CURRENT RESEARCH IN EDUCATION

EDITORS
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MARCH 2022

gece kitaplığı

İmtiyaz Sahibi / Publisher • Yaşar Hız

Genel Yayın Yönetmeni / Editor in Chief • Eda Altunel

Editörler / Editors • Assoc. Prof. Dr. Onur Zahal

Dr. Halil Taş

Kapak & İç Tasarım / Cover & Interior Design • Gece Kitaplığı

Birinci Basım / First Edition • © Mart 2022

ISBN • 978-625-430-035-6

Gece Kitaplığı / Gece Publishing
Türkiye Adres / Turkey Address: Kızılay Mah. Fevzi Çakmak 1.
Sokak Ümit Apt. No: 22/A Çankaya / Ankara / TR
Telefon / Phone: +90 312 384 80 40
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Baskı & Cilt / Printing & Volume
Sertifika / Certificate No: 47083

CHAPTER 4

MULTI-USER VIRTUAL ENVIRONMENTS IN FORMAL AND INFORMAL LEARNING SETTINGS: STUDENT AND TEACHER PERCEPTIONS[1]

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1 This study is produced from the dissertation titled "The perceptions and experiences of students and teachers in formal and informal learning settings that uses MUVEs: Quest Atlantis case" completed by the first author at the Graduate School of Natural and Applied Sciences at Middle East Technical University.

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1. Introduction

With the wide use of technology, the way societies live has been changing. It is a necessity of the era we are in that educational institutions, as one of the indispensable priorities of the society, should keep up with technology. Increasing exposure to technology is changing the habits of learners and differentiating their interests. Today's students, called digital natives, have different thinking, reading, research, socialization and learning skills because they are intertwined with technology from the moment they are born; preferring visuals to texts while learning, being able to carry out many tasks simultaneously, being active in learning and preferring digital games to homework can be counted among the prominent features of this generation (Prensky, 2001a, 2001b). For this reason, it is important to restructure educational environments with technology supported by concrete and interesting learning content, in which students actively participate.

The educational use of technology provides students with effective learning environments (Agrawal & Mittal, 2018) where they can construct new knowledge through exploring, experimenting, and interacting (Jonassen, Peck & Wilson, 1999). Students can either work individually or collaboratively while being engaged in an educational problem (Nelson, 2007). They regard technology as a means to be used in education for information search, collaboration, communication, writing and visualization (Lindberg, Olofsson & Fransson, 2017). The use of technology removes the borders of learning (Livingstone, 2012), promotes creative, integrative and active learning (Raja & Nagasubramani, 2018) and fosters adaptive learning (Hernandez, 2017). Having its origins from Multi-User Dungeons (MUDs), Object-Oriented Multi-User Dungeons (MOOs) and Internet Relay Chats (IRCs) (Damer, 1997), Multi-User Virtual Environments (MUVEs) can be regarded as a good example of recent technologies to be used in educational settings.

1.1. MUVEs

As technology evolves, the educational media and methods used in classrooms have also changed. MUVEs are one of the promising technologies to conduct or to support educational activities. MUVEs are 3D online virtual environments where large number of users can interact with each other and with non-player characters (NPCs) (Nelson, Ketelhut, Clarke, Bowman & Dede, 2005). MUVEs "enable multiple simultaneous participants to access virtual contexts, to interact with digital artifacts, to represent themselves through "avatars" to communicate with other participants and with computer-based agents, and to enact collaborative learning activities of various types" (Ketelhut, Clarke, Dede, Nelson & Bowman, 2005, p. 2). According to

Chen, Yang and Loftin (2003) the characteristics of MUVEs are 1) centering the curriculum on real-life problems, 2) allowing communities of practices emerge, 3) letting students involve in inquiry-based learning activities, and 4) ensuring knowledge construction where the students are active and can collaborate with each other. MUVEs can be used with a wide range of age groups when the technological infrastructure in schools suffice the requirements and they meet the curricular aims. As Dede, Clarke, Ketelhut, Nelson and Bowman (2005a) claim, MUVEs are more like computer games in terms of their similarity to creating real-life-like learning experiences that are immersive and problem-based.

As a popular media among youth, MUVEs make it possible to meet people across the world. This interaction among people can possibly go beyond having chat and can turn into a learning community where students collaborate (Hong, 2013). Once you log in to these portals, you step up to a 3D environment where you can also do shopping, participate in business meetings, meet new people, or just have fun. In addition to these real-life-like occasions, these environments provide with experiences to people for enrolling in learning opportunities that is either pure online or designed as a supportive part for a face-to-face class. Nevertheless, these open to public MUVEs (e.g. SecondLife) have been criticized since it enables students move out of the educational context, to communicate other people misbehaving, and to interact with malicious content, because it is free and there are also other people around using the same places for different purposes (Pence, 2007; Antonacci & Modaress, 2008; Harris & Rea, 2009). Therefore, for formal education, especially with young age group of students, these 3D places can turn into a threatening place, which is a sufficient reason for people for disuse of MUVEs in education. There are other examples of MUVEs (such as Quest Atlantis, River City) designed specifically for educational purposes and they are safer virtual settings for young students by only allowing groups of teachers' and students' access.

1.2. MUVEs in Education

MUVEs are relatively new technology-based environments and they let teachers provide their students with tools that situate theoretical content (Barab et al., 2007; Fokides & Chachlaki, 2020). Dede, Clarke, Ketelhut, Nelson and Bowman (2005b) assert that MUVEs can be effective environments for students to participate in learning. Barab, Gresalfi and Arici (2009, p. 77) name the type of the learning experience in MUVEs as "transformational play" in which "a player must become a protagonist who uses the knowledge, skills, and concepts embedded in curricular content to make sense of a fictional situation and make choices that transform that situation". According to the authors, playing in or visiting virtual worlds does not always result in learning; rather, transformational play is necessary in order to ensure learning. Having involved in transformational play, the students are immersed in the learning environment and experience the subject matter.

MUVEs with educational purposes let students involve in inquiry-based learning practices that are highly immersive (Erlandson, Nelson & Savenye, 2010). Within these immersive environments, the students act on their own learning by studying the ill-structured problem (Parson & Bignell, 2017). They "gather data, comment on and annotate it, synthesize and analyze, and distribute content essentially in real time" (Steinkuehler & Squire, 2009, p. 10). Moreover, students take on a role and internalize it (Barab, Gresalfi & Arici, 2009), through which they get the feeling of social presence, too (Omale, Hung, Luetkehans & Cooke-Plagwitz, 2009).

MUVEs, as being interactive learning environments, have many advantages. Students can be involved in a motivating, fun and effective learning process (Fokides & Chachlaki, 2020). Ensuring learner engagement, MUVEs allow knowledge construction in which the learner actively participates and therefore empowers cognitive skills (Kalyuga, 2007). The visual features of MUVEs give a chance to the users to have a feeling of being in that virtual area (Warburton, 2009), which increases the sense of social presence (Esteve-González, Cervera & Martínez, 2016). The multi-user feature of the MUVEs gives opportunity for the students to interact with other students with a variety of skills all around the world.

2. Purpose of the Study

The curriculum of Turkey was changed recently in accordance with constructivist approach. The aim was to shift education into a more student-centered approach. It was restructured in a manner that students would be equipped with skills such as communication, inquiry skills, problem solving, creative thinking, critical thinking and computer and Internet use proficiency (Board of Education, 2005). Regarding this change, teachers have been encouraged to use technology based materials in their classes as well. With this new curriculum and the change in the learning approach, it is important to provide students with variety of learning opportunities so that they gain expected skills and qualifications. As the literature review above shows, MUVEs seem promising in this respect. When an innovative technology is integrated into educational environments, it is important to analyze the perceptions of teachers and students. With this aim, the current study investigates the following research questions.

1. What are the students' perceptions of using MUVE?

a. How do they perceive their experiences that they have while using MUVE?

b. What are students' likes and dislikes regarding MUVE?

c. How do they compare learning experiences in MUVE with learning in traditional classrooms?

2. What are the teachers' perceptions of using MUVE?

a. How do they perceive the use of MUVE as a technology based educational material?

b. How do they evaluate students' learning in MUVE?

c. How do they perceive their role during the implementation of MUVE?

3. Methodology

For this study, qualitative research methodology was chosen since the purpose was to investigate the research problem in a detailed way and to understand the situation from the participants point of view. As the type of the qualitative research method, multiple case study was selected. According to Gillham (2000, p. 1) case means "a unit of human activity embedded in the real world; which can only be studied or understood in context; which exists in the here and now; that merges in with its context so that precise boundaries are difficult to draw". Case study is defined as "an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context" (Yin, 2009, p. 18). A case study may investigate an individual, a group, or a community. Multiple case study method allows the researchers to deeply analyze more than one case (Stake, 2006). In the scope of this research, the selected cases are student groups and their teachers from two private schools, and student groups from a non-governmental organization (NGO). All the implementations were conducted in computer labs.

Case 1 – Formal Learning Setting: First case was selected from a private school in which the classrooms were equipped with a computer and a projector. Science classes took place in classroom and science labs. The teacher was female and had twenty-five years of teaching experience. The research implementation took five weeks in this case (orientation time not included).

Case-2 – Formal Learning Setting: This case was selected from another private school. The school was equipped with technology and open to technological innovations. As in the first case, science classes took place in classroom environment and science labs. The teacher was female and she had ten years of teaching experience. The implementation took four weeks (orientation time not included).

Case-3 and Case-4 – Informal Learning Setting: Both cases took place in the same NGO. The organization aims to contribute to educational practices executed in school. The target group is students aged from seven to sixteen. There are no teachers but volunteers facilitating the educational activities. This research implementation was presented during summer period as an extra-curricular and voluntary activity. Implementations took three weeks long in each case; nevertheless, it took longer than the first two cases on an hourly bases.

Facilitating the implementations and collecting data in all cases, the first author was participant-observer (Merriam, 1998; Fraenkel & Wallen, 2003; Johnson & Christensen, 2004). In cases 1 and 2, implementations were facilitated by the first author; the teachers were present, guiding and observing as well. Teachers did not want to carry out the activities as they both said they did not feel competent enough with the MUVEs and did not have time to be prepared. In the cases 3 and 4, the first author took the volunteer role in the organization and facilitated the implementations, too.

3.1. Characteristics of the Cases

Student Demographics: The distribution of participants in each case is provided in Table 1. The students in the formal learning settings had families with high socio-economic status (SES) and had home computer with Internet access. More than half of the students had a game console, and playing computer and console games were their favorite pass time activity. The games they played had high-graphics resolution. The majority of the students had been using computers and Internet for more than five years.

For the students in the informal learning setting, the SES of families were low and most of the parents were primary or secondary school graduates. Mothers were housewives and fathers were self-employed. The students had been enrolled in government schools, some of which did not have a science lab. Half of the students had home computer; but, few had Internet access and game console at home. They had been using computers for 2-3 years in case 3 and 1 year or less in case 4. The games they played were casual; only few played games with high-graphics resolution.

Table 1 *The comparison of cases*

	Case 1	Case 2	Case 3	Case 4
Setting	Formal	Formal	Formal	Formal
Number of students	20 (7 female, 13 male)	24 (12 female, 12 male)	9 (3 female, 6 male)	16 (10 female, 6 male)
Home computer	20	24	4	8

Internet access at home	18	24	3	7
Game console	14	16	1	4

Teacher Demographics: In school cases, science teachers were both female, teaching in private school and had special interest towards technology usage in education. Types of the technology use in their classes were mainly making PowerPoint presentations (mainly scanned pages of science book), and showing videos and pictures related with the lesson. Type of the activity their students sometimes enrolled was simulations of experiments. Teachers rarely used the computer lab due to availability issues.

3.2. The MUVE: Quest Atlantis

Also conceptualized as a meta-game, Quest Atlantis (QA) is a multi-user virtual environment. It was designed as an innovative technology-rich learning environment including curricular tasks "to provide a meaningful context for significant learning and pedagogy" (Barab, Arici & Jackson, 2005, p. 15). According to Barab, Thomas, Dodge, Carteaux and Tuzun (2005, p. 2), QA "leverages a 3D multi-user environment, educational quests, unit plans, comic books, a novel, a board game, trading cards, a series of social commitments, various characters, ways of behaving, and other participant resources". Target group is elementary school students aged nine to fifteen. The virtual environment is immersive in that students take active role in their learning. It allows students to experience and learn in a content- and context-rich game-like environment (Codier, 2016). The aim is not only to support students with learning activities but also to let them have fun while studying and to improve social responsibility skills through QA Social Commitments. Quests cover a variety of subject areas. Students can either work individually or collaboratively. Each student has an online portfolio. With Teacher Toolkit, teachers can manage their classroom activities, follow their students' progress, review logs and statistics.

In addition to providing with a game-like 3D virtual environment, QA supports students with 2D web interface and chat options (Fig. 1). Students have the opportunity to browse on the online web-pages while communicating with their friends online as they walk in 3D space with their avatars.

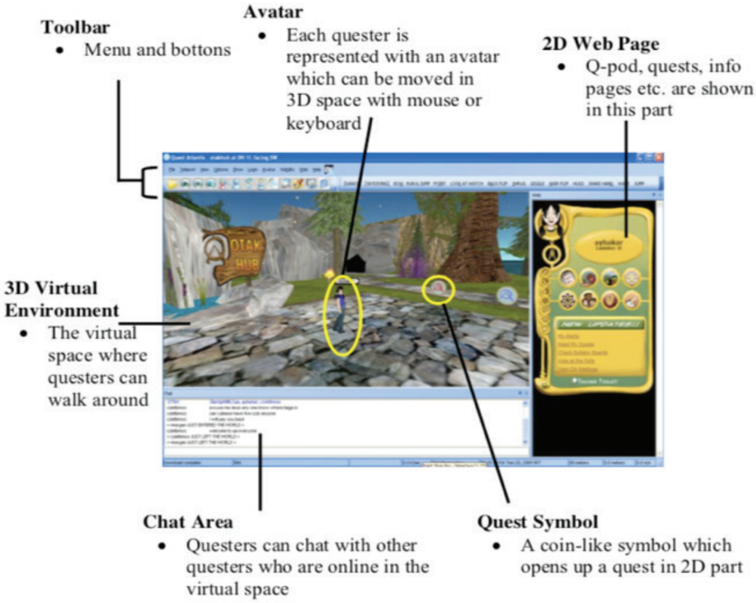

Fig. 1 *The interface of QA*

3.3. The Implementation

In QA, there are some virtual worlds, with their own narrative, presenting a multidimensional immersive problem. The Taiga world is one of them. Taiga covers the multifaceted problem of water quality in the Taiga Natural Park that causes the decrease in the fish population. Barab et al. (2007, p. 753) defines this underlying narrative of Taiga as not a simple story, but as "transactive trajectories that unfold in relation to evolving student understanding and application of disciplinary formalisms". The activity starts with a letter from Ranger Bartle, the park administrator, explaining the current problem they have been through and asks for students help to solve this environmental issue. After that, the students, as field investigators, start conducting research and collecting data about the possible reasons of the problem. Meanwhile, they take notes on their worksheets. Students are required to approach the issue from a multidimentional perspective (Barab, Sadler, Heiselt, Hickey & Zuiker, 2007). There are groups of people living around Taiga river, park administrators trying to sustain the park and several other NPCs. Students can interact with each character; each of which tells the story from their perspectives, gives information about the problem and mainly blaming other groups. Students can also take photos of the area from different locations, read notes, graphs or tables, and analyze water samples of the river. After this multifaceted research, students come up with a solution.

When they submit their work, they are teleported to the future version of Taiga where they can see the results of their suggestion.

Since the original world was in English, for this study Taiga world is cloned with all the quests attached to it; and translated to Turkish. Moreover, to make the topic more relevant, the story was associated to the longest river in Turkey, Kızılırmak. By preserving the original story, a number of minor changes have been made to make the activity in line with the curricular objectives and to shorten the activity due to time constraints.

3.4. Data Collection Methods

Qualitative research method requires in depth data collection (Patton, 2002), therefore, a variety of data collection methods were utilized in order to better understand each case in detail (Table 2). Each tool was developed by the researchers, reviewed by field experts and pilot tested. The interviews were tape-recorded and the observations were video-recorded. In case 2 due to permission issues, the student data was relied on the observation records, field notes and instant questions asked during the implementations. For the teacher perceptions of cases 3 and 4, the results was deduced from observations and field notes by the first author.

Table 2 *Data collection tools*

	Case 1	Case 2	Case 3	Case 4
Students demographics questionnaire	✓	✓	✓	✓
Teacher interviews	✓	✓		
Student interviews			✓ (3 students)	✓ (10 students)
Student perception questionnaire	✓			
Teacher perception questionnaire	✓	✓		
Observations	✓	✓	✓	✓
Field notes	✓	✓	✓	✓

3.5. Data Analysis

Qualitative studies end up with a large amount of data collected through different methods. The analysis starts with reading through the data to get a sense of it. What comes next is “line-by-line analysis” (Strauss and Corbin, 1998, p. 57). Codes emerge from the data and make sense in the scope of the study. The analysis of the data in this study went through three main steps: 1- transcription of all data, 2- reading through each data set to make a sense of it, 3- conducting content analysis to create themes and codes and explain each by giving examples coming from the data set. Data analysis was conducted with QSR NVivo.

Trustworthiness refers to validity and reliability issues in case study research (Bassey, 1999). To provide with trustworthiness, issues considered by the researchers included triangulation (Johnson and Christensen, 2004), peer review (Miles and Huberman, 1994), rich descriptions, and long term interaction.

4. Results

The results from the cross-case data analysis is provided in this part regarding research questions.

4.1. Research Question 1 – Student Perceptions of Using QA

Table 3 shows the results of cross-case analysis of students' experiences. Students explained their experiences of the implementation by stating that they enrolled in a scientific activity taking place in 3D environment in which they acted as a researcher/scientist, investigated the problem case, collected data, and took field notes. Moreover, they stated that they had learned throughout the project. According to most of the students in informal cases, the project and the MUVE contributed to their learning (such as science concepts, environmental awareness, making research, inquiry skills, computer literacy skills, and self-confidence). Most of the students in each case thought that the project was easy to finish since it was easy to collect data and to finish planned tasks. There were just a few students who found the project difficult to finish due to work load. The students in all cases found the project a fun way of learning. As the project required collecting several versions of data, the printed notebook helped students combine and sort the data and their field notes.

Table 3 *Student perceptions about their experiences*

	Case1	Case2	Case3	Case4
Easy project	✓	✓	✓	✓
Difficult project	✓			
Contributing to learning			✓	✓
Taking notes helped solving the problem			✓	
Fun way of learning	✓	✓	✓	✓

The cross-case analysis results of students' likes are summarized in Table 4. In all of the cases the students liked gaming elements situated in 3D environment such as driving cars, having an avatar, walking around with it in 3D environment, discovering new places, and even swimming. They also liked being able to see and interact with friends online in 3D worlds. Being presented in the form of a human-like-avatar made them feel they are really experiencing the environment in person and they see and feel the presence of their friends online. Students liked acting like a researcher trying to solve an environmental problem. The students in cases 3 and 4 also liked the opportunity of interacting with NPCs in Turkish since they had lack of English knowledge. This issue did not come out in cases 1 and 2 because the students were well-educated in English. Regardless of the cases the students liked being involved in the project and liked learning science concepts in a game-like environment.

Table 4 *Students' likes*

	Case1	Case2	Case3	Case4
Gaming elements (e.g. avatars, driving cars)	✓	✓	✓	✓
Interaction with friends	✓	✓	✓	✓
Interaction with NPCs			✓	✓
Being involved in the project and learning in QA	✓	✓	✓	✓
Acting like a scientist/researcher	✓		✓	

Students' dislikes across cases were provided in Table 5. In all of the cases, students stated that they disliked technical problems (slow Internet access, deficient capacities of computers) and bugs. It was not very common but when happened, it prevented students complete their work and caused QA software stop running. Then the students had to restart either the software or the computer, which distracted their studies. In school cases time limitation emerged as a dislike. In the cases that take place in informal learning setting, the students experienced the problem of being lost in 3D worlds. QA's English interface also made it harder for them to get rid of this situation. This could also be due to their prior gaming habits. Using QA was more exciting experience for the students in informal cases, because they did not have a similar experience before. On the other hand, some of the students of cases 1 and 2 found the software deficient in terms of gaming elements and graphical features due to their previous gaming habits. Some students in case1 even stated that they did not like QA at first but their opinions changed as the implementation progressed. For some of the students, the project was complex, reading through all the data was kind of boring, and they also disliked taking notes on their printed notebooks. In all of the cases, this was the first time the students involved in a MUVE project and it seemed they expected more gaming than reading or writing.

Table 5 *Students' dislikes*

	Case1	Case2	Case3	Case4
Technical problems and bugs	✓	✓	✓	✓
Limited time for implementation	✓	✓		
Complex, reading through all the data and taking notes	✓	✓	✓	✓
Getting lost in 3D world			✓	✓
Deficiency of QA in terms of gaming elements	✓	✓		

Students were asked to compare their regular science class activities with the inquiry-based science project in QA (Table 6). In all of the cases, students found the project fun and useful for their learning as bringing fun and learning together. They asserted that the project led them to science and to become a scientist, and it increased their interest towards either to science or environmental issues. On the other hand, few students in case 1 could not relate the project with science curriculum. This might be due to the project was a more different type of an educational activity than what they got used to. In fact, the project was chosen with the opinions and approval of the science teachers as being compatible with learning outcomes. Comparing with their school homework, the students found QA as more fun way of doing homework, with the opportunity to communicate with their friends, being online and being able to use the computer.

Many students asserted QA and the project was more motivating than their in-class science activities. QA project was mainly student-centered. The main teaching method in traditional class setting was lecturing, sometimes enrichened with lab experiments, and the main material was textbook. Especially in case 3 and case 4, the students complained about the science lessons as being teacher-centered and not having opportunity to express themselves or to practice what they have learned. The problem was related with crowded classrooms and teacher centeredness in their schools.

Table 6 *Students' comparison of QA implementation with traditional class setting*

	Case1	Case2	Case3	Case4
QA - More motivating / increased interest	✓	✓	✓	✓
QA - Could not relate with curricular science content	✓			
QA - Learning and fun together	✓	✓	✓	✓

Class - The use of text-books as the main source	✓	✓	✓	✓
Class - Lecturing in class as the main teaching method	✓	✓	✓	✓
Student-centered vs. teacher-centered			✓	✓
QA - Can express their opinions			✓	
Crowded classrooms in school			✓	✓
QA - Feeling more successful			✓	✓
Class - Teacher authority			✓	✓

4.2. Research Question 2 – Teachers' Perceptions of Using QA

Teachers' opinions about the use of QA as a technology-based supportive educational materials are summarized in Table 7. According to the results, using QA was beneficial for students to learn and to practice, and it was also more motivating when compared to regular in-class activities. The teachers found QA as an effective material with that the students could better remember what they had learned.

About the reading/writing parts of the project, the amount was found excessive in all cases. Students did not want to read or write much, which caused some students lose their motivation. However, none of them gave up because they were thrilled by the project. The time limitation in school cases was more of limiting. The teachers asserted that if there were more time, it could have been better.

Table 7 *Teachers' opinions about using QA*

	Case1	Case2	Case3	Case4
Beneficial	✓	✓	✓	✓
Motivating		✓	✓	✓
Learning by doing / practicing knowledge	✓	✓	✓	✓
Excessive reading/writing	✓	✓	✓	✓
More time needed	✓	✓		

Teachers' opinions about students' learning in the QA setting are summarized in Table 8. Teachers' opinions were positive in general. According to case 1 teacher, this project showed students could learn through games, however students needed some time to gain the discipline of this new learning method and to get used to it. Students were accustomed to learn through lecturing as the main teaching method and books as the main material. Using MUVEs for learning could be a handicap for them. Both teachers claimed that students mostly were interested in the project;

nevertheless, there were few uninterested students who were not very much into either the project or QA. There were just a few students with lower level of interest in cases 3 and 4 as well. This might be the related with different student learning styles.

In all cases, the potential of MUVE in providing students learn visually and by doing was pointed out. Moreover, the teachers believed that it enhanced students' skills (e.g. creative thinking, scientific thinking, analytical thinking, reading skills, critical thinking, problem solving). The teachers and the first author claimed the students could easily transfer what they learned to real life. They became aware of how important it was to protect their environment, the trees, and the animals as ecology was a complex system.

The teachers agreed that the students liked technology and they used it in their daily lives. Even case 1 teacher claimed that her students were more competent in technology use than herself. Case 2 teacher claimed the project did not only increase students' knowledge and awareness about environmental issues, but also enhanced their technology use skills. She also added that with the features QA provided, students could track their own learning progress as well.

In cases 3 and 4, scaffolding of students, especially of the younger ones, was emerged as an important theme. The field notebook was very helpful in scaffolding students in organizing their work and the data they collected. Field notebook gave clues to the students about what to do next to successfully complete the activity. Scaffolding was also conducted through classroom discussions that were held in order to make students share information with each other, decide on how to use the data they collected and think about the problem considering about others' perceptions of it. In informal cases, collaboration and competition among students emerged as a theme as well. The students who were more competent using QA helped peers during the project. They also competed with each other in order to complete the project first.

Table 8 *Teachers' opinions about students' learning*

	Case1	Case2	Case3	Case4
Enhances students' thinking strategies	✓	✓	✓	✓
Visual learning	✓	✓	✓	✓
Learning by doing	✓	✓	✓	✓
Students like technology	✓	✓	✓	✓
Students can track their progress		✓		

Transfer of learning	✓	✓	✓	✓
The importance of scaffolding			✓	✓
Collaboration and competition			✓	✓

The teachers mentioned about teacher's role in an educational environment where MUVEs are used (Table 9). Case 1 teacher believed in the effectiveness of technology-related implementations. She asserted that the current curriculum was open to technology-based implementations, but it was at the same time turned into a struggle due to curricular load. The other teacher also indicated that she liked being a teacher in a technology rich environment and mentioned about time problem and curricular load.

Comparing teaching in an educational environment using MUVE to teaching in a traditional classroom environment, case 1 teacher stated the former was more difficult. Feeling confident about technology usage case 2 teacher found it easier in terms of classroom management, assessing students learning and doing the implementation. In fact, as a participant-observer, the first author thought that using MUVEs in classroom environment was not easy at all. Time limitation, technical problems and the need to follow each student continuously and facilitating the activity in a crowded classroom environment was challenging especially in formal cases. In cases 3 and 4, classroom management was still an issue as the project took place in informal setting as a summer-time activity.

Table 9 *Teachers' opinions about teacher role*

	Case1	Case2	Case3	Case4
Teaching was easy		✓		
Teaching was difficult	✓		✓	✓
Like teaching with QA	✓	✓		
Want further use	✓	✓		
Teacher should be proficient	✓		✓	✓
The importance of teacher/facilitator in class		✓	✓	✓

Both teachers claimed that they would use the MUVE in the future. In cases 3 and 4, the importance of facilitator was an emerging theme. It was a complex learning activity and students could easily get lost in the virtual environment or in the activity. The facilitator (or the teacher) should be proficient enough in controlling students' progress, asking inspiring questions, making class discussions, supporting active participation, and scaffolding students.

5. Discussion

MUVEs are known as virtual environments where users can walk around and do tasks while interacting with other users, NPCs, content, or virtual objects (Ketelhut, Nelson, Clarke & Dede, 2010). In this study, the students defined their experiences in QA in a similar way. According to students, QA was a 3D environment where they could wander and interact their online friends and NPCs. They also pointed out that QA let them learn and have fun at the same time because it included both educational activities and game-like features. There are other studies showing students' likes about learning through MUVEs (Bayırtepe & Tüzün, 2007; Bakar, Tüzün & Çağıltay, 2008; Lee & Liu, 2017; Tüzün, Arkun, Bayırtepe-Yağız, Kurt & Yermenday-Uğur, 2008). In fact, in general, learning is imposed to the students as a "work" (e.g. homework or schoolwork) that should be completed before they can play computer games, this is like "eating one's vegetables before getting dessert" (Barab, Arici & Jackson, 2005, p. 15). This idea may transform "learning" to a must-done-work rather than an activity they would like being involved, and therefore cause "over-theorizing and over-valuing product and under-valuing the rich processes of learning, the joy, fun, challenge, and meaning have, in part been stripped out of educational activity" (Barab, Arici & Jackson, 2005, p. 19-20). As the results of the current study showed books were the mainly used materials and the way the teachers used the technology was still teacher-centered. In order to change this and providing constructivist student-centered learning environments, MUVEs can be used as a more fun and engaging way of learning.

Although not been measured through standardized tests in the current study, the students asserted that they learned things like facts about science, environmental issues, how to do research, collecting and analyzing data, and how to be a scientist. The teachers also agreed on this issue by stating QA allowed students learn by doing. In fact, the project was presented as part of the science class in formal cases, but it was an environmental project in informal cases. Despite this, the students in informal cases related their involvement as learning about science, too. The issues students learned were not only about content-related but also about some other skills and knowledge. Studies also claim that students who involved in educational activities in MUVE learn (Borona, Tambouris & Tarabanis, 2018; Dede, Ketelhut & Ruess, 2002; Dempsey, Lucassen, Haynes & Casey, 1996; Lan, 2015; Lim, Nonis and Hedberg, 2006; Loh, Harper & Howard, 2019; Tokel & Cevizci Karataş, 2014; Tüzün, Bilgiç & Elçi, 2019) sometimes even more than their peers who learn through traditional methods (Dede, Clarke, Ketelhut, Nelson & Bowman, 2005a; Ketelhut, Dede, Clarke & Nelson, 2006). They also have fun while learning with a MUVE (Chen, 2016;

Tüzün, Barab & Thomas, 2019), have more satisfaction (Vrellis, Avouris & Mikropoulos, 2016), and become more active (Kuznetcova, Glassman & Lin, 2019). In a similar study using Taiga world in QA, the researchers found "strong evidence that QA intervention supports transfer to externally developed, high-stakes achievement tests" (Barab et al., 2007, p. 768). At this point it is important to point out that MUVEs may not always ensure learning. The way the MUVE structured is very important; situating activities, scaffolding or facilitating learners, supporting interaction, providing with learning opportunities and the quality of the content are all important factors (Squire, 2002). It should be more than just walking around 3D space, which may not result in engagement (Lim, Nonis & Hedberg, 2006) or learning. It depends on the way how the technology and the pedagogy was combined (Squire, 2002). Parson and Bignell (2017) also claim problem-based learning scenarios increase the effectiveness of a MUVE in helping students learn.

Being game-like environments, MUVEs are motivating for the students (Chen & Kent, 2020; Fokides & Chachlaki, 2020; Pares-Toral, 2013; Tuzun, 2004; Tüzün, Yılmaz-Soylu, Karakuş, İnal & Kızılkaya, 2009). In the current study, students and teachers found QA as a motivating instructional material. In addition to game-like features, the mysterious story of virtual worlds and the complex problematic situations to be solved increase students' curiosity and interest towards the applications and learning (Dede, Clarke, Ketelhut, Nelson & Bowman, 2005b). Students' existing interest towards these environments can be used in either formal or informal learning settings with structured learning activities. Prensky (2001c) claim that there is a relationship between learning and having fun: the more students have fun, the more they become motivated towards learning. MUVEs, as game-like environments, offer a different type of learning experience than traditional ones because "it is about finding joy and fascination in the world, asking questions and engaging in inquiry, developing expertise and participating in social practice, and developing an identity as a member within a community" (Squire & Jenkins, 2003, p. 29). In the current study, regardless of the cases, the students thought that QA let learning and fun together. Comparing with science-classes, they added that QA was more motivating and it increased their interests. There are similar findings available in the literature. Tüzün, Yılmaz-Soylu, Karakuş, İnal and Kızılkaya (2009) claim that students have high level of intrinsic motivation and low level of extrinsic motivation while learning in a MUVE. According to Parson and Bignell (2017) MUVEs increase student motivation and makes fun and learning possible together. According to teachers' and students' perceptions, the reasons behind high student motivation could be that MUVEs allowed learning by doing, visually enhanced learning, sense of involvement, fun way of learning, students' control over their learning process, transfer of learning, and rich interaction.

From the teachers' point of view, QA enhanced students' thinking strategies, made transfer of learning easier and allowed collaboration and cooperation. Gamage, Tretiakov and Crump (2011) claim that teachers thought that MUVEs had positive effects on students' learning by providing students with authentic learning activities. The results were compatible with other studies in the literature. According to studies, MUVEs enhance students' skills, such as creative thinking (Songkram, 2015; Bourgeois-Bougrine, Richart, Lubart, Burkhardt & Frantz, 2019), critical thinking (Warren, Dondlinger & Barab, 2008), collaboration (McFarlane, Sparrowhawk & Heald, 2002; Tüzün, Bilgiç & Elçi, 2019), scientific thinking (Nelson et al., 2005), analytical thinking (Sardone & Devlin-Scherer, 2008), problem solving (McFarlane, Sparrowhawk & Heald, 2002), self-directed learning (Brown, Gordon & Hobbs, 2008) and spatial skills (Yıldırım & Zengel, 2014; Tüzün & Özdinç, 2016). The theme collaboration emerged by itself even though the implementation was planned as an individual activity. Collaboration can be regarded as the social activity that is required for knowledge construction according to socio-constructivists (Dickey, 2005). In the current study, students asked each other for their opinions about the problem-case and worked together at some points throughout the activity. Additionally, the students who were more computer-competent took the leadership role in class and helped other students. Having avatars were found as an enabler of collaboration among the students (Hong, Jeong, Kalay, Jung & Lee, 2016). Collaboration is not only good to share information with others, but also a motivating factor in MUVEs (Dede, Clarke, Ketelhut, Nelson & Bowman, 2005b). Collaborative learning has the potential of supporting students' communication and critical thinking skills (Roberts, 2005). It also gives students a chance to see others' perspectives (Veerman & Veldhuis-Diermanse, 2001). As MUVEs allow multiple users, students are able to see others in 3D environment and follow their friends' progress via clicking on their avatar and displaying their online portfolios.

Depending on student interviews, teacher interviews and observations, the results of this study asserted that scaffolding in this type of learning environments is very important. That is because getting lost in 3D environment or in the project may cause students lose their motivation and their self-efficacy. Lim, Nonis and Hedberd (2006, p. 226) also point out the importance of scaffolding in complex learning environments and say that when students are not provided with scaffolding "they might suffer cognitive overload that, in turn, might then result in disengagement".

Therefore, teachers, who want to implement similar projects in their classrooms, should ensure providing scaffolding for their students and facilitating them throughout the project. According to other research, teacher involvement in MUVE makes the learning context positive and might enhance students' learning (Zulkanain & Rahim, 2018), which is in fact very much related with the technology competency of the teachers (Sipilä, 2014). Collaboration among students can be a way of scaffolding, too. As Reiser (2004) asserts peers, who are more experienced, can scaffold to the students especially if they are learning in a complex learning environment. This concept is also very much related with the term "zone of proximal development" described by Vygotsky (1978). Another way of providing scaffolding can be provided with informative guiding tools, just like field notebooks used in the scope of this project.

6. Conclusion

Implementing the MUVE activity either in formal or informal learning environment requires extensive time which turn into a more challenging issue in formal learning environments because schools are more structured, there is a curriculum to complete, and teachers have an extensive work load. The use of MUVE results in different experiences with the students who are not privileged of technology use neither in school or at home or in the settings that are more flexible. The good thing is that, as this study shows, the students enjoy learning in a MUVE regardless of being in a formal or informal learning setting. The experience of learning in an immersive and fun virtual environment, using technology for learning or actively involving in learning process may be the factors influencing students' feelings about their learning in the current study. Learning in game-like MUVEs is not only a fun activity students love (Lan, 2015) but also easier than learning in school for the students (Dede, Ketelhut & Ruess, 2002). From the teachers' perspective MUVEs have the potential to enhance students' skills of using technology, thinking and collaboration. They are also motivating and effective learning environments that allow active student participation, retention and visualization of learning content. The use of MUVEs support high level of student engagement (Claman, 2015). Therefore, it is possible to say that providing students with learning environments using MUVEs does not only give them the opportunity for having fun but also for actively participate in learning.

References

Agrawal, A. K., & Mittal, G. K. (2018). The role of ICT in higher education for the 21st century: ICT as a change agent for education. *Multidisciplinary Higher Education, Research, Dynamics & Concepts: Opportunities & Challenges For Sustainable Development, 1*(1), 76-83.

Antonacci, D. M., & Modaress, N. (2008). Envisioning the educational possibilities of user-created virtual worlds. *AACE Journal, 16*(2), 115-126.

Bakar, A., Tüzün, H., & Çağıltay, K. (2008). Öğrencilerin eğitsel bilgisayar oyunu kullanımına ilişkin görüşleri: Sosyal Bilgiler dersi örneği. *Hacettepe* Üniversitesi *Eğitim Fakültesi Dergisi, 35*, 27-37.

Barab, S., Arici, A., & Jackson, C. (2005). Eat your vegetables and do your homework: A design-based investigation of enjoyment and meaning in learning. *Educational Technology, 65*(1), 15-21.

Barab, S., Thomas, M., Dodge, T., Carteaux, R., & Tuzun, H. (2005). Making learning fun: Quest Atlantis, a game without guns. *Educational Technology Research and Development, 53*(1)*,* 86-107.

Barab, S., Zuiker, S., Warren, S., Hickey, D., Ingram-Goble, A., Kwon, E. J., Kouper, I., & Herring, S. C. (2007). Situationally embodied curriculum: Relating formalisms and contexts. *Science Education, 91*(5), 750-782.

Barab, S., Sadler, T. D., Heiselt, C., Hickey, D., & Zuiker, S. (2007). Relating narrative, inquiry, and inscriptions: Supporting consequential play. *Journal of Science Education and Technology, 16*(1), 59-82.

Barab, S. A., Gresalfi, M., & Arici, A. (2009). Why educators should care about games. *Educational Leadership, 67*(1), 76-80.

Bassey, M. (1999). *Case study research in educational settings*. Buckingham: Open University Press.

Bayırtepe, E., & Tüzün, H. (2007). Oyun-tabanlı öğrenme ortamlarının öğrencilerin bilgisayar dersindeki başarıları ve öz-yeterlik algıları üzerine etkileri. *Hacettepe* Üniversitesi *Eğitim Fakültesi Dergisi, 33*, 41-54.

Board of Education. (2005). *Curriculum development studies by board of education (Talim Terbiye Kurulu Program Geliştirme* Çalışmaları*)*.

Borona, S., Tambouris, E., & Tarabanis, K. (2018). The use of 3d multi-user virtual environments in computer assisted second language learning: A systematic literature review. *International Journal of Learning Technology, 13*(3), 249-274.

Bourgeois-Bougrine S., Richard P., Lubart T., Burkhardt J.M., & Frantz B. (2018). Do virtual environments unleash everyone's creative potential?. In: Bagnara S., Tartaglia R., Albolino S., Alexander T., Fujita Y. (eds) Proceedings of the 20th Congress of the International Ergonomics Association (IEA

2018). IEA 2018. Advances in Intelligent Systems and Computing, vol 824. Springer, Cham.

Brown, E., Gordon, M., & Hobbs, M. (2008). Second life as a holistic learning environment for problem-based learning and transferable skills. *ReLIVE08 Conference*, The Open University, Milton Keynes, November 20–21.

Chen, J. C. (2016). The crossroads of English language learners, task-based instruction, and 3D multi-user virtual learning in Second Life. *Computers & Education, 102*, 152-171.

Chen, J. X., Yang, Y., & Loftin, B. (2003). MUVEES: A PC-based multi-user virtual environment for learning. In proceedings of the IEEE Virtual Reality 2003 (VR'03). IEEE Computer Society Press: New York. April 2003, 163-170.

Chen, J. C., & Kent, S. (2020). Task engagement, learner motivation and avatar identities of struggling English language learners in the 3D virtual world. *System, 88,* 1-14.

Claman, F. L. (2015). The impact of multiuser virtual environments on student engagement. *Nurse Education in Practice, 15,* 13-16.

Codier, E. (2016). Solo learning activities in content- or context-rich MUVEs: The MUVE as a learning crucible. In *Teaching health care in virtual space: Best practices for educators in Multi-User Virtual Environments* (pp. 47-55). Honolulu: University of Hawai'i Press.

Damer, B. (1997). Inhabited virtual worlds: A new frontier for interaction design. *SIGGROUP Bulletin, 18*(2), 21-26.

Dede, C., Ketelhut, D. & Ruess, K. (2002). Designing for motivation and usability in a museum-based multi-user virtual environment. Paper presented at the Annual Meeting of the American Educational Research Association, San Diego, CA.

Dede, C., Clarke, J., Ketelhut, D. J., Nelson, B., & Bowman, C. (2005a). Students' motivation and learning of science in a Multi-User Virtual Environment. Paper presented at the American Education Research Association, Montreal, Canada.

Dede, C., Clarke, J., Ketelhut, D. J., Nelson, B., & Bowman, C. (2005b). Fostering motivation, learning, and transfer in Multi-User Virtual Environments. Paper presented at the American Educational Research Association Conference, Montreal, Canada.

Dempsey, J. V., Lucassen, B. A., Haynes, L. L., & Casey, M. S. (1996). Instructional applications of computer games. Paper presented at the 1996 annual meeting of American Educational Research Association, New York City

Dickey, M. D. (2005). Three-dimensional virtual worlds and distance learning: Two case studies of Active Worlds as a medium for distance education. *British Journal of Educational Technology, 36*(3), 439-451.

Erlandson, B. E., Nelson, B. C., & Savenye, W. C. (2010). Collaboration modality, cognitive load, and science inquiry learning in virtual inquiry environments. *Educational Technology Research and Development, 58,* 693-710.

Esteve-González, V., Cervera, M. G., & Martínez, J. G. (2016). Exploring the social presence in 3D virtual learning environments. In *European Conference on Games Based Learning* (p. 977).

Fraenkel, J. R., & Wallen, N. E. (2003). *How to design and evaluate research in education*. New York: McGraw -Hill Company.

Fokides, E., & Chachlaki, F. (2020). 3D multiuser virtual environments and environmental education: The virtual island of the Mediterranean monk seal. *Technology, Knowledge and Learning, 25*(1), 1-24.

Gamage, V., Tretiakov, A. & Crump, B. (2011). Teacher perceptions of learning affordances of multi-user virtual environments. *Computers & Education, 57*(4), 2406-2413.

Gillham, B. (2000). *Case study research methods.* London and New York: Continuum.

Harris, A. L., & Rea, A. (2009). Web 2.0 and virtual world technologies: A growing impact on IS education. *Journal of Information Systems Education, 20*(2), 137-144.

Hernandez, R. M. (2017). Impact of ICT on education: Challenges and perspectives. *Propósitos y Representaciones, 5*(1), 325-347.

Hong, S. W. (2013). *The affordance of online multiuser virtual environments (MUVE) for creative collaboration* (Publication No. 3593812) [Doctoral dissertation, University of California, Berkeley]. ProQuest Dissertations & Theses.

Hong, S. W., Jeong, Y., Kalay, Y. E., Jung, S., & Lee, J. (2016). Enablers and barriers of the multi-user virtual environment for exploratory creativity in architectural design collaboration. *CoDesign, 12*(3), 151-170.

Johnson, B., & Christensen, L. (2004). *Educational research: Quantitative, qualitative, and mixed approaches*. Boston, MA: Pearson Education Inc.

Jonassen, D. H., Peck, K. L., & Wilson, B. G. (1999). *Learning with technology: A constructivist perspective.* Upper Saddle River, NJ: Merrill.

Kalyuga, S. (2007). Enhancing instructional efficiency of interactive e-learning environments: A cognitive load perspective. *Educational Psychology Review, 19*, 387-399

Ketelhut, D. J., Clarke, J., Dede, C., Nelson, B., & Bowman, C. (2005). Inquiry teaching for depth and coverage via multi-user virtual environments. Paper presented at the National Association for Research in Science Teaching, Dallas, TX.

Ketelhut, D. J., Dede, C., Clarke, J., & Nelson, B. (2006). A multi-user virtual environment for building higher order inquiry skills in science. Paper presented at the American Educational Research Association, San Francisco, CA.

Ketelhut, D., Nelson, B., Clarke, J., & Dede, C. (2010). A multi-user virtual environment for building higher order inquiry skills in science. *British Journal of Educational Technology, 41*(1), 56-68.

Kuznetcova, I., Glassman, M., & Lin, T. J. (2019). Multi-user virtual environments as a pathway to distributed social networks in the classroom. *Computers & Education, 130,* 26-39.

Lan, Y. J. (2015). Contextual EFL learning in a 3D virtual environment. *Language Learning & Technology, 19*(2), 16-31.

Lee, A. M., & Liu, L. (2017, March). Student Perceptions about Using Second Life in Online Communication: A Case Study. In *Society for Information Technology & Teacher Education International Conference* (pp. 1689-1694). Association for the Advancement of Computing in Education (AACE).

Lim, C. P., Nonis, D., & Hedberg, J. (2006). Gaming in a 3D multiuser virtual environment: Engaging students in Science lessons. *British Journal of Educational Technology, 37*(2), 211-231.

Lindberg, O. J., Olofsson, A. D., & Fransson, G. (2017). Same but different? An examination of Swedish upper secondary school teachers' and students' views and use of ICT in education. *The International Journal of Information and Learning Technology, 34*(2), 122-132.

Livingstone, S. (2012). Critical reflections on the benefits of ICT in education. *Oxford Review Education, 38*(1), 9-24.

Loh, V., Harper, B., & Howard, S. (2019). Using a MUVE to support knowledge and skill development with complex information science content. In Y. W. Chew, K. M. Chan, and A. Alphonso (Eds.), *Personalised Learning. Diverse Goals. One Heart. ASCILITE 2019 Singapore* (pp. 503-506).

McFarlane, A., Sparrowhawk, A. & Heald, Y. (2002). Report on the educational use of games: An exploration by TEEM of the contribution which games can make to the education process. TEEM, St Ives, Cambridgeshire, UK.

Merriam, S. B. (1998). *Qualitative research and case study applications in education*. San Francisco: Jossey-Bass.

Miles, M. B., & Huberman, A. M. (1994). *An expanded sourcebook: Qualitative data analysis.* Thousand Oaks, CA: Sage Publications.

Nelson, B., Ketelhut, D., Clarke, J., Bowman, C., & Dede, C. (2005). Design-based research strategies for developing a scientific inquiry curriculum in a multi- user virtual environment. *Educational Technology, 45*(1), 21–28.

Nelson, B. C. (2007). Exploring the use of individualized, reflective guidance in an educational multi-user virtual environment. *Journal of Science Education and Technology, 16*(1), 83-97.

Omale, N., Hung, W.C., Luetkehans, L. & Cooke-Plagwitz, J. (2009). Learning in 3- D multiuser virtual environments: Exploring the use of unique 3-D attributes for online problem-based learning. *British Journal of Educational Technology, 40*(3), 480-495.

Pares-Toral, M. T. (2013). *The effect of the use of the 3-d multi-user virtual environment Second Life on student motivation and language proficiency in courses of Spanish as a foreign language* (Publication No. 3603801) [Doctoral dissertation, Nova Southeastern University]. ProQuest Dissertations & Theses.

Parson, V., & Bignell, S. (2017). An investigation into cooperative learning in a virtual world using problem-based learning. *Online Learning, 21*(2).

Patton, M. Q. (2002). *Qualitative research & evaluation methods.* Thousand Oaks, CA: Sage Publications.

Pence, H. E. (2007). The homeless professor in second life. *Journal of Educational Technology Systems,* 36(2), 171-177.

Prensky, M. (2001a). Digital natives, digital immigrants part 1. *On the Horizon, 9*(5), 2-6.

Prensky, M. (2001b). Digital natives, digital immigrants part 2: Do they really think differently. *On the Horizon, 9*(6), 2-6.

Prensky, M. (2001c). Digital game-based learning. New York: McGraw Hill.

Raja, R., & Nagasubramani, P. C. (2018). Impact of modern technology in education. *Journal of Applied and Advanced Research, 3*(1), 33-35.

Reiser, B. J. (2004). Scaffolding complex learning: The mechanisms of structuring and problematizing student work. *The Journal of the Learning Sciences, 13*(3), 273-304.

Roberts, T. S. (2005). Computer-supported collaborative learning in higher education: An introduction. Ch 1 In T. S. Roberts (Ed.), Computer-supported learning in higher education. Hershey, PA: Idea Group Publishing, 1-18.

Sardone, N. B., & Devlin-Scherer, R. (2008). Teacher candidates' views of a multi-user virtual environment (MUVE). *Technology, Pedagogy and Education, 17*(1), 41-51.

Sipilä, K. (2014). Educational use of information and communications technology: Teachers' perspective. *Technology, Pedagogy and Education, 23*(2), 225-241.

Songkram, N. (2015). E-learning system in virtual learning environment to develop creative thinking for learners in higher education. *Procedia – Social and Behavioral Sciences, 174*, 674-679.

Squire, K. (2002). Cultural framing of computer video games. *The International Journal of Computer Game Research, 2*(1). Retrieved in June, 2001 online from http://www.gamestudies.org/0102/squire/

Squire, K., & Jenkins, H. (2003). Harnessing the power of games in education. *Insight, 3*(1), 5-33.

Stake, R. E. (2006). *Multiple case study analysis.* New York: The Guilford Press.

Steinkuehler, C., & Squire, K. (2009). Virtual worlds and learning. *On the Horizon, 17*(1), 8-11.

Strauss, A., & Corbin, J. (1998). *Basics of qualitative research: Techniques and procedures for developing grounded theory* (2nd ed.). Sage Publications, Inc.

Tokel, S. T., & Cevizci Karataş, E. (2014). Three-dimensional virtual worlds: Research trends and future directions. *Mersin University Journal of the Faculty of Education, 10*(1), 1-12.

Tuzun, H. (2004). Motivating learners in educational computer games. Unpublished doctoral dissertation, Indiana University, Bloomington.

Tüzün, H., Arkun, S., Bayırtepe-Yağız, E., Kurt, F., & Yermeydan-Uğur, B. (2008). Evaluation of computer games for learning about mathematical functions. *I-manager's Journal of Educational Technology, 5*(2), 64-72.

Tüzün, H., Yılmaz-Soylu, M. Karakuş, T., İnal, Y. & Kızılkaya, Y. (2009). The effects of computer games on primary school students' achievement and motivation in geography learning. *Computers & Education, 52,* 68-77.

Tüzün, H., Barab, S. A., & Thomas, M. K. (2019). Reconsidering the motivation of learners in educational computer game contexts. *Turkish Journal of Education, 8*(2), 129-159.

Tüzün, H., Bilgiç, H. G. & Elçi, S. Y. (2019). The effects of 3D multi-user virtual environments on collaborative learning and social presence. *International Electronic Journal of Elementary Education, 11(3),* 221-231.

Tüzün, H., & Özdinç, F. (2016). The effects of 3D multi-user virtual environments on freshmen university students' conceptual and spatial learning and presence in departmental orientation. *Computers & Education, 94*, 228-240.

Veerman, A., & Veldhuis-Diermanse, E. (2001). Collaborative learning through computer-mediated communication in academic education. In proceedings of the first European conference on CSCL, P. Dillenbourg, A. Eurelings, & K. Hakkarainen (Eds.), European perspectives on computer-supported collaborative learning., McLuhan Institute, University of Maastricht, Maastricht (2001), 625-632.

Vrellis, I., Avouris, N., & Mikropoulos, T. A. (2016). Learning outcome, presence and satisfaction from a science activity in Second Life. *Australasian Journal of Educational Technology, 32*(1), 59-77.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological proces*s. Cambridge-Massachusetts: Harvard University Press.

Warburton, S. (2009). Second Life in higher education: Assessing the potential for and the barriers to deploying virtual worlds in learning and teaching. *British Journal of Educational Technology, 40*(3), 414-426.

Warren, S. J., Dondlinger, M. J., & Barab, S. A. (2008). A MUVE towards PBL writing: Effects of a digital learning environment designed to improve elementary student writing. *Journal of Research on Technology in Education, 41*(1), 113-140.

Yıldırım, I., & Zengel, R. (2014). The impact of cognitive styles on design students' spatial knowledge from virtual environments. *TOJET: The Turkish Online Journal of Educational Technology, 13*(3), 210-215.

Yin, R. K. (2009). *Case study research: Design and methods.* Thousand Oaks, CA: Sage Publications.

Zulkanain, N. A., & Rahim, E. E. A. (2018). Assessing the students' perceptions towards their virtual learning experience bases on adapted multi-user virtual environment (MUVE) indicators. *Advanced Science Letters, 24*(11), 8778-8781.