicated, or both, and to get people to train

themselves. This promise seems to have been fulfilled already as Pierce (2013) concluded that there is evidence of the benefits of specifically designed games, notably in the areas of phonological awareness, differentiating relationships, memory enhancement, coordinated motor skills, and mathematical development. This means that, according to Barab, Gresalfi and Ingram-Goble (2010), educational games are technological and methodological means for creating curricula that are immersive, interactive and experientially consequential.

To date, little research has thoroughly examined the delivery medium of DGBL especially when preschoolers are the users. While it has been attempted by many researchers (e.g. Milovanović et al., 2009; All, Castellar & Van Looy, 2014; Chen, Tseng & Hsiao, 2016) to prove that DGBL, as a new learning paradigm, is more effective than traditional instructional methods in the educational sphere, the learning platform to be used whether handheld device or computer has not yet been analyzed in terms of which is more effective if digital game-based learning, as an enhancement to teaching and learning process, will be used by primary age children.

This paper will explore the primary considerations educational leaders need to take into an account before choosing the suitable learning medium that can deliver the game-based learning approach more effectively. Customarily, the decision with regards to the choice of platform solely relies on the availability of knowledge and programming skills of the IT professional who will develop the game. While DGBL is in fact remarkably uniform, at least in terms of its expected results, choosing the learning platform in order to arrive at its set learning outcomes must be put into consideration as it can either aid or hinder the learners in successfully achieving what students should know or be able to do at the end of the DGBL delivery.

1.1. The Concept of Computer Game-Based Learning (CGBL) and Mobile Game-Based Learning (MBGL)

Play is essential to development because it contributes to the cognitive, physical, social, and emotional well-being of children and youth (Goldstein, 2012). When technology revolutionized the lifelong learning sector, it brought various pedagogic approaches that transformed the way kids play. Schrier (2016) contended the increasingly popular flipped classroom model of instruction, where students engage with a digital learning experience outside of classroom time so that collectively the class can then build on that experience during classroom time, offers possibilities for game-based learning as well. Digital revolution thereby gives birth to Digital Game-Based Learning (DGBL) which has been used as part of the flipped classroom.



Figure 2. DGBL – Common Properties

The vanishing differences between devices such as computer and mobile are noticeable in the recent years made possible by latest technologies such as HTML5 & CSS3. In fact, people can now play the same game with the device of their choice as there are various desktop and mobile game engines and frameworks (Phaser, Kiwi, etc.) at the disposal of game developers. It is different, however, when you are going to use games as an engaging teaching and learning

technique let alone when the preschoolers are the users. There are a lot of factors and theoretical requirements to be considered first. Weighing up which device best meets preschoolers digital learning needs is as important as selecting the educational game to be used by them as the chosen device will serve as their second classroom environment.

1.1.1 Computer Game-Based Learning (CGBL)

CGBL refers to the use of computers (desktop and laptop) as a key component when delivering a game-based approach in the educational environment. These computer games which are purposely developed to improve the student learning are either bought from a game software vendor then installed in a computer or by playing it in a web browser using Internet typically developed using Flash technology, Unity Web, or a Java applet.



Figure 3. Gameplay of the Super Covert Removal of Unwanted Bacteria, or S.C.R.U.B.

According to several experimental researches (Can, 2003; Mitchell & Savill-Smith, 2004), educational computer games can be used for educational purposes effectively. Numerous authors have developed their own games such as S.C.R.U.B. (Magerko et al., 2008), ECOJET (Yang et al., 2012) and Decimal Point (McLaren et al., 2017) to perform rigorous evaluations of the game and to broaden the acceptance of usage of digital game-based education.

1.1.2 Mobile Game-Based Learning (MGBL)

MGBL is considered to be the ability to use mobile devices (smartphone or tablet) to support teaching and learning through the use of applications that can be installed in it. Valk, Rashid & Elder (2010) indicated that mobiles can support the great amount of learning that occurs during the many activities of everyday life, learning that occurs spontaneously in impromptu settings outside of the classroom and outside of the usual environment of home and office.



Figure 4. Game Intro of Pitch Paradise: A Mobile Game as an Educational Tool for Music

Several local and foreign authors have created prototype and implemented games as pedagogical device such as Pitch Paradise (Respino et al., 2011), Word Infection (Red et al., 2013), HiStorya (Nisperos et al., 2014), Larong Pinoy (Autriz et al., 2016) and The MOBO City (Fotouhi-Ghazvini et al., 2009), ARTournament (Froschauer et al., 2012), Treasure-HIT (Kohen-Vacs et al., 2012), Volcanic Riddles (Katmada et al., 2014), respectively, to investigate its impact to the students and validate its role in the field of education. Consequently, the development of these mobile learning games (Shiratuddin & Zaibon, 2010) furnish us with ideas, features, functionality, game plan, storyline and content suitable for development.

2. OBJECTIVES

The purpose of this study was to compare computer and mobile as the delivery medium of digital game-based learning on preschoolers.

The specific questions investigated in the study were as follows:

1. Scrutinize the technical aspects of computer and mobile to ascertain the implications of the selected device in delivering digital game-based learning;
2. Administer a device assessment to the preschoolers using various criterion to establish the basis of choosing the appropriate device for digital game-based learning;
3. Determine the significant difference between computer game-based learning and mobile game-based learning when used as a teaching and learning tool; and
4. Provide a basis to educational leaders and game developers with regards to the device that should be used as a learning framework in the integration of DGBL.

3. KEY DIFFERENCES BETWEEN COMPUTER AND MOBILE AND ITS IMPLICATION TO THE DGBL DELIVERY

By making a differentiation between computer and mobile in terms of the factors that makes it different to one another, educational leaders can make the correct choice about which device is the best for the preschoolers because its implications to the DGBL are evident.

Table 1. Technical Comparison of Mobile and Computer

Variables	Mobile	Computer
Screen Size	Not Recommended	Recommended
Power	Not Recommended	Recommended
Hardware Components	Recommended	Not Recommended
Processor	Not Recommended	Recommended

Storage	Not Recommended	Recommended
Connectivity	Not Recommended	Recommended
Game Repository	Recommended	Recommended
Safety	Recommended	Recommended
Portability	Recommended	Not Recommended

Table 1 shows the recommended device based from the variables used such as screen size, power, portability, processor, storage, connectivity, and game repository. Computer is recommended in 8 out of 10 variables while mobile got 4 out of 10 variables. The discussion below will examine the basis of the variable recommendation results.

One of the most conspicuous difference between computer and mobile is the screen size whereas mobile screen is smaller than computer monitor. This formal feature of media influences audience's viewing experience, in fact, larger screen display can lead to higher emotional arousal (Lombard, Reich, Grabe, Bracken, & Ditton, 2000) and memory (Detenber & Reeves, 1996). When younger kids are your users, device with small screen tends to be a poor platform mainly because they have yet to develop full motor skills resulting to difficulty in performing delicate movements or targeting small objects. When buttons are hard to hit and result of action upon clicking it is not presented responsive enough, it may result to clicking a different button than the one they intended. This situation can also lead to rapidly pressing of the button multiple times in hope to find the interactive object, or worse, cause frustration.

Power should also be taken into consideration if we are to provide a good analysis between computer and mobile. Computer has its own power supply while mobile runs on batteries. With this, the usage time of the device could be an issue. Children between the ages of 4 and 10 spend an average of almost 2 hours a day playing computer games (Sălceanua, 2014). The average number of hours spent playing games is not a problem if the device to be used is a computer; it is a different thing, however, if it is on mobile. Battery would not be an issue if a kid is to play a game for two hours straight since a mobile phone could last a day if it is barely used. If the time spent playing games is, however, to be accumulated for the whole day, bring it to school and/or combined it with Internet usage and other mobile phone's features like listening to music or watching video, then power can be a factor when selecting the right device.

Another important aspect that should be considered as well is the hardware components. While a vast majority of gamers particularly adults prefer to use a mouse and a keyboard combined with other gaming accessories such as flight system, racing wheel, etc. especially with complex games, a touch-based input is easier to learn to use for younger users as it allows them to manipulate the device straightforwardly. A "less is more" approach is mandatory for preschoolers since it would be hard for beginners to control the mouse and use a keyboard at the same time. Additionally, keyboard is useless at this stage as the majority of children ages 3-6 are not equipped yet with the knowledge of forming words through letters and reading skills to understand what they are typing and/or reading on the screen. If children can easily manipulate the device on their own, it can help establish and make self-directed learning more accessible.

One more key difference is the processor. Mobile devices generally have much less processing power than desktop computers. Albeit mobile CPU designs provided substantial performance improvements generation-after-generation by rapidly adopting desktop level design techniques at an unprecedented pace (Halpern, Zhu & Reddi, 2016), it can't offer a comparable performance to PC processors, yet. In a nutshell, poor processor means poor gaming performance, hence, device with good processor is recommended. Gamers, and that include young children, are at risk of becoming more impulsive when they are irritated with slow and laggy device. This can pose an important question of the deleterious impact on children.

Storage is a key part of a device as well; in fact, the amount of internal storage space influences the decision to buy one device over another. Computer hard drive capacities already exceeded one terabyte (TB) while most smartphones and tablets come with between 8 GB and 128 GB of built-in storage. Consequently, mobile will offer less storage capacity than a computer and this would be an issue if a child wants to have many games in the device especially now that the average game download sizes are on the rise. Device with small storage capacity won't be able to accommodate many games, hence, limiting the game options by the preschoolers.

Connectivity can also be a factor when delivering game based learning. Computers generally come with Ethernet capability while smartphones and tablets can connect to Wi-Fi networks. Internet access is needed in order to download and install a game (for mobile) or play a flash game online (for computer). If a game requires a continuous Internet connection in order to play, the type of connection whether it is wired or wireless can make a difference. Using physical cables to transfer data between devices and computer systems can generally maintain a faster internet speed. When it comes to playing online games or games that partially require an online connectivity, faster connection can only mean comfortable gaming performance.

Lastly, the game repository must also be deliberated. While there are lots of educational games (both free and paid) which can be downloaded from Apple App Store, Google Play Store and other mobile app markets to be played in mobile devices like smartphones and tablet PCs, there is also a numerous of web games that have usually been developed with Flash technology and downloadable games. The game repository is considered as a variable since it will provide game options for children to allow them to play other games to continuously arouse their interest and learning adventure since most kids do not stick to a single game for long. Generally, both platform has lots of games at their disposal, however, the games that can be played on a web browser might not be available in a mobile app store, and vice versa.

When it comes to parental apprehensions, safety is one of the most common issues. Parents are normally concerned with the risks of surfing the web as kids can inadvertently stumble onto website that is violent, sexual, or just plain disturbing in nature. Child-safe browsers that allows parents block inappropriate sites in many categories, among other things, must be subject to parent-imposed limitation in order to provide safer internet surfing environment. In computers, there are full-scale parental utilities like Net Nanny, Qustodio and Salfeld Child Control as well as browser extensions that work as a web content filtering tool. On the other hand, numerous mobile applications such as Kidslox, Ourpact and Kurbi can also be downloaded and installed in a mobile device that strengthen parental control as it allows parents to manage screen time allowance, block applications and websites, and also filter the web contents.

Learning anywhere and anytime is one of the learning goals of DGBL, hence, the importance of portability aspect despite the fact that loss of physical device is a common scenario when kids are the users. Since mobile is lightweight by design and can fit in a pocket, it can be taken everywhere – the very definition of portability. On the other hand, computer especially desktop computers are not usually considered portable unless a laptop computer will be used. Therefore, mobile is recommended as compare to computer when portability is the subject.

To summarize, computer seems to be the recommended choice for preschoolers compared to mobile based from the variables used as discussed above even though mobile devices become more capable and more powerful than the generation preceding it. While it is the recommended choice, it doesn't guarantee that it's the suitable learning medium for preschoolers.

4. SUPER WHY! – A SERIES OF EDUCATIONAL GAMES

To assess the effectiveness of the learning mediums, the researchers scoured the Internet to find an educational game suitable for children ages from 3 to 6 that can be played both for mobile and computer. After an extensive and rigorous search, the only game that matched the criteria is Super Why! – a series of educational games that makes reading an empowering adventure while having fun identifying letters, practicing letter sounds and making words.

The games were derived from the animated television series entitled Super Why! that tells the story of Whyatt Beanstalk (also known as Super Why), the leader of the group of characters who become the "Super Readers", and their Super Story Adventures where they encounter obstacles which can only be solved by applying their literacy skills.

Table 2. List of Super Why! Games for Mobile and Computer

Computer	Mobile
Super Why! Phonics Fair	Super Celebrations: Cake Maker
Super Why! App	Super Celebrations: Super Duper DJ
Super Why! Power to Read	Super Why Saves The Day
Super Why! ABC Adventures	Princess Presto's Spectacular Spelling Play

As can be seen on the Table 2 above, there are lots of Super Why! games that can be played by children excluding unofficial games both computer games and mobile applications created by other developers inspired by the Super Why TV series. All of these games have the same educational goal which is to help children ages from 3 to 6 with the critical skills such as alphabet skills, word families, spelling, comprehension and vocabulary they are going to need in order to learn to read as recommended by the National Reading Panel. Games, regardless of the platform, usually have the same design and user interface as can be seen on Figure 5.



Figure 5. Super Why Gameplay in Computer and Mobile

5. RESEARCH DESIGN AND METHODOLOGY

A comparative research approach has been applied in this research study. To understand how preschoolers perceive a game depending on the device used, Super Why! games were used. The target population of this study was preschoolers from Valenzuela City whose total was 10,418 both public and private schools at the time of the study. The valid sample size is 371 using 0.05 as the margin of error with 95% confidence level.

Table 3. Total Number of Schools and Population of Preschoolers per District

District	Number of Schools	Preschoolers Population
North District	12	2,051
South District	8	1,369
East District	13	3,464
Central District	12	3,534
Total	41	10,418

The schools in the Division of City Schools – Valenzuela is divided into four districts as can be seen on Table 3. The four districts are North District with 12 elementary schools and 2,051 preschoolers (19.69%), South District with 8 elementary schools and 1,369 preschoolers (13.14%), East District with 13 elementary schools and 3,464 preschoolers (33.25%) and Central District with 12 elementary schools and 3,534 preschoolers (33.92%).

Table 4. Proportionate Stratified Sampling Determining Sample Size

Strata	Population		Sample Size
	Size	Stratum Weight	
North District	2,051	19.69%	73
South District	1,369	13.14%	49
East District	3,464	33.25%	123
Central District	3,534	33.92%	126
Total	10,418	100%	371

To determine the sample size of the population, a stratified random sampling procedure was used. As can be seen on Table 4, the chosen sample for study is composed of 73 preschoolers from the North District, 49 preschoolers from the South District, 123 preschoolers from the East District and 126 preschoolers from the Central District using 371 as the valid sample size.

The questionnaires were administered directly to the chosen sample with the help of the respective preschool teacher per class resulting to an efficient and faster data gathering. The questionnaire was divided into two sections. Section A was on device assessment where they chose between four devices such as computer, laptop, smartphones and tablet PC (Computer and Laptop = Computer, Smartphone and Tablet PC = Mobile) and Section B was on game assessment using either computer or mobile. Section A was administered right away while Section B was done after the students played the Super Why! games; one mobile game and one computer game which are the same game in a sense yet different in terms of the way they were designed depending on the device used. The age of the respondents which normally ranges from 3 to 6 was considered in the creation of the questionnaire, hence, the instruction of coloring their answers using crayon was made to make the survey fun and suitable for children.

6. RESULTS AND DISCUSSIONS

The research was conducted to determine the effects in learning precipitated by the device used when incorporating digital game-based learning in the reinforcement of the teaching and learning process within the elementary schools of Valenzuela City. When it comes to technical

aspects, computer seems to be the recommended choice; however, mobile devices are quickly becoming the preferred media choice for children since it is considered as a kid-friendly device.

Table 5. Results of Device Assessment Survey

Variable	Computer		Mobile		Both		None	
	F	%	f	%	f	%	f	%
Availability	0	0.00	228	61.46	138	37.20	5	1.35
Technical Adequacy	24	6.47	203	54.72	129	34.77	15	4.04
Usability	1	0.27	228	61.46	139	37.47	3	0.81
Preference	2	0.54	164	44.20	205	55.26	0	0.00
Enjoyment	1	0.27	170	45.82	200	53.91	0	0.00
Game Repository	1	0.27	166	44.74	203	54.72	1	0.27

It is presented on the Table 5 the results of the assessment of the preschoolers with regards to the device used when playing games in terms of various variables.

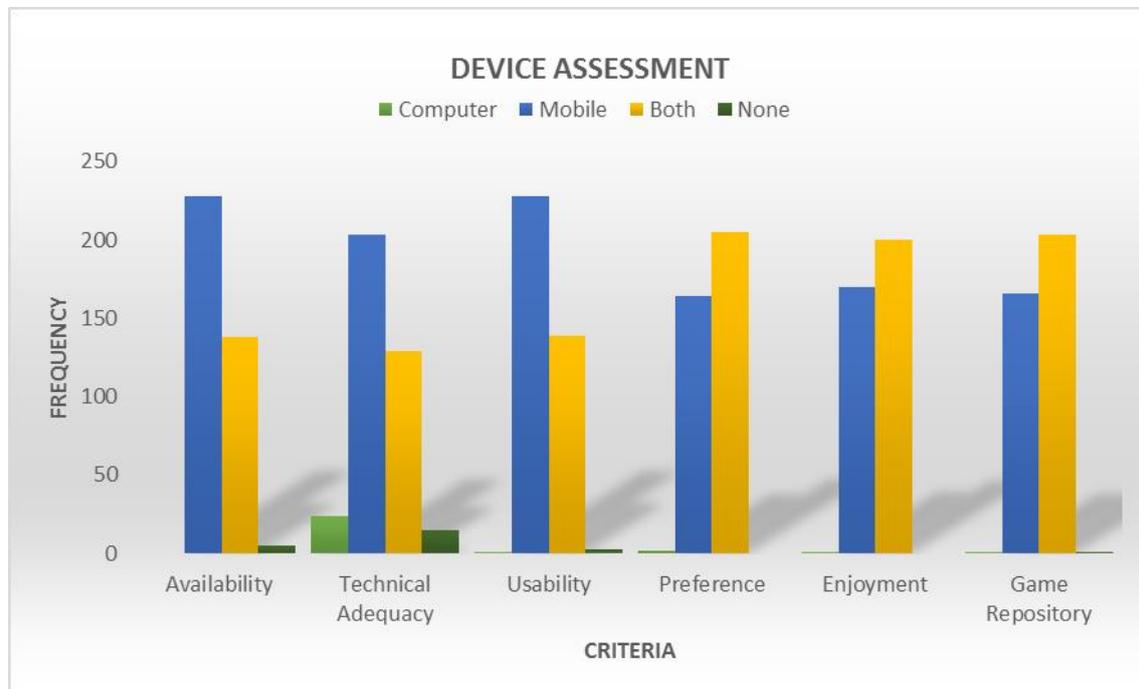


Figure 6. Device Assessment Results

To further comprehend the results shown on Table 5, figure 6 is presented wherein it clearly shows the choice of the preschoolers in terms of the learning device.

Table 6. Results of Game Assessment Survey and Chi-Square Test

Criteria	Computer		Mobile		Asymp. Sig. (2-sided)
	F	%	F	%	
Learning Objective	133	35.8	238	64.2	.000
Learning Experience	101	27.2	270	72.8	.000
Learning Engagement	45	12.1	326	87.9	.000
Skill Scaffolding	78	21.0	293	79.0	.000
Game Storyline	85	22.9	286	77.1	.000

Table 6 shows the result of the game assessment and chi-square test between the devices used in every criterion. From the result analysis, there is clearly a significant difference between computer and mobile in learning objective, learning experience, learning engagement, skill scaffolding and game storyline using the margin of error of 0.05. Evaluating Super Why! games in both mobile and computer provided insight into how preschoolers respond to the criteria. It is evident from the results that preschoolers can enhance their reading comprehension, which is the learning objective of the game, using mobile as compare to computer. Also, the mobile game provides multiple experiences to enhance learning and skills as compare to the computer game. Preschoolers were engaged more in the mobile version in terms of learning environment of the game as it offers an ideal mix of fun and challenging material than the computer version. Moreover, the skill scaffolding of the students was easily manifested when mobile, instead of computer, was the device used as they were able to play the game easily. Lastly, preschoolers appreciated the storyline of the game when they were using mobile as compare to computer even though they are playing the same game. Overall, preschoolers responded well to the use of mobile instead of computer when playing a game.

6. CONCLUSIONS AND FUTURE WORK

The study clearly revealed that mobile is an effective medium when game-based learning is chosen to be the promoter of curricular knowledge. Compared to computer-based learning, mobile game-based learning offers more learning opportunities for preschoolers since they appreciated it more in terms of the game learning objective, learning experience, learning engagement, skill scaffolding and game storyline. This finding is consistent with another study from digital learning discussion setting which have reported by (Lee, 2015) that “mobile phone-based discussion offers more valuable learning opportunities in aspects of self-directed learning outcome and immersion of the learning process than the computer-based web learning.”

This study has some limitations which have to be pointed out. The data were derived from preschoolers from various elementary schools in Valenzuela City. It is possible that the findings of this study are not generalizable. Future studies conducted in other cities or countries might address this issue. Also, the game assessment focused only on the Language subject which is why it is suggested for future research to test the findings of this study by using other preschool subjects depending on the curriculum. In the near future, the researchers would like to conduct an experimental study using a two-arm parallel design randomized controlled trial which will consist of pre-intervention, intervention, and post-intervention using a customized game.

In conclusion, this study suggested that mobile is a more suitable and effective framework than computer when delivering game-based learning for preschoolers. Educational leaders can use the findings of this study as a basis when choosing between computer game-based learning and mobile game-based learning. Instead of relying on the programming skills of the game developer, the medium to be used must be considered first as it was statistically proven by this study that there is a significant difference in terms of the device used in DGBL. While computer is the recommended device in terms of technical aspects with respect to the implications of the selected device, mobile is the suitable learning medium if preschoolers are the users.

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