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## **Between Purpose and Method: A Review of Educational Research on 3D Virtual Worlds**

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### **ABSTRACT**

This study aims to enhance our holistic understanding of 3D virtual worlds by providing a detailed analysis of the research methods and research trends related to the research of 3D virtual worlds for educational environments. Data was collected by searching for the ubiquitous term, “virtual world,” from databases. Snowball sampling was also employed. The researchers critically analyzed the literature as data focusing on how virtual worlds were applied in individual studies, what research methods were used, and what disciplines were examined in the studies. The results indicate that virtual worlds are mainly used for the simulation of space, and they are used in different ways depending on discipline and temporal scope. Virtual worlds are increasingly being used in blended learning contexts. While descriptive research methods were most used in research studies on the educational applications of virtual worlds, experimental approaches are increasingly being used by researchers. Based on these results, this study suggests an appropriate research direction for the application of virtual worlds in educational contexts in the future.

## 1. Introduction

Three-dimensional (3D) virtual worlds are nowadays being considered as a potential medium to provide learners with new educational environments (Dass, Dabbagh & Clark, 2010; de Freitas, Rebolledo-Mendez, Liarokapis, Magoulas, & Poulouvassilis, 2010; Delwiche, 2006; Jarmon, Lim & Carpenter, 2009). The educational attempt to use 3D virtual worlds is especially highly evaluated with the affordances of expressing learners' actions and intentions (de Freitas, & Veletsianos, 2010; Ge, Thomas, & Greene, 2006; Thorne & Reinhardt, 2008). In the field of educational, virtual worlds have presented some controversy as this is an emerging technology (Wang & Lockee, 2010). For instance *Educational Research*, published by the National Foundation for Educational Research (NFER), devoted a special issue to 'Virtual Worlds and Education' in 2010. The Association for Educational Communication and Technology (AECT) is also actively participating in promoting the educational application of virtual worlds using Second Life, one of the more popular 3D virtual world platforms. In the movement toward virtual worlds, many virtual world studies in educational fields have claimed that instructional designers and educators might be able to expect great potential in the use of 3D virtual worlds for school settings (Bonk & Dennen, 2005; Dickey, 2005). In educational settings, virtual worlds have been regarded as a tool for providing the possibility of rich learner engagement, the ability to explore, construct and manipulate virtual objects, and situate representations of complex ideas (Dalgarno, & Lee, 2010).

However, despite the numerous claims that virtual environments might be beneficial in educational contexts, the research has yet to offer sufficient practical suggestions on how to apply virtual worlds in school-based educational settings (Lee & Kim, 2010). Jacobson and Azevedo (2008) argued that clarity with respect to the application of virtual worlds for learning remains elusive. Wang and Lockee (2010) also claimed that very few studies to date have been conducted on the actual application of virtual worlds in classroom settings. When instructional designers attempt to use virtual worlds in educational courses to facilitate interaction and learners' self-direction, they might have difficulty in searching for literature that offers prescriptive instructional methods.

The importance of research on the application of virtual worlds in educational settings is gathering momentum. We need to investigate how virtual worlds have been applied and analyzed in the existing literature. The actual application and analysis of the results are of great significance in that they may provide more concrete ways for the educational application and design of future instructional activities using virtual worlds.

This study analyzes research trends in 3D virtual worlds in terms of K-12 and higher education educational settings. It explores how virtual worlds have been applied in terms of educational applications in previous research. It summarizes the research methods used in these studies. It also seeks to explore the application of virtual worlds in terms of field or discipline by analyzing participants' majors and institutions. Through analyzing the results, we provide a fundamental resource that may inform future directions for research on the educational use of virtual worlds.

## 2. Literature Review

### 2.1 The Educational Potential of 3D Virtual Worlds

According to Bell (2008), a 3D virtual world is, "a synchronous, persistent network of people, represented as avatars, facilitated by networked computer" (p. 3). The term '3D virtual world' represents

a new computer medium that allows many users to simultaneously access the same computer generated space as virtual placeholders called avatars. In such space they can communicate and exchange data with each other using textual chat or real-time voice chat tools (Delwiche, 2006). It has been claimed that such environments offer the possibility of an immersive experience for learners through the use of realistic 3D graphics, simulations of real world physics, and binaural sound systems (Delwiche, 2006; Gee, 2003; Grasser, Pearson, Lu, & Jeon, 2005; Libbon, 2004).

The expansion in interest reflects the educational significance of virtual worlds. First, in virtual worlds, learners feel as if they are ‘there.’ This provides a sense of space, locality, presence, and dynamic conditionality with other users offering an immersive experience in a computer generated simulative environment (van der Land, Schouten, van den Hooff, & Feldberg, 2011). Virtual worlds, then, can provide opportunities for synchronous interaction in a designed space with objects and conditions created by the designer. Even though existing e-learning tools offer a great deal of flexibility for designing learning environment, they cannot provide the deep sense of environmental and conditional immersion for multiple users afforded by virtual worlds. Education using 3D virtual worlds, may involve real-time interaction with multiple participant so that more social, constructivist, and collaborative approaches to learning may be employed (Steinkuehler & Williams, 2006; von Der Emde, Schneider, & Kotter, 2001). There is, then, reason to believe that the use of virtual worlds for learning may lead to more effective learning environments particularly when users are at a distance or safe simulation experiences are required for learning.

Virtual worlds also provide a more advanced form of interaction than the real-time online messenger does. By complexifying the interaction, users may experience true simulations of real world conditions. This has profound implications for learning environments. Unlike messengers, virtual worlds enable users to have *many-to-many* communication as well as verbal and non-verbal communication through avatars (Robbins, 2007). Verbal communication is synchronous based on text while non-verbal communication uses gestures or facial expressions of avatars to convey a particular meaning (Robbins, 2007). In that sense, virtual worlds help overcome a sense of psychological alienation by making it possible to express different feelings in detail through avatars (van der Land et al., 2011). Text-based interaction is complemented when users exist as avatars in a virtual environment leading to a more active and interactive experience in virtual worlds than more common text-based chat environments.

Virtual worlds may also offer the security of the anonymity for participants by way of their avatars (van Deusen-Scholl, Frei & Dixon, 2005). The interaction through avatars can change the existing face-to-face relationship between teachers and learners, providing opportunities to take part in the class to learners who were neglected. In other words, learners in virtual worlds can equally communicate with other learners regardless of their social position, race, religion, and personal background (Grasser et al., 2005; Steinkuehler & Williams, 2006; von Der Emde, Schneider, & Kotter, 2001). Learners can also find their identity and experience social interaction through avatars (Gee, 2009). All of this points to the importance of understanding how virtual worlds may be used for effective learning and understanding if they indeed lead to more effective or more practical and therefore more desirable learning experiences.

## **2.2 Review of Content-Analyses in Educational Application of Virtual Worlds**

As mentioned earlier, virtual world studies have suggested that virtual worlds may offer new possibilities for educational contexts. However, many of the studies have focused only on the possibilities of virtual worlds (Kim, 2011). Jacobson and Azevedo (2008) argue that this focus on the

possible applications of virtual worlds indicates a lack of research on the use of virtual worlds for educational applications. To overcome this problem, recent content-analyses have attempted to illuminate how virtual worlds have been studied. For instance, Sivunen and Hakonen (2011) conducted a content-analysis on virtual worlds for educational uses. The study analyzed a total of 47 articles to illuminate the characteristics of virtual world studies, focusing on social interaction and group dynamics. Lee and Kim (2010) analyzed 38 virtual world studies, focusing on the methodologies used in educational virtual world studies. Wang and Lockee (2010) analyzed four studies to explore the characteristics of virtual worlds for distance education. Hew and Cheung (2010) also made an effort to analyze virtual world studies for education. By analyzing 15 previous studies of the application of virtual worlds, they explained the characteristics of virtual world in terms of categories of virtual world usage, research method, and research topic and effect. Hew and Cheung's (2010) research is significant in that they analyzed the previous research based on the standard of empirical data collection and suggested the criteria for classification for future content-analysis.

However, previous content-analyses contain significant gaps for the following reasons. First, except for Hew and Cheung's (2010) study, most studies concentrate on the potential educational applications of virtual worlds such as using it for collaborative learning and distance education. Second, the studies could not suggest research trends, as they excluded from their analysis the dates of the research. Classification by year is essential to understanding research trends in virtual worlds since virtual world affordances continue to evolve at an astonishing rate. Third, many of the studies are simply not up to date. For instance, the study of Wang and Lockee (2010) includes data until 2009 and Hew and Cheung (2010)'s covers only until 2008. These reasons suggest that follow-up research is needed.

### 3. Method

In order to collect research articles on virtual worlds that would serve as data for this study, we performed a keyword search using several databases (Academic Search Premier, Education Research Complete, ERIC). Literature was filtered using the keyword, *virtual world*, from articles in peer reviewed journals (published until December, 2011). We then removed duplicate articles and scanned the article abstracts and methodology sections to determine if they would be included in this study. We focused on searching for application studies of virtual worlds for K-12 school contexts as well as higher education contexts. To acquire as much data as possible, we added two articles using the snowballing method. Through this process, we were able to find 65 relevant articles. Comparing this sample to previous content-analyses on virtual worlds, (Sivunen & Hakonen, 2011, n=47; Lee & Kim, 2010, n=38; Hew & Cheung, 2010, n=15; Wang & Lockee, 2010, n=5), and considering the quantity and the newness of the publications, we concluded that the sample size of 65 scholarly articles would be appropriate for the purpose of this study.

We analyzed data according to the categories *application*, *method*, and *research field*. First, the classification criteria in terms of the application were *the manner of application*, the *degree of application* (blended application and on-line application), and the *software* used. For analyzing the manner of application, the criteria, *communication space*, *simulation of space*, and *experiential space* were used (Hew & Cheung, 2010). Communication space means using virtual worlds to exchange information for verbal or non-verbal forms of communication. Simulation of space means using virtual worlds for the curriculum contained in them. Experiential space means to provide learners opportunities to construct objects in virtual worlds. The term *combined space* is used when more than two manners of application were satisfied. For analyzing the degree of application, we determined whether the articles

reported on studies of ‘blended’ or ‘on-line’ educational contexts. In the cases where virtual worlds were used in actual classrooms and teachers teach or evaluate learners face-to-face, we considered this to be a blended application of virtual worlds. In contrast, when almost all teaching activities were conducted in the virtual world, we considered it an on-line application, even though the application of the virtual world was in the classroom. For analyzing software, we categorized the applied platform of the virtual world, such as Second Life, Active Worlds.

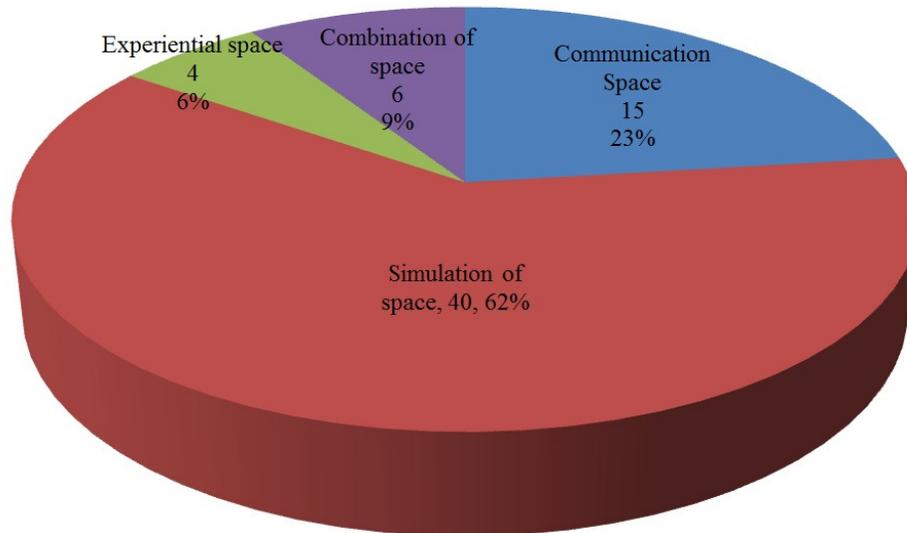
Second, this study used descriptive and experimental design as classification criteria of research methods. Descriptive design was defined as a method describing spontaneously generated situations without any artificial operation on educational fields in virtual worlds (Creswell, 2007; Knupfer & McLellan, 1996). In contrast, experimental design deliberately controls possible variables and compares experimental groups with control groups to prove the hypothesis and causation. In the study, we also classified quasi-experimental research into experimental research (Howell, 2007).

Third, for research fields, we used criteria grounded and induced from the data. These classification criteria included major fields and grade of institutions. Major fields included computer education, foreign language education, economy education. Research subjects were classified by grades into elementary education, secondary education, and higher education. To analyze relationship among results, we used correspondence analysis method (Greenacre, 2007). Correspondence analysis explains the relationship among cases of similar patterns using the results from frequency analysis to explain relations among variables and trend analysis by year of publication pointed to a shift from descriptive to experimental studies of virtual worlds.

## **4. Results**

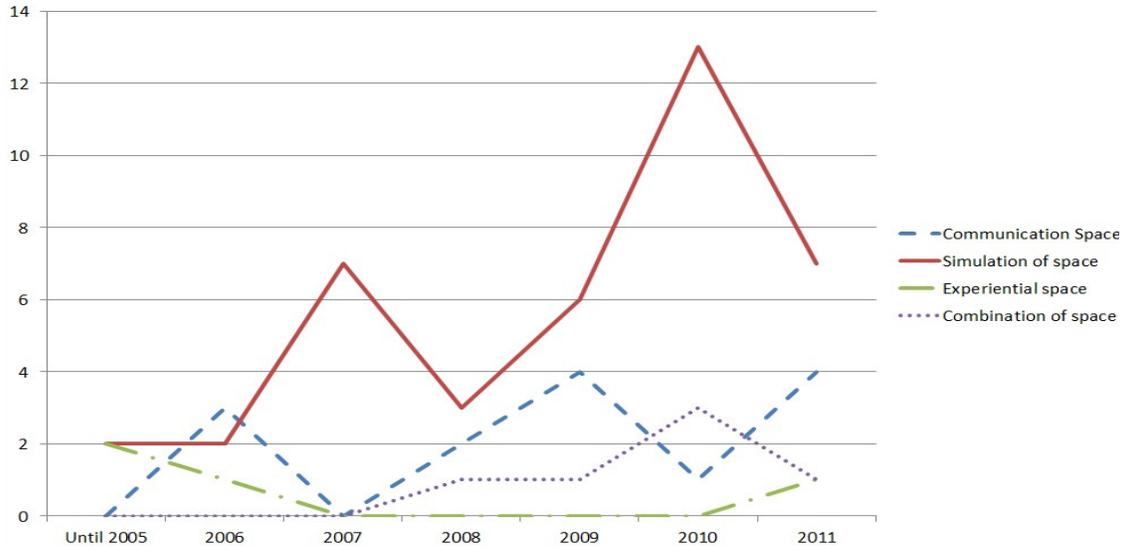
### **4.1 Application of virtual worlds**

According to the analysis of the way of application of virtual worlds in 65 published papers, as shown in Figure 1, studies about the simulation of space formed the most, at 40, followed by communication space, at 15, combined space, at 6, and experiential space, at 4. That is, the most studies about the educational application of virtual worlds were based on the simulation of space in virtual worlds.



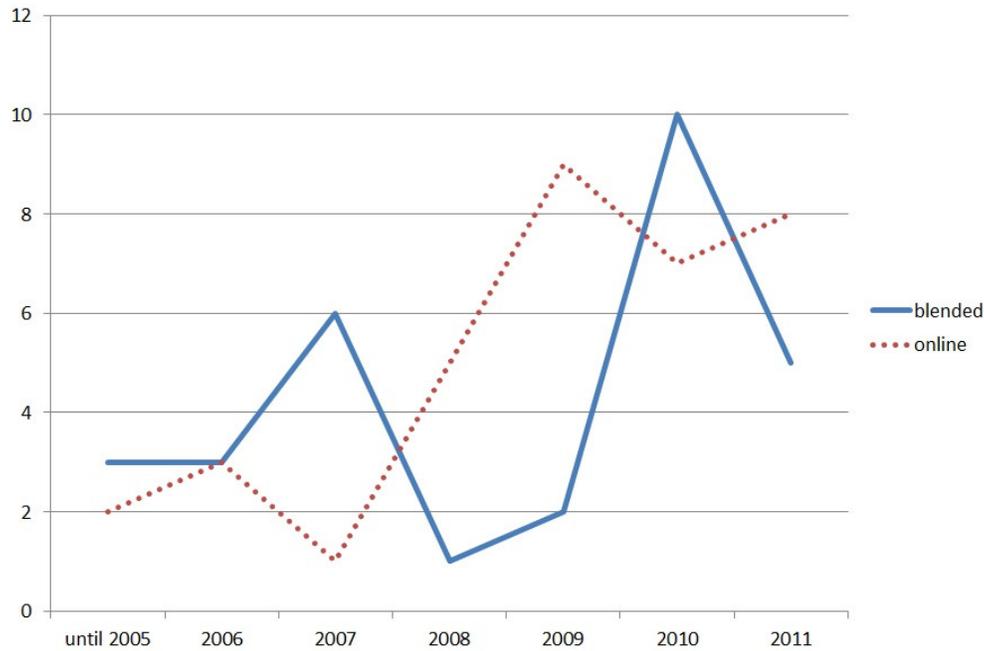
**Figure 1: The way of application of virtual space**

The analysis results by year suggest that virtual worlds have been used as communication spaces since 2005, this constantly being a major focus of research. It showed that virtual worlds have been used as combined space where various ways of application were used in combination since 2008 (see Figure 2). The result from 2001 to 2005 was put in a bar together for there was not enough research for this period. The change in trend about the way of research showed that, compared to the previous research, the use of virtual worlds as a simulation of place and communication place has increased more than the use as an experiential space. It could be because this study was focusing on data for the educational application of virtual worlds. In other words, virtual worlds as experiential spaces appeared in the fields of media or art rather than research on education, if they needed creativity, including the design of avatars. The increase in the educational use of virtual worlds was focused on utilizing the functions of existing virtual worlds.



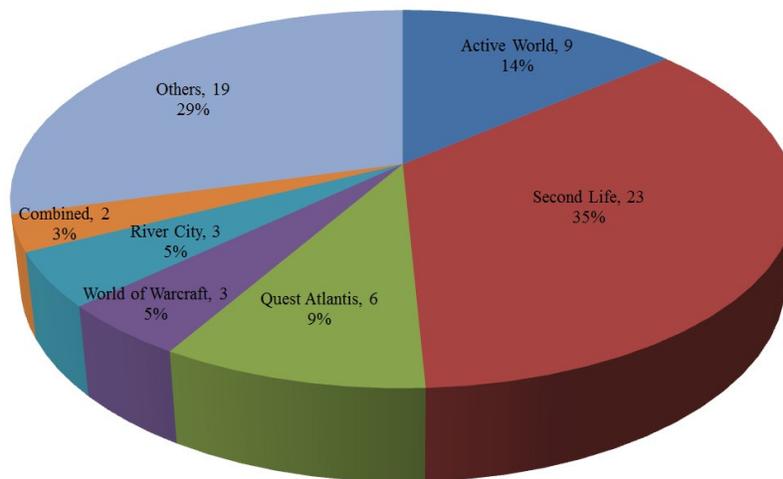
**Figure 2: Analysis of the way of application of virtual space by year**

In terms of the degree of application, the blended application of virtual worlds was covered in 35 and the on-line application was covered in 30 of the studies, which meant the blended form was used more in applying virtual worlds in education. Again, in this study, the on-line application of virtual worlds means that almost all learning activities occur in the virtual world, even in cases where the implementation was conducted in the classroom. According to the analysis of the degree of use by year, results showed that virtual worlds were usually used in the form of blended application until 2007. However, the on-line application of virtual worlds has increased since 2008. This suggests that there is increasing interest in exploring the educational significance of independent virtual worlds. This corresponds with the research trend that virtual worlds can be used as independent forms for teaching and learning with active interactions among multiple participants (Dickey, 2011; von der Emde et al., 2001), and verbal and non-verbal communication through avatars (Robbins, 2007). Additionally, it is because recent application studies have focused primarily on the virtual-embedded effect of the classes.



**Figure 3: Form of classes using virtual worlds by year**

In terms of software applied, as shown in Figure 4, there were 23 papers for Second Life, 9 for Active World, 6 for Quest Atlantis, 3 for River City, 3 for World of Warcraft, 2 for combined use, 19 for others (e.g., Wonderland, Everquest 2, Virtualand, Appalachian Tycoon, Sims); in the analysis of research on software used, Second Life had the most attention by the scholars.



**Figure 4: Analysis of research on software used for virtual worlds**

The most commonly used applications were Second Life, Active Worlds and Quest Atlantis, which were used twice as often as other software titles. So the analysis by year was conducted for only those three software titles. There was eight papers for Active Worlds until 2008 and one was added after 2008, and four for Second Life since 2007 and nineteen were added until December, 2011, suggesting the research on Second Life has been increasing since 2007 (see Figure 5). These results correspond with the trend that universities have been trying to build virtual universities in Second Life. Additionally, the graph shows that the use of other software is rapidly increasing. This means that instructional designers now have more choices in applying virtual worlds for their educational contexts.

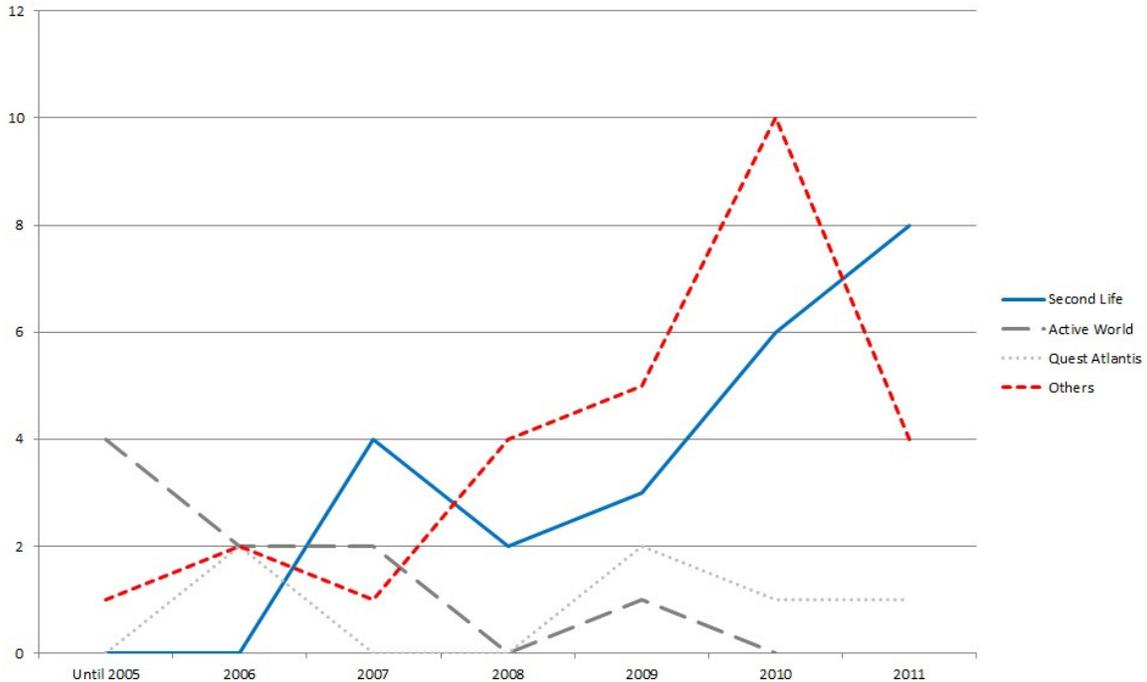
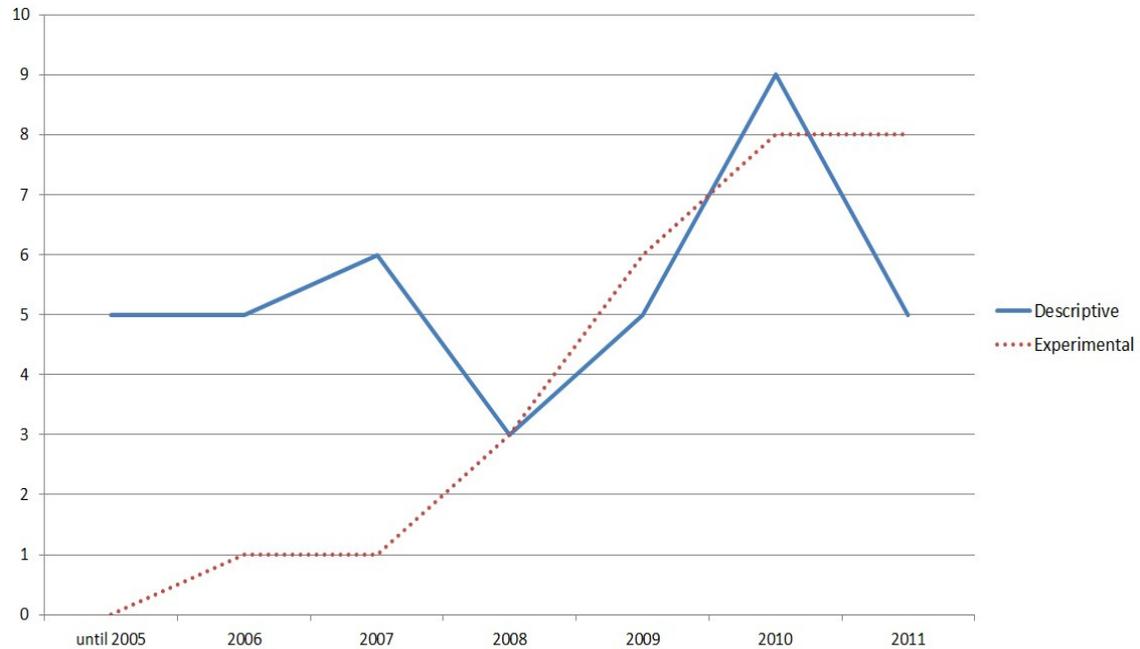


Figure 5: Analysis of the frequency of software used by year

#### 4.2 Research method

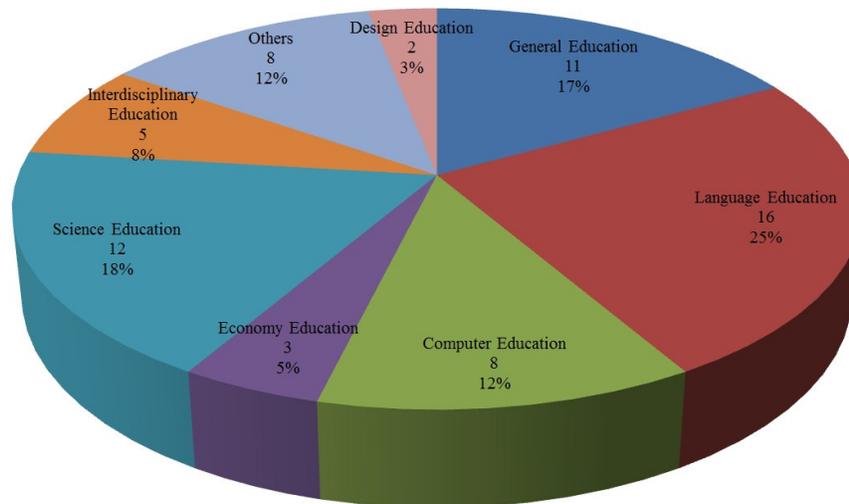
In terms of research method, the result shows that there were 38 descriptive research studies (58%) and 27 experimental research studies (42%) out of 65. Compared to the result of Hew and Cheung (2010) for data by February, 2008 (93.3% of descriptive research and 6.7% of experimental research), experimental research has remarkably increased. These results also could have been caused by the fact that quasi experimental research was included in this category. Considering that there have been few virtual world studies for education, it is recommended that we work to understand the results of these increasingly common experimental studies of virtual worlds. This trend toward experimental rather than descriptive research on virtual worlds could be identified when research methods were analyzed by year (see Figure 6). Experimental research had not been conducted until 2005; it was started in 2006 and is still growing. The rise of experimental research methods means that research on virtual worlds was more than just describing and understanding the variables of the natural environment.



**Figure 6: Analysis of research methods on virtual worlds by year**

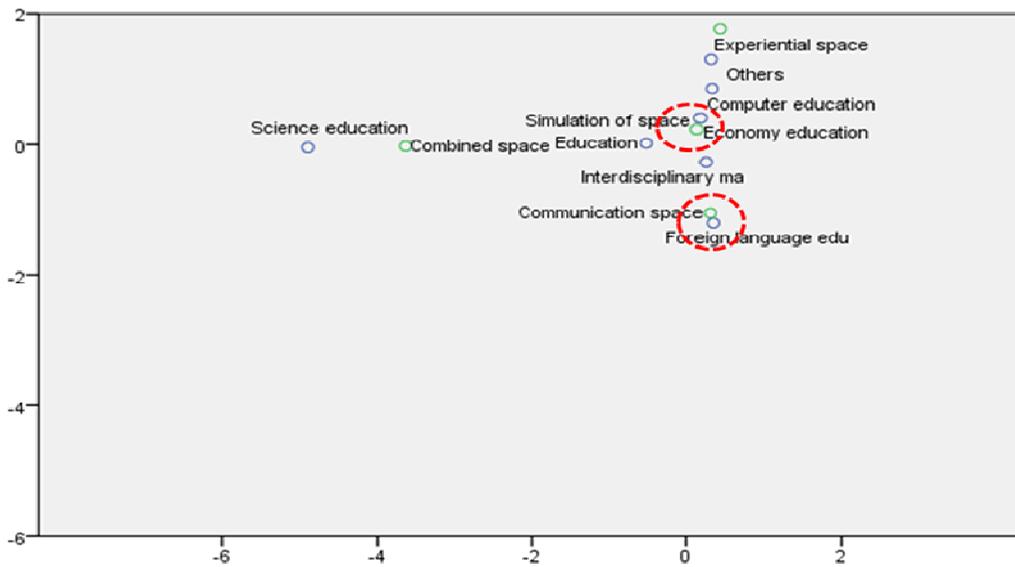
### 4.3 Analysis of research fields

The analysis of research fields using virtual worlds by academic discipline showed 16 papers for foreign language learning and 8 for computer education, 11 for general education, followed by 12 for science education, 5 for interdisciplinary education, 3 for economy education, 2 for design education, and 8 others (e.g., health education, philosophy education) (see Figure 7). Such distribution suggests that research using virtual worlds was conducted in a wide range of academic fields, including related ones.



**Figure 7: Analysis of research fields using virtual worlds by major**

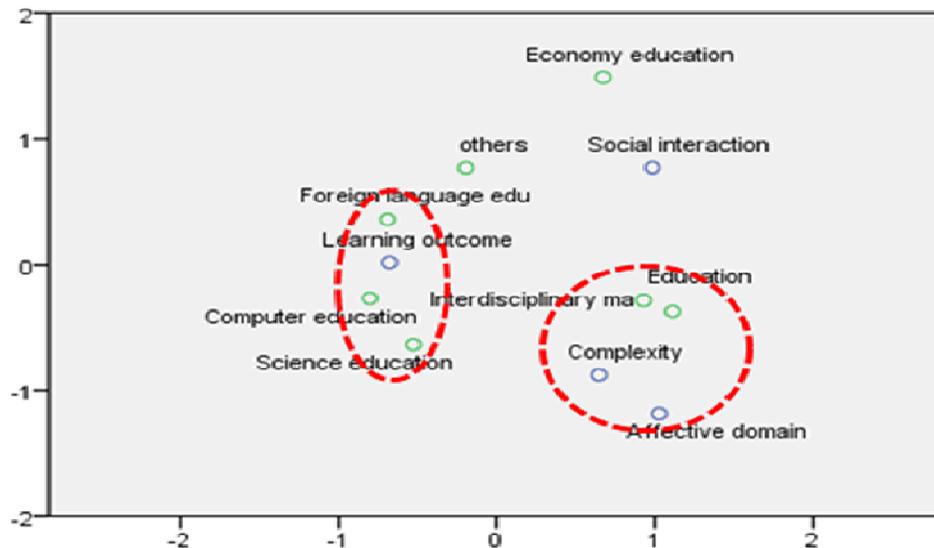
The correspondence analysis for the uses of virtual world applications and majors showed 1.03\*\* of inertia, suggesting a close relation between research field and the type of application. The result of the correspondence analysis is shown in Figure 8. The items in a circle had certain relations with each other, and the closer the distance is, the closer the relations are.



**Figure 8: Correspondence analysis of the types of application by major fields**

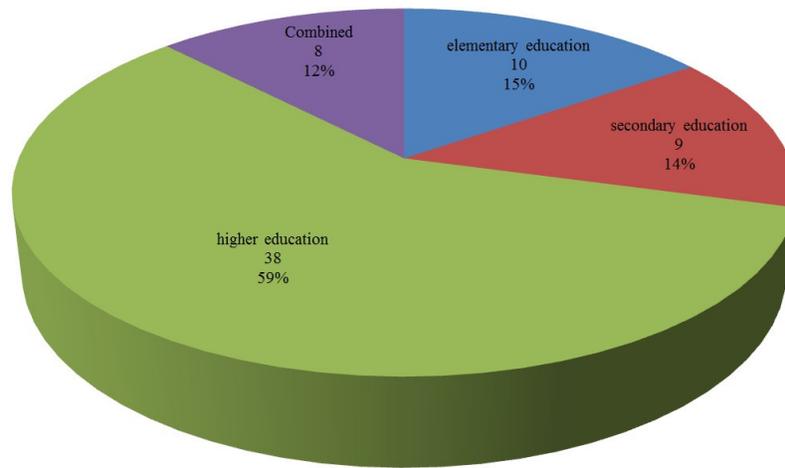
While virtual worlds have been used in classes as simulation of space in general, they have been used in various ways such as space for communication, simulation of space, experiential space, and combined space in research of general education and computer education. The most outstanding relation was in the field of foreign language education. Out of 16 papers about foreign language education, 13 (81%) showed use of virtual worlds as spaces for communication, which agreed with the result of previous research suggesting that the users were naturally exposed to the target language through virtual worlds (Kim, 2011; Zheng et al., 2009; Zheng, 2006). The function of virtual worlds as spaces for communication illustrated that virtual worlds have been mainly used for foreign language education.

According to the result from correspondence analysis to see the educational effect of using virtual worlds by major fields, inertia was .58, suggesting there existed relevance between using virtual worlds and educational effect, as shown in Figure 9. The fields of foreign language education, computer education, and science education, on the left, tried to look for the educational effect by using virtual worlds from the aspect of learning outcome. In contrast, the fields of general education and interdisciplinary major saw the educational effect from the aspects of affective domain and complexity. The field of economy education studied social interaction in virtual worlds. In other words, each major field had different expected effects for the educational application of virtual worlds.



**Figure 9: Correspondence analysis of major fields and expected effect**

Education level was classified into elementary education, secondary education, and higher education (see Figure 10). Higher education comprised 45% (17 papers) of the research by education level, whereas all ages comprised 21% (8 papers), elementary education comprised 18% (7 papers), and secondary education comprised 16% (6 papers), to be balanced. It showed that the research on education using virtual worlds was conducted the most widely aiming at higher education.



**Figure 10: Analysis of research fields using virtual worlds by educational level**

## 5. Conclusions

Previous research on the educational application of virtual worlds has presented a blueprint about educational possibilities, such as synchronous communication, multi-participation and cooperation. A body of literature claimed virtual worlds might create *learner-centered* educational environments. However, through this study, we acknowledge that there is still insufficient research showing how virtual worlds should be used for educational purposes. The educational application of virtual worlds needs specification, verification and diversity. We argue that research must avoid simply presenting a cookie-cutter blueprint. For this purpose, we analyzed research trends on the application of 3D virtual worlds for educational contexts. The conclusions are as follows.

First, previous research showed that virtual worlds have been most commonly used for the simulation of spaces. The virtual world for simulation of space is a form of education, which means the reproduction of reality using avatars, objects or tasks. Using a virtual campus and classrooms could be examples of the research. Several design studies for a formal or informal curriculum with virtual worlds also fall into this category (Kim, 2011). Considering the immersive educational environment of virtual worlds, it is anticipated that this trend would be continued. However, the type of application of virtual worlds depends on the research field. The function of being synchronously exposed to a target language suggests that virtual worlds can be used as communication spaces. The research on foreign language education using virtual worlds is increasing in non-English speaking countries, thanks to synchronous communication, easy access, and the potential for anonymity by way of avatars (Luppicini, 2007; Peterson, 2010).

Second, there were more studies on analyzing virtual worlds on the basis of face-to-face educational contexts than exclusively on virtual worlds. The analysis of the recent research trends suggests that research on the online educational effect on learners who are using existing virtual worlds is also increasing. Educational research on virtual worlds is now focusing on understanding the immersive

characteristics of virtual worlds, such as making learners feel as if there exists an online learning space (van der Land et al., 2011).

Third, descriptive research is the research method used the most. It implies that research has been conducted as a way for suggesting ideas of various environments in a new educational setting, not as a way of proving existing hypotheses. However, the recent trend of increase in experimental research shows that the research on education using virtual worlds is becoming more mature. In comparison to the somewhat dated literature, recent studies are more focusing on showing the learning outcomes of virtual worlds (e.g., Montoya, Massey, & Lockwood, 2011).

Fourth, virtual worlds have been used in different ways depending on field. In general, research on education using virtual worlds has been conducted widely in the fields of foreign language education, K-12 education, general education, computer education, and science education. The expected effects on learning using virtual worlds were related to the field of research. Research in the fields of foreign language education, computer education, and science education has focused on learners' achievement, while research in the field of general education has generally focused on affective domains and interaction among learners. In the blended fields of interdisciplinary majors, a variety of research on social interaction has been conducted. In terms of education, in fields using virtual worlds by grade, research for higher education comprised the most, but research for elementary and secondary education has been increasingly conducted, suggesting research for every grade is on the rise.

This study indicates that it is important to consider what software to apply for educational contexts. While doing the literature review and coding the articles included in the sample, we realized that in many of the studies, the authors did not explain why they used a certain virtual world platform for the specific contexts. Currently, the most widely applied software is Second Life. However, as this study shows, the use of other platforms is increasing remarkably. For readers and educators who want to use virtual worlds for educational contexts software choice is an important issue. For instance, Delwiche (2006) argues that for effective use of virtual worlds it is important to consider the genre, extension, and accessibility of the software. Because various virtual worlds have different capabilities (Robbins & Butler, 2009), future research needs to carefully consider the reasons particular software packages are chosen.

It is important that terms that relate to virtual worlds and the direction of virtual world research be settled. The nomenclature used on a regular basis play an important role in determining the direction of the research. In particular, the research trend on the educational application of virtual worlds could be categorized into MUVE (Multi-User Virtual Environment), whereas the trend to value informal education in natural circumstances could be categorized into MMOG (Massively Multi-player Online Game). However, these are sometimes deliberately defined or used ambiguously, resulting in confusion in interpretation. Along with the various interpretations of the term *game*, whether virtual worlds and games should be distinguished or not needs to be decided.

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