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The effects of 3D multi-user virtual environments on freshmen university students' conceptual and spatial learning and presence in departmental orientation

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A B S T R A C T

The purpose of this study was to examine the usefulness of 3D multi-user virtual environments (MUVEs) for freshmen orientation purposes. To do so, a virtual orientation environment was developed on the Active Worlds MUVE. The study sample included 55 students who were enrolled in a university department. The study has a quasi-experimental control group design. The orientation was carried out a week before the academic semester. The virtual departmental orientation was conducted with 25 participants in the 3D MUVE, while the authentic departmental orientation was conducted with 30 participants who were led through the department by a guide. Both groups were administered a Conceptual Knowledge Test before and after their orientations along with a Spatial Knowledge Inventory and an Orientation Evaluation Questionnaire after the interventions. In addition, the Presence Questionnaire in Virtual Environments was administered to the virtual orientation participants. While the conceptual knowledge posttest scores of experimental and control groups increased significantly, there was no significant difference between them. It was found that students in the virtual orientation recalled spatial route details better than the participants in the authentic orientation, while there was no significant difference between the groups in terms of spatial landmark details and overall spatial scores. When the groups were compared in terms of evaluation factors, significant differences were observed in the effect on general learning and simplicity in favor of the virtual orientation, while there were no significant differences in perceived usefulness and enjoyment. Participants perceived a high level of presence in the virtual orientation. There was a small positive correlation between presence and conceptual knowledge and a moderate positive correlation between presence and spatial knowledge. Decreasing distraction factors in the virtual environment had a positive influence on students' conceptual and spatial learning. In general, the virtual orientation has similar or better results than authentic orientation in terms of the variables examined in this study. These findings demonstrate that 3D MUVEs can be effectively used by freshmen students for orientation purposes.

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1. Introduction

Orientation is a requirement for students at all levels when they start their university education (Pesch, Calhoun, Schneider, & Bristow, 2008). At educational institutions, the purpose of arranging orientations is to help students to adapt to their new environment and prevent them from feeling disempowered and out of place. Orientations increase students' satisfaction level and their perception of the reputation of the university (Alnawas, 2015). In order for an orientation to serve its purpose, sufficient preparation and organization must be done at the beginning of the school year before the students arrive (Poirier, Santanello, & Gupchup, 2007).

Orientations for freshmen include activities that help students adapt to the university environment more rapidly, such as providing information about the university and faculty and explaining the rules of university life. Some universities provide orientations on campus before the academic year begins, while others include it in the curriculum as a course. One relevant study found that the affordances of exploration, interaction, and immersion in 3D multi-user virtual environments (3D MUVEs) can provide rich opportunities for learning about the conceptual and spatial characteristics of a place (Tüzün, Yılmaz-Soylu, Karakuş, İnal, & Kızılkaya, 2009). These affordances in MUVEs might be used to design a virtual environment for student orientations, and this study implements this suggestion. The details and effects of this implementation are presented in this paper.

2. Theoretical framework and relevant literature

2.1. 3D multi-user virtual environments

Dickey (2003) describes 3D virtual environments as interconnected desktop virtual reality environments, while Maher, Skow, and Cigonani (1999) describe them as environments that enable users to navigate and do activities in a virtual environment and communicate among themselves at the same time. Although a majority of the initial 3D environment research focused on very expensive immersive environments worn as a headset rather than the desktop environments with standard computer hardware, Robertson, Card, and MacKinlay (1993) claim that the use of desktop 3D virtual environments is much easier than these immersive environments since people are more accustomed to them. Thanks to the development and popularization of the Internet, multiple users from different environments can come together and use multi-user 3D environments (Dalgarno & Hedberg, 2001). In recent years, bandwidths and the capacity of display cards have expanded and processor speeds have increased. Therefore, the obstacles to the popularization of the 3D environments have been eliminated, which resulted in the increase of the examples such as Active Worlds (1995), Moove (2000), Second Life (2003), There (2003), IMVU (2004), Kaneva (2004), vSide (2006), Smeet (2007) and PlayStation Home (2008), allowing designers and users to implement them in a variety of ways. For instance, Harvard University, Missouri University, Bradley University and approximately 80 other educational institutions use Second Life virtual environment in their distance education systems (Bell, Pope, & Peters, 2007), while Barab, Thomas, Dodge, Carteaux, and Tuzun (2005) leverage Active Worlds for a technology-rich educational game. MUVEs provide 3 important advantages to their users: a 3D space, avatars that represent users and real-time communication between users (Dickey, 2003).

It is also possible to create games, social activities and educational communities in MUVEs (Maher et al., 1999). The MUVEs have the potential to enable individuals gain more meaningful and long-lasting information when compared to traditional interactive multimedia environments. Not only navigating in the virtual environment but also changing the environment will enable students improve their comprehension levels. Kalyuga (2007) describes MUVEs as highly interactive since they provide dynamic feedback based on students' experiences and propose real-time individualized task selection. Kim, Lee, and Thomas (2012) analyzed the studies that use MUVEs for educational purposes. They classified the studies according to their educational practices, research techniques, platforms and the disciplines studied. The most widely studied subjects are foreign languages, science, computer science and general education. Moreover, Inman, Wright, and Hartman (2010) indicated that the studies in this field comprise student-centered activities such as role-playing, simulation, project-based learning, group learning, and learning by discovery. Tokel and Cevizci Karataş (2014) conducted a content analysis of the studies that use 3D MUVEs in education and concluded that virtual worlds had three different types of usage: e-learning, learning by experience and social interaction.

A MUVE can provide exploration, interaction and immersion affordances. It can also offer experiences that endow learners with more dependable and permanent knowledge than real life experiences (Jones & Warren, 2008). With all these features, MUVEs can be effective tools for distance learning (Dickey, 2003). MUVEs make it possible to recreate authentic environments in virtual worlds. Individuals not only can perform tasks and learn new things, but also participate in beneficial experiences to understand different concepts (Chittaro & Ranon, 2007). MUVEs can offer experiences that are not possible in real life (Eschenbrenner, Nah, & Siau, 2008), such as visiting historical sites, distant locations and the ocean floor (Dalgarno & Hedberg, 2001).

In some studies, researchers used 3D environments that enabled users to navigate in the places created. For instance, Popovici and Marhan (2008) designed an environment named Ozanne that made it possible to navigate in a virtual city. Ozanne is a 3D environment that makes it possible for users to attend virtual tours guided by an expert and make use of different communication tools in the virtual environment to contact each other. The guide indicates the locations that would attract their attention and the necessary information simultaneously. The guide can also change the scenario dynamically according to the behavior of the visitors. Larmore, Knaus, Dascalu, and Harris (2005) used an environment called VCampus at Nevada Reno University for the orientation of students and personnel, workers and visitors. They allowed users to navigate in the environment from both a first-person and a third-person view. They also made it possible to navigate on foot and by flying. The VCampus software gives information about the buildings on the campus and shows maps to indicate their locations. This environment also supports multi-user real time interaction, which makes it possible for users to communicate mutually or as a group. There are also 3D virtual environments created to inform users about specific places that, like the one in this study, allow users to navigate in the environment. Some are navigation environments created for the purpose of examining places (Chim, Lau, Leong, & Si, 2003; Yilmaz, Baydas, Karakus, & Goktas, 2015), some are virtual cities, virtual museums (Almeida & Shigeo, 2002) and virtual libraries (Tüzün et al., 2009; Dede & Ketelhut, 2003). While these studies are valuable since they detail the specification, design, and functionality of the 3D MUVE software, the current study adds value by reporting multiple influences, such as conceptual and spatial learning, presence, and user experience, of the 3D MUVE on participants in addition to its planning and implementation.

MUVEs are electronic environments that use metaphorical physical spaces and give users the feeling of "being there" (Maher et al., 1999). When taking the space into consideration, there are two possible frames of reference: egocentric frame of reference, where the user is the reference point, and allocentric frame of reference, where the environment is the reference point (Bae et al., 2012). 3D MUVE software put these frames of reference into service by allowing the use of either first-person view (egocentric frame of reference) or third-person view (allocentric frame of reference) for navigation. The adaptation of these environments to learning environments created some problems, such as the use of 3D interfaces and difficulties with navigation in the environment (Youngblut, 1998). A main aspect that is used to evaluate the adequacy of MUVEs with respect to these issues is the concept of presence (De Lucia, Francese, Passero, & Tortora, 2009; Whitelock, Brna, & Holland, 1996). Three-D virtual worlds provide a stronger feeling of presence than video or conference systems, which helps them to create interaction (de Freitas & Veletsianos, 2010).

2.2. *Presence in virtual environments*

MUVEs are accepted as instruments that can be used to introduce a certain place, which raised the question of increasing their effectiveness in the designing process. Accordingly, some researchers have advanced the concept of presence in 3D virtual environments (e.g., Schubert, Friedmann, & Regenbrecht, 1999; Witmer & Singer, 1998). Studies on the perception of presence have attracted a significant amount of attention recently for many reasons. For example, a strong perception of presence suits the entertainment industry since it creates a realistic, exciting and, at the same time, a safe environment for audiences (Weich, 1999).

Steuer (1992) describes presence as the feeling of being in an environment. Loomis (1992) indicates it is a feeling created by a learning experience. Thie and Wijk (1998) describe presence as a person's feeling in a 3D virtual environment that users can communicate with each other and navigate. IJsselsteijn and Riva (2003) describe it as the feeling of being there. Presence refers to the degree to which users feel like part of the virtual environment (Hofmann & Bubb, 2003). Users with a strong perception of presence perceive the virtual environment as the reality that surrounds them rather than as images on screens (Slater, Linakis, Usoh, Kooper, & Street, 1996). In many studies, users have the perception of being a part of the virtual environment (e.g., Slater, 1999; Usoh, Catena, Arman, & Slater, 2000; Witmer & Singer, 1998).

Presence is sometimes confused with immersion. Immersion is a term for technologies that increase the perception of presence (Hofmann & Bubb, 2003; Slater, 2000). According to Steuer (1992), the concept of presence can be divided into detachment from and immersion in the virtual environment. Presence is distracted in cases of detachment and it is increased in cases of immersion (Thie & Wijk, 1998). As Witmer and Singer (1998) indicate, the perception of presence can be influenced by control factors, sensory factors, distraction factors and realism factors. If users' interaction with the virtual environment and their control over events is created in a natural way, the user experience will change according to the instructions of the user. The minimization of the distractors in the environment increases the immersion of the user in the environment and positively influences their participation. Since presence is hard to account for, empirical research should be conducted to determine its role, value and necessity in learning environments (Whitelock & Jelfs, 1999). A part of the current research is an attempt in this direction by studying the perception of presence in the virtual environment.

2.3. *Spatial learning*

A virtual environment designed for orientation is expected to both create the perception of presence and give users the opportunity to learn about the places they navigate. There are a variety of options for learning spatial information about an authentic environment. Spatial knowledge can be learned both directly by physical navigation in the environment and from secondary sources such as maps (Darken & Peterson, 2002). In addition, photographs, verbal information and, now, MUVEs can be spatial learning instruments (Jansen-Osmann, 2002).

Spatial knowledge was divided into landmark, route and survey knowledge by Siegel and White (1975) and Thondyke and Goldin (1983). According to this model, landmarks are the first thing people notice when they enter an environment. Landmarks are unique and static. They are also independent from each other. The connection of landmarks with paths creates the knowledge of routes. Survey knowledge links previously known locations and paths. Thus, being informed about the objects and locations in the environment plays a key role in getting to know about other paths. Studies of spatial learning in virtual environments indicate that MUVEs provide results similar to those of real-life spatial learning experiences (e.g., Waller, Hunt, & Knapp, 1998; Wilson, 1999). These studies also indicate that the perception of presence in virtual environments and its correlation with spatial learning are issues to be considered. A part of the current research is an attempt in this direction by studying the correlation between the perception of presence in the virtual environment and conceptual/spatial learning.

2.4. The relation between presence in virtual environments and spatial learning

The relation between presence and performance is not quite clear in the spatial learning tasks in previous studies (Stanney et al., 1998). Although one study on virtual environments found a positive correlation between presence in virtual environments and task performance (Witmer & Singer, 1994), another study of the same tasks found no such correlation (Singer, Ehrlich, Cinq-Mars, & Papin, 1995). Similarly, one study found a positive correlation between presence in virtual environments and spatial learning (Singer, Allen, McDonald, & Gildea, 1997), while another study using different measurement tools (Bailey & Witmer, 1994) found no correlation. Slater et al. (1996) studied a complicated 3D object and events related to that object using a control group experimental design to determine the correlation between presence perception and spatial performance. They found that navigating with a first-person view instead of a third-person view in the virtual environment increased presence and immersion. However, presence and spatial performance were not found to be correlated.

2.5. Purpose of the study

Reasons such as the insufficient numbers of experts and students' obligation to spend a certain amount of time in orientations present in an authentic environment reduce the student participation in authentic orientations and, accordingly, their effectiveness. When participation in orientations at universities is not obligatory, students may prefer not to attend them. In the process of adaptation to the school environment, there is need for a more individualized service. To make students more willing to participate in orientations, they should be given in a more interesting way. Recently, some universities have begun to orient their students while entertaining them at the same time, instead of having them passively led around the campus. Providing orientations on the Internet using MUVEs may spare them from the obligation to be present at a certain time in a physical environment and enable them wander around the places they want to learn about whenever they wish. MUVEs can bring students together in a virtual environment and give them the feeling of walking around a real environment. For all these reasons, MUVEs may be a good alternative for student orientations; however, their potential to orient students about specific places needs to be confirmed. This unique study is an attempt in this direction by involving multiple influences of the 3D MUVEs on participants not available in previous similar studies.

This study aimed to determine the practicality of using Active Worlds and similar 3D MUVEs for freshmen orientation. The researchers developed and used a virtual orientation environment and obtained information about its planning, implementation, and influence on students. The research questions are: 1) What is the influence of orientation method on conceptual learning when virtual and authentic orientation environments are used? 2) What is the influence of orientation method on spatial learning when virtual and authentic orientation environments are used? 3) Is there any difference between virtual and authentic orientation environments in terms of orientation evaluation factors? 4) Does the MUVE used in the study successfully create a perception of presence in the virtual environment? 5) What is the correlation between the perception of presence in the virtual environment and conceptual learning? 6) What is the correlation between the perception of presence in the virtual environment and spatial learning?

3. Methodology

This is a quantitative study which used the control group research model, a quasi-experimental design (Fraenkel, Wallen & Hyun, 2012).

3.1. Research context and participants

The participants were freshmen students in a Computer Education and Instructional Technology (CEIT) Department at a large state research university in central Turkey. There was no official university or departmental orientation in the academic year when the study was conducted. The study sample consisted of 55 participants. The experimental group included 25 students (12 females and 13 males), and the control group included 30 students (13 females and 17 males).

3.2. Design of the virtual orientation environment

The authors used Active Worlds (AW) in the study, which is a 3D multi-user virtual environment (http://www.activeworlds.com). The users are represented by virtual characters called avatars in the AW virtual environment. The Active Worlds interface has 4 components (Fig. 1). On the left, there is a 3D space in which users can navigate. On the right, there is a web browser on which information and instructions appear. At the bottom, there is a chat window which users can use for real-time communication with each other, and at the top, there are toolbars that can be used to change different

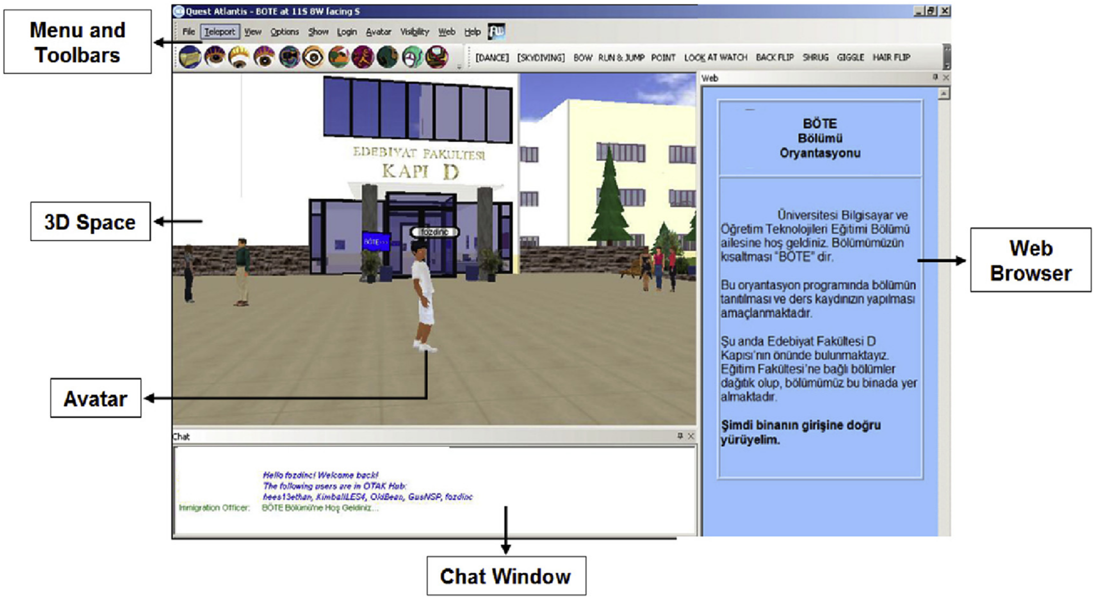

Fig. 1. Components of the Active Worlds interface.

settings. Users can resize these components as they wish by dragging and dropping or close them, except for the 3D component.

The researchers developed and used a virtual environment for student orientation in the AW environment. The initial design of the virtual environment was made by undergraduate students in a design course. The virtual world in question was further developed by the researchers for student orientation, including the iterative processes.

The researchers took photographs of the authentic environment before arranging the virtual environment. The researchers also walked through the department and the virtual environment together with the academicians in the department to determine possible arrangements. All objects were placed in their actual locations in the real environment to reflect the environment thoroughly. The authors found the virtual counterparts of the objects that were most similar to them. The authors also consulted the help page of Active Worlds. The objects that could not be found were created using objects on hand. For instance, the projection device was not among the objects found, so the authors reproduced one using a camera and a few boxes.

After arranging the environment, the authors did a usability test on the 3D virtual environment with 4 academicians who were knowledgeable about the authentic environment, and a visitor who came to the department for the first time. This was intended to allow the environment to be used by different users and benefit from their different perspectives and experiences. The users were asked to navigate all its sections and record any difficulties and their suggestions. The researchers rearranged the environment based on these data.

The virtual orientation environment was designed starting from the building gate including the classrooms, laboratories, and the offices of the faculty. The design aimed to enable the users to navigate in the environment. Although users were able to see and interact with other users in the 3D MUVE, the virtual orientation was designed as a solitary experience and did not require any collaboration or interaction among users. Fig. 2 shows the images of the authentic and virtual environments from air view. The authors considered the elements required by a student orientation (Güven, 2008; Kaya, 2007; Yeşilyaprak, 2005) and designed the scenario of the 3D virtual department orientation to allow users to navigate the classrooms and laboratories of the department one by one, to get information from the department chair, to be introduced to their advisor, and finally, to enable them to walk around the department independently and meet the department staff. The virtual world allows users freedom of movement and an open-ended experience in which they are not told when to stop.

Virtual orientation users were required to follow the information and instructions in the web browser. The instructions were shown when a user interacted with (i.e., mouse clicked) Non-Player Characters (NPCs) such as secretary, research assistants, faculty members, department chair, and freshmen students' advisor. The same level of interaction was also possible with some objects; for example, clicking a computer object in the 3D space showed the hardware specifications of that computer in the web browser. Information and instructions in the web browser prevented freshmen from missing the locations, such as classrooms, laboratories, and offices, which would be beneficial for them to know while navigating the virtual environment. For this purpose, the researchers used invisible objects in the virtual environment that triggered information and instructions in the web browser. These invisible objects could not be seen by users and can only be seen on the administrator screen used by the environment's designer. These invisible objects were used to update the web browser with the appropriate information and instructions based on user's navigation. The invisible objects were also used as barriers to

Fig. 2. Authentic and virtual environments from air view.

prevent students from going to some places. This kept students from moving to another section before navigating in another one. Manipulation of objects in the 3D space was limited to door objects in the virtual orientation to provide an equal experience with the authentic orientation. In this sense, when a user interacted with (i.e., mouse clicked) the closed door of a location, the door was opened solely for that user.

3.3. Procedures

The authors interacted with the students during their admission process, which took place at the registrar's office, and briefly informed them about the research and distributed pamphlets indicating the time and place of the orientation. The students were reminded of these by e-mail one week before the orientation. Almost all of the participants visited the department for the first time on the day of the orientation. Based on a random selection, students with an even student number were included in the virtual orientation (the experimental group), and those with an odd student number were included in the authentic orientation (the control group). Three-D virtual orientation was conducted in the morning, and the authentic orientation was conducted in the afternoon. Participants in the control group were not admitted into the building until their designated time slot to preserve their prior conceptual and spatial knowledge.

3.3.1. The experimental group

Before the orientation, the students were gathered in a classroom and were informed about the research, the orientation and their purposes along. They were briefly trained how to use AW. The authors administered a demographic questionnaire and a conceptual knowledge pretest. Then, the students were taken to the two laboratories where they would perform the virtual orientation tour. Beforehand, the researchers started the computers in the laboratory, which included 17-inch LCD monitors, 3 GHz Intel Pentium 4 processors, 512 MB RAM memory, and 80 GB Hard Disk Drives, and logged in to the AW environment with a first-person view using the usernames and passwords prepared for the use of students in the virtual world. Three research assistants in the department were in the laboratories to guide the students' use of the virtual environment. It was observed that the students did not have much difficulty using the virtual orientation environment and navigated it successfully with no problems. The virtual orientation lasted approximately half an hour. The authors waited for all students to complete the orientation. Those who finished it earlier were recommended to navigate the virtual environment freely. After all students completed the orientation, the group left the laboratories and went back to the classroom. The students were administered the Presence Questionnaire in Virtual Environments, the conceptual knowledge posttest and the Orientation Evaluation Questionnaire, respectively. Afterwards, the students were asked to draw a sketch of the department.

3.3.2. The control group

While the control group was given an orientation in the authentic environment, their experiences were similar to those in the virtual environment. The researchers met the students in a classroom and gave them information about the research, the orientation and their purposes. The students were administered a demographic questionnaire and a conceptual knowledge pretest. Then, they were taken to the gate of the department's building to start the orientation. The information and instructions in the virtual orientation were used unchanged in the authentic orientation to ensure similar experiences for both groups. The authors also planned where and how to transfer this information to the students beforehand. During the orientation, the students did not stand in each other's way and could see the guide. The guide led students around while giving them the information. The group was stopped before giving information to students, and the briefing started after making sure that all students could see and hear the guide. The guide stood on a higher platform when possible to be seen clearly by the students.

It was ensured that all students entered the relevant locations such as classrooms, laboratories, and offices. After all the students entered the location, they were asked to stand around the guide. Then, the guide gave information while walking around the students, approaching and pointing at the objects or locations in discussion. Of the three research assistants who attended the orientation, one took photographs, one did video-recording, and one observed the process. The authentic orientation lasted approximately half an hour. After the authentic orientation, the students were taken back to the classroom and were administered the conceptual knowledge posttest and the Orientation Evaluation Questionnaire. Then, they were asked to draw a sketch of the department.

3.4. Data sources

The data were collected using the 27-item Presence Questionnaire in Virtual Environments, the 18-item Conceptual Knowledge Test, the 15-item Orientation Evaluation Questionnaire, the Spatial Knowledge Inventory, and a demographic questionnaire.

3.4.1. The Presence Questionnaire (PQ) in virtual environments

The questionnaire was created by Witmer and Singer (1998). The items in the questionnaire were translated into Turkish to be used in the study. The PQ is a 7-point Likert type scale consisting of 4 factors and 32 items. It measures users' perceptions of presence in virtual environments. Control factors, sensory factors, distraction factors and realism factors are the elements that influence users' perceptions of presence in virtual environment experiences (Witmer & Singer, 1998). Since this study's virtual environment did not include audio or haptic elements, the authors excluded 5 items concerning these elements from the scale, leaving 27 items. Witmer and Singer (1998) calculated the Cronbach's alpha coefficient of the scale to be 0.81, while this value is 0.77 in this study.

3.4.2. The conceptual knowledge test

The authors created and used a Conceptual Knowledge Test with 18 multiple choice questions. It tests the students' knowledge of the department's objectives, locations, personnel and such relevant information. There are four options for each question on the test. Each correct answer in the test earns 1 point, so the maximum possible score on the test is 18.

3.4.3. The orientation evaluation questionnaire

This questionnaire was adapted from Cheung and Huang (2005) to learn about students' orientation experiences. Its 15 questions concern the factors of influence on general learning, perceived usefulness, enjoyment and complexity. The questionnaire uses a 5-point Likert type scale.

3.4.4. The spatial knowledge inventory

The students in both groups were asked to sketch all the elements they saw during the orientation, draw the objects, locations and paths they remembered, and label the locations. The aim of these sketches was to determine the students' spatial learning in the orientation based on Siegel and White (1975) and Thondyke and Goldin (1983) framework of landmark (objects and locations) and route (paths). The authors prepared a Spatial Knowledge Inventory for students' aerial view sketches of the department. The sketches were scored for the objects, locations and paths shown on them. To make a clearer distinction between the sketches, the authors conducted a detailed evaluation of the direction of each path and orientation of each location.

Schmelter, Jansen, and Heil (2009) solicited aerial view sketches of virtual environments from users after their experiences in them. While evaluating them, they scored the correctness of the turns to the left and right from the start to the finish. In the current study, the authors considered whether the relevant path was drawn or not. If the path was drawn, then they considered the correctness of its direction. If the path was drawn in an incorrect direction, it scored 0.5 points. If it was drawn in the correct direction, it scored 1 point. The correctness of the direction of the path was determined by checking its direction relative to the previous path. If the path before the relevant path was not drawn, then the authors decided by looking at the latest path drawn correctly by its direction. Ten paths starting at the building's entrance were included in this evaluation (Fig. 3). If the location was drawn, then the correctness of its orientation was considered. If the location was drawn in an incorrect orientation, it scored 0.5 points. If it was drawn in the correct orientation, it scored 1 point. Each of 6 objects scored 1 point. The maximum score for locations is 27 and it is 6 for objects. The maximum possible spatial learning scores are 33 for landmarks, 10 for routes, and 43 overall.

3.4.5. Demographic questionnaire

Gender, university entrance examination scores, and high school grades of the participants were collected through this questionnaire.

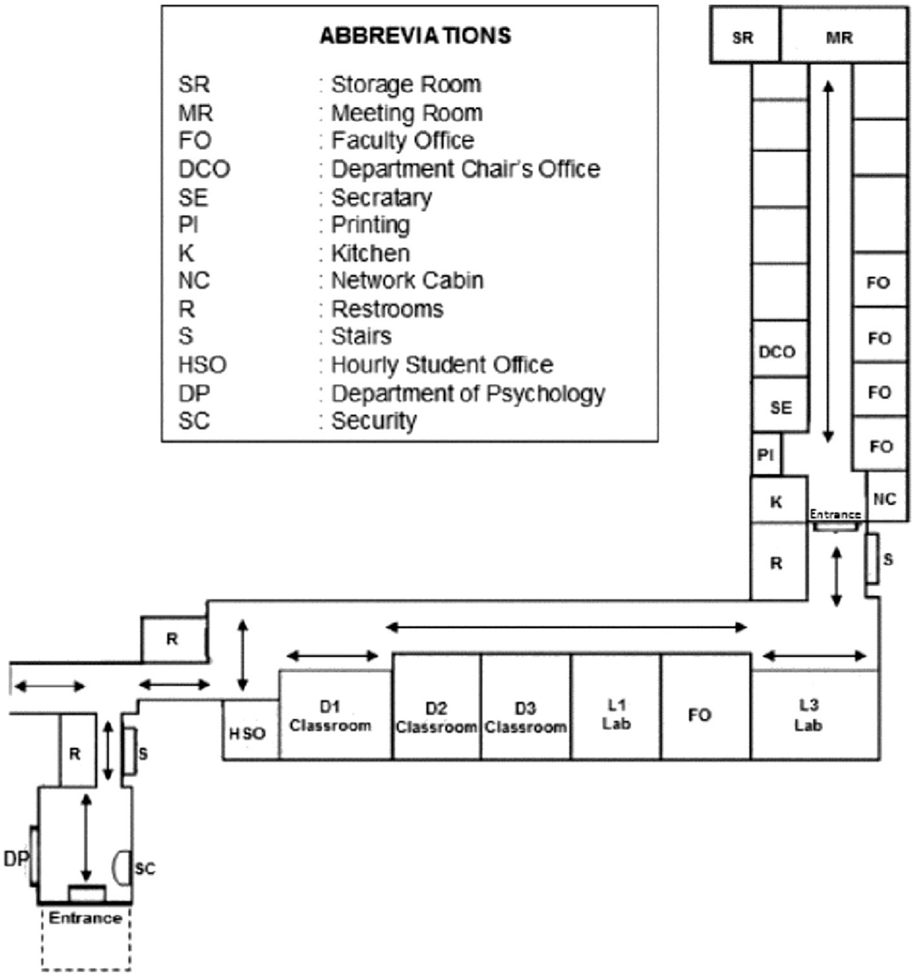

Fig. 3. Orientation environment from air view.

3.5. Data analysis

An independent samples t-test was conducted to determine any differences between experimental and control groups in terms of university entrance examination scores, high school grades, conceptual knowledge pretest scores, spatial learning scores and orientation evaluation scores. A paired samples t-test was conducted to determine any differences between the conceptual knowledge pretest and posttest scores of experimental and control groups. To measure the influence of orientation method on conceptual learning, the authors analyzed all the students' conceptual knowledge pretest and posttest scores using ANCOVA. The authors used bivariate correlation to determine any significant relation between the perception of presence in the virtual environment and conceptual learning and between the perception of presence in the virtual environment and spatial learning.

4. Findings

Before analyzing the data related to the research questions, the university entrance examination scores and the high school grades of the experimental and control groups were compared to evaluate the similarity of the groups. The university entrance examination scores of the experimental group ($X = 352.56$, $SD = 2.73$) and the control group ($X = 352.30$, $SD = 3.15$) are close to each other, and there is no statistically significant difference between them ($t_{53} = -0.324$, $p > 0.05$). The high school grades of the experimental group ($X = 86.30$, $SD = 6.79$) and the control group ($X = 86.40$, $SD = 7.65$) are close to each other, and there is no statistically significant difference between them ($t_{53} = 0.56$, $p > 0.05$). These results indicate that experimental and control groups are similar.

4.1. What is the influence of orientation method on conceptual learning when virtual and authentic orientation environments are used?

The conceptual knowledge pretest found no statistically significant difference ($t_{53} = -1.981$, $p > 0.05$) between the experimental (X = 4.64, SD = 2.10) and the control groups (X = 3.67, SD = 1.54). In order to determine whether conceptual learning was realized or not, a paired-samples t-test was conducted for each group. The experimental group's posttest mean score (X = 12.24, SD = 1.96) is higher than the pretest mean score (X = 4.64, SD = 2.10), and this difference is statistically significant ($t_{24} = -20.558$, $p < 0.001$). The control group's posttest mean score (X = 12.30, SD = 2.23) is higher than the pretest mean score (X = 3.67, SD = 1.54), and this difference is statistically significant ($t_{29} = -27.31$, $p < 0.001$). These findings indicate a positive change in the conceptual learning of students in both groups.

The orientation methods used additionally were compared in terms of their effects on conceptual learning. An independent samples two-way analysis of covariance (ANCOVA) was conducted by using the pretest scores as the co-variant and the orientation method as the fixed factor. The results indicate that there is no significant difference between the posttest mean scores of the groups ($F_{1-52} = 2.343$, $p > 0.05$). The magnitude of the differences in the means was very small (eta squared = 0.043).

4.2. What is the influence of orientation method on spatial learning when virtual and authentic orientation environments are used?

The spatial learning mean score (maximum possible score = 43) for the sketches of the experimental group (X = 17.76, SD = 6.14) is higher than that of the control group (X = 15.76, SD = 7.84); however, this difference is not statistically significant ($t_{53} = -1.045$, $p > 0.05$).

The spatial learning of experimental and control groups were also analyzed by landmarks and routes. The spatial learning scores of the groups by landmarks were compared (maximum possible score = 33) and it was found that the mean score of the experimental group (X = 13.39, SD = 5.95) is higher than that of the control group (X = 12.91, SD = 7.89); however, this difference is not statistically significant ($t_{53} = -0.252$, $p > 0.05$). The spatial learning scores of the groups by routes were compared (maximum possible score = 10) and it was found that the mean score of the experimental group (X = 5.65, SD = 1.73) is higher than that of the control group (X = 4.46, SD = 1.83) and this difference is statistically significant ($t_{53} = -2.465$, $p < 0.05$). In this case, the magnitude of the differences in the means was very large (eta squared = 0.67).

4.3. Is there any difference between virtual and authentic orientation environments in terms of orientation evaluation factors?

The orientation evaluation questionnaire was analyzed regarding the factors of influence on general learning, perceived usefulness, enjoyment and complexity. When the groups are compared regarding the influence on general learning, the difference between the experimental group (X = 3.94, SD = 0.49) and the control group (X = 3.54, SD = 0.59) is statistically significant ($t_{53} = -2.684$, $p < 0.05$) and favors the experimental group. When the groups are compared for perceived usefulness, the difference between the experimental group (X = 4.22, SD = 0.31) and the control group (X = 3.99, SD = 0.57) is not statistically significant ($t_{53} = -1.859$, $p > 0.05$). When compared for enjoyment, it is observed that the difference between the experimental group (X = 4.17, SD = 0.54) and the control group (X = 3.90, SD = 0.64) is not statistically significant ($t_{53} = -1.662$, $p > 0.05$). In the 5-point Likert rating for complexity, 5 means more complicated, and 1 means less complicated. When the groups are compared for complexity, the difference between the experimental group (X = 1.44, SD = 0.41) and the control group (X = 1.94, SD = 0.67) is statistically significant ($t_{53} = 3.240$, $p < 0.05$).

4.4. Does the MUVE used in the study successfully create a perception of presence in the virtual environment?

The Presence Questionnaire in Virtual Environments is a 7-point Likert type scale. Positive views about the reflection of presence perception in the virtual environment are expressed with grades close to 7 and the negative views are expressed with views close to 1. The maximum possible score on this scale is 189 (27×7). The mean value of the presence in the virtual environment (X = 137.52, SD = 12.04) is higher than the mid-point level, which is 108 (27×4). Individual results range between 115 and 161. These values indicate that the perceptions of presence of all participants in the study are above the mid-point level. This shows that the virtual environment used in this study has high level of presence for the participants.

The Presence Questionnaire in Virtual Environments was analyzed for control factors, sensory factors, distraction factors and realism factors. In the distraction factor, 1 expresses the state of distraction and 7 expresses the state of a lack of distraction. The mean PQ score of the control factors (X = 5.15, SD = 0.43), sensory factors (X = 5.29, SD = 0.65) and realism factors (X = 5.60, SD = 0.68) are above the mid-point level, while the mean score of the distraction factors (X = 4.27, SD = 0.76) is almost at the mid-point level.

4.5. What is the correlation between the perception of presence in the virtual environment and conceptual learning?

If the correlation coefficient (as an absolute value) is between 1.00 and 0.50, it is deemed to be a high level of correlation. If it is between 0.49 and 0.30, it is moderate, and if it is between 0.29 and 0.10, then it is low (Cohen, 1988). The significance of r is strongly influenced by the size of the sample, and in a small sample (i.e., $n = 25$ in this study), there can be moderate correlations that do not reach statistical significance at the traditional $p < 0.05$ level.

There is a low level positive correlation between the perception of presence in the virtual environment and conceptual learning ($r = 0.181$, $n = 25$, $p = 0.386$) (see Table 1). There is a moderate positive correlation between the distraction sub-factor and conceptual learning ($r = 0.421$, $n = 25$, $p < 0.05$). For the distraction factor, 1 expresses a state of distraction and 7 expresses a lack of distraction. Therefore, it was found that students' conceptual learning increases in less distracting virtual environments.

Table 1
Correlations between presence and its sub-factors and conceptual learning.

	Presence	Control	Sensory	Distraction	Realism
Conceptual learning	0.181	−0.035	0.07	0.421*	0.101

Note. *$p < 0.05$.

4.6. *What is the correlation between the perception of presence in the virtual environment and spatial learning?*

There is a moderate positive correlation between presence in the virtual environment and spatial learning ($r = 0.303$, $n = 25$, $p = 0.141$) (see Table 2). There is a moderate positive correlation between distraction, which is a sub-factor of presence in the virtual environment, and spatial learning ($r = 0.368$, $n = 25$, $p = 0.07$). For the distraction factor, 1 expresses a state of distraction and 7 expresses a lack of distraction. Therefore, it was found that students' spatial learning increases in less distracting virtual environments.

Table 2
Correlations between presence and its sub-factors and spatial learning.

	Presence	Control	Sensory	Distraction	Realism
Spatial learning	0.303	0.023	0.055	0.368	0.279

5. Discussion

The main objective of this study is to examine the usefulness of 3D multi-user virtual environments for student orientations. In line with the previous studies (e.g., Tüzün et al., 2009), this study supports the idea that the affordances of exploration, interaction, and immersion in 3D MUVES can be used for learning about the conceptual and spatial characteristics of a place.

The conceptual knowledge of students significantly increased after both virtual and authentic orientations. The authors provided an effective orientation to the students by following the orientation design principles dictated by Yeşilyaprak (2005). When the virtual and authentic orientations are compared regarding conceptual learning, there is no statistically significant difference between them. In other words, students gained approximately the same amount of conceptual knowledge from both orientation experiences. Presumably, this is a result of the fact that the virtual orientation environment was designed to be exactly the same as the authentic orientation.

The spatial learning score of the virtual orientation group regarding routes is higher than that of the authentic orientation group. This difference is statistically significant. Although there is no significant difference between the scores, the spatial learning score for landmarks and overall spatial learning score are higher for the virtual orientation group than they are for the authentic orientation group. The spatial learning results indicate that the students who navigated the virtual environment attained more spatial learning. Apparently, this resulted from the fact that the virtual orientation group observed it from a first-person view and controlled the pace of the orientation. As a supporting evidence, Bae et al. (2012) found that egocentric representation influenced presence and perceived realism more strongly compared to allocentric representation. Further, research in authentic environments has revealed that those who navigate by driving learn more spatial information than those who ride passively in cars (Sandamas & Foreman, 2007). Since each student navigates the environment at their own pace in the virtual experience, the possibility of having a crowd around them is relatively lower than it is in the authentic orientation. In the authentic orientation, students navigated in a 30-person group, they had a narrower view and thus, they were distracted. Students who attended the authentic orientation said that they thought the orientation was too crowded, which supports this view.

Students' perceptions on general learning differed by the orientation method. This may be because students could control their own learning process in the virtual environment. Further, students in the authentic orientation found the environment more complicated. This may be because the orientation was conducted with a large group of students. A review of the negative opinions of students about the authentic orientation indicates that their main complaint was the large number of participants. Orientations at universities are usually conducted with a guide and groups of 20 or 30 students. Students attending the authentic orientation said that it should be done with smaller groups of students. However, limitations related to specialist personnel, equipment and resources prevent conducting the authentic orientations with smaller groups (Yeşilyaprak, 1989). Virtual orientation environments designed by specialists in orientation may make it possible to overcome these limitations. Regarding usefulness and enjoyment, there are no significant differences between the two groups, both of which said they had fun during the experience. Williams (2014) determined a high level of correlation between enjoyment and presence perception. Similarly, it is possible that the students were amused by the virtual orientation thanks to a high perception of presence.

Yang and Tong (2012) compared presence, eye movements and visual fatigue in a 3D environment experience. An increase in presence reduced visual fatigue, although it increased eye movements. This indicates that presence should be regarded as an important design element in virtual environments to ensure that users have an engaging experience. The 3D MUVE used in this study creates a high level of presence. Similarly, Noh, Park, and Jang (2014) found that the presence and social presence effects of 3D games on users were stronger than those of 2-dimensional games. Bulu (2012) indicates that place presence increases the satisfaction that users have in a virtual environment. In this study, students' high presence levels and positive views about the environment support this notion. On the other hand, some researchers have claimed that 3D MUVEs could be insufficient for creating presence since they are open to any possible distraction from the physical environment of the users (Kober, Kurzmann, & Neuper, 2012). The lower mean score of the distraction in compared to other sub-factors of presence supports this notion.

A review of the previous studies that analyze the relation between presence and learning reveals conflicting results. Singer et al. (1997) found a statistically significant relation between presence in virtual environment and spatial learning, while Bailey and Witmer (1994) conducted their study using different measurement tools and did not find any correlation. Witmer and Singer (1998) determined a strong relation between presence perception in the virtual environment and learning, and they claimed that an increase in presence will also increase learning and performance. This claim is validated by this study. The study found that there was a low-level and positive correlation between students' perception of presence in the virtual environment and their conceptual learning while there was a moderate positive correlation between their presence perception in the virtual environment and spatial learning. Moreover, less distracting virtual environment had a positive influence on students' both conceptual and spatial learning. Similarly, Witmer and Singer (1998) argued that minimizing distractions in a virtual environment would enhance adaptation to it.

Considering universities' administrative costs, the findings of this study are a favorable reason for preferring virtual environments for orientations. For instance, yearly official student orientations were initiated at the university where this study was conducted after the research was completed. Each year nearly 7500 freshmen students are invited to a 5-day authentic orientation the week before the semester begins. In the 2014 orientation, 250 student peers and 75 academicians conducted the orientation. Presentations with a capacity of nearly 40,000 seats and activities with a capacity of nearly 80,000 seats were held. Considering the travel and catering costs, the university begins to plan these orientations months beforehand, and their organization is also very costly. The productivity of the authentic orientation is also influenced by students' schedules during the orientation week since they try to meet needs such as accommodation. At the university in question, approximately two-thirds of the students participate in the one-week orientation. Since today's students are inclined to use information technologies, they might prefer to attend a virtual orientation over a longer period before their courses start instead of coming to school for an authentic orientation and spending their time.

Although students might prefer 3D MUVEs for orientations, their design and sustainability should be considered by university administrations. The costs of the 3D MUVE software and the servers where it is to be installed may be underestimated. Furthermore, one criterion for the licensing fees of 3D MUVE software is the number of users who can log in to the virtual environment simultaneously. This increases the procurement costs of universities with large student populations. Once the infrastructure is in place, the university undertakes a lengthy design process. This process requires establishing a group of designers, examining the authentic environments, doing a task analysis, developing paper prototypes, transferring these prototypes into the electronic environment and conducting usability tests with potential users (Tüzün, 2009). The first prototype of the virtual environment used in this study was created by undergraduate students in a design course. Thus, using crowdsourcing for designs may help reduce costs. After the MUVE infrastructure is established, and the design is completed based on this infrastructure, the next difficulty is the sustainability of the orientation design. The spatial changes in the physical structures and the changes in conceptual knowledge make it necessary to update the design. It is recommended that a team be established in Information Technology Services to work on these updates. Universities should only choose either virtual or authentic student orientations after considering the administrative expenses of virtual orientation environments.

6. Conclusion and future work

As Tuzun (2004) suggests, a space is just a space unless it is furnished with focused content, and the 3D MUVEs are not an exception even though they are considered the new frontier (Damer, 1996; Schroeder, Huxor, & Smith, 2001). Researchers and practitioners have been experimenting with this new frontier, and this research can be considered a pioneer wagon on a journey of discovery. Overall, the virtual orientation has similar or better results than authentic orientation in terms of conceptual and spatial learning, and participants perceived a high level of presence in the virtual orientation. Further challenges lie in this frontier for future pioneers. This study was conducted with the freshmen students of a single department and for that reason the sample size is relatively small. Future studies might involve freshmen students of multiple departments or entire school to address this limitation. In this study, the spatial experience was created on a single floor. In future studies, researchers need to examine users' movements in Z axis and examine the influence of their spatial experiences on multiple floors. In previous studies, audio feedback given to the participants created a stronger perception of presence than the other variables; especially, the voice given as assistance to navigation made users feel in a dynamic environment. This study did not include the use of audio elements in the virtual environment, and future studies should examine the influence of these elements on orientation. This study did not use the affordance of collaboration and future studies can make use of this affordance in virtual orientation environments for ice breaking and socialization activities and examine its effects. With these efforts future researchers can move further into the wilderness and reveal the settlement potential of 3D MUVEs for orientation purposes.

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