Teachers' and Students' Perceptions of Presence in Virtual Reality Instruction

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Abstract: This exploratory study examined middle school teachers' and students' perceived presence after learning science with a virtual reality system. The goal was to determine if the presence assessment was valid and reliable for youth and adults. Students and teachers (novice and experienced) completed 4 sessions learning about the heart and electrical circuits with the virtual reality system. Participants completed a presence survey about four constructs of presence (control, sensory, distraction, and realism) and teachers participated in an interview. Results showed that the presence survey had high reliability for all presence constructs. Differences in students' and teachers' responses were compared and only one significant difference was found between the two groups. Students were much more likely than the teachers to rate the virtual reality experience as realistic. Possible influences of cognitive development are discussed.

Key-Words: virtual reality, presence, science education

1 Introduction

Rapid advancements in computer technologies have resulted in virtual reality (VR) moving from military and training applications to new tools for education. For the first time, students can now experience a fully interactive 3 dimensional virtual reality system to explore and investigate science and engineering [5, 7, 8]. Today's VR applications allow the user to see a projected virtual heart in 3 dimensions, feel it beat in real-time with a haptic stylus, cut into the heart and see the valves in action, and explore the movement of the heart with each beat while tracing cardiac blood flow. Virtual reality applications not only provide high quality graphic images and simulated movements but also have reached the point that these applications challenge educators to question the efficacy of physical objects and investigations compared to those created with virtual reality. This paper explores this question of "realness" or "presence" in virtual reality and describes assessments of presence in educational contexts.

1.1 Defining Presence

A number of different researchers have attempted to define presence (i.e. telepresence, mediated presence, or virtual presence) in various fields including media (e.g. television), communication (e.g. teleconferences), and gaming (e.g. virtual simulations) [3, 9, 11]. Presence has been described as involving participation [16] or perceptions of being in another environment [17]. Early in the development of virtual reality, presence was described as a perception of being in a location at a distance [12]. Researchers have also defined presence as a perception of being in an environment with others (i.e. social presence) [6]. For others, the focus of presence is on objects where presence is the perception of virtual objects as actual objects [9]. More recent definitions of presence involve "the sense we are located in and acting from within the VE (virtual environment) and the sense that we are concentrating on the VE thus ignoring the real environment "[p. 269, 15].

1.2 Factors Influencing the Perception of Presence

Presence is influenced by characteristics of the virtual technology as well as psychological factors that the learner brings to the learning context.

There are a number of factors that have been identified that contribute the degree to which students are able to interact with virtual environments. First, the amount to which the student is able to have a sensory experience with the virtual reality technology shapes the extent to which the environment is perceived as realistic [18]. Augmented experiences that include sight, sound, movement, and haptics all contribute to a more realistic virtual environment. Although individuals may interpret sensory feedback differently, there is general agreement that the more a virtual environment engages the senses that are used in physical environments, the more realistic the perception of the virtual experience to the user [2, 18].

Vividness is often associated with the degree to which participants report being present in virtual environments [18]. Vividness refers to the realness of a character, environment or voice. This largely depends on the quality of the sound, sight or feel; the holistic experience of the virtual environment [6]. Sensory depth and breadth are believed to contribute to vividness. Breadth includes the number of different sensory dimensions found in the virtual environment and sensory depth refers to resolution of sensory information. Steuer (1992) argues that redundancy of the sensory information positively contributes to the perception that the virtual environment is real. More modern virtual reality environments, which include head and eye tracking, are used to provide this sensorial redundancy and provide an experience that is rich in the types of sensory information that one experiences in the natural world.

The perception of presence is also highly dependent on the individual experiencing the virtual environment [19]. Each person brings to a learning context unique experiences, knowledge and dispositions that can influence how the virtual world is interpreted. Moreno and Meyer (2004) maintain that one of the most significant individual variables at play in the perception of presence is the attention that individuals allocate for learning in the virtual environment rather than focusing on the characteristics of the technology.

Moreover some researchers have argued that presence is closely associated with the degree to which an individual is willing to suspend disbelief and “accept incoming stimuli at face value without close scrutiny [9, p. 47]. It is not yet clear why some individuals are more willing to enter the virtual world with a disposition towards accepting the virtual information at face value. One possible explanation offered is that development may be a factor. It has been argued that children are more likely to enter into virtual social relationships with technology whereas adults may be more remotely engaged [11].

1.3 Education and Virtual Reality Environments

Although there has been research on the perception of presence in gaming and other commercial and business applications [6], researchers are only beginning to examine how to measure the degree of presence students feel in learning contexts [14]. This presence study tackles this issue though the validation of a survey designed to measure presence specific to virtual environments with the objective of learning science. Here we examine the factors that Witmer and Singer (1998) identified as essential components of presence: control, sensory, distraction, and realism. Control factors include the degree to which the learner can control the virtual environment as well as how responsive the system is to changes the learner makes while navigating the virtual world. Sensory factors include the vividness and redundancy of sensory information that the learner receives. Distraction is particularly salient for youth due to their emerging cognitive development. In this context, refers to the learner's willingness to disregard external stimuli outside of the virtual technology to learn. And last, realism refers to the perception of the virtual environment as mapping accurately on a natural environment and the degree to which the virtual environment is seen as meaningful [4].

2 Methodology

2.1 Research Questions

What are the students' perceived presence (how real of an experience) during a 3-D VR haptic enabled investigation?

What are the teachers' perceived presence (how real of an experience) during a 3-D VR haptic enabled investigation?

2.2 Participants

Study participants included 10 middle school students (aged 12-13 years; 5 males and 5 females; 2 Hispanic and 8 Caucasian) and 7 middle school teachers (6 females, 1 male; all Caucasian) from two different public middle schools in the south eastern United States. Purposeful sampling was conducted among the 7th grade students to ensure the participants were approximately of the same age, were average or above in ability (i.e. based on recommendations of the teacher) and equally represented by sex (i.e. half male, half female). Half of the participants selected for the study were identified by their parents as attention deficient or attention deficient/ hyperactive. Teacher participants included both in-service (experienced) middle grade teachers and pre-service (novice) teachers.

2.3 Instruction

Each participant (teachers and students) completed four separate instructional sessions, approximately 40-45 minutes to three hours total on the zSpace® system. The first two sessions were designed for participants to become acquainted and comfortable with the features of the virtual reality system (e.g. wearing the eye-glasses and using the stylus). Although the company stated that 30 minutes would be an adequate amount of time for participants to develop expertise using the technology, researchers elected for more time to not only reduce the novelty of the tool but also to have some additional time to develop a rapport and trust between the students and themselves. The participants were provided a large menu of objects to explore during these preliminary treatment sessions. The third and fourth session taught the students about the human heart and electrical circuits (components of the 7th grade science curriculum). Participants were provided instruction about heart anatomy, function and cardiac circulation. For the circuit lesson, participants explored electron flow, differences between series and parallel circuits and evaluated circuit functionality. These final two sessions were audio recorded and video recorded. Upon completion of all four treatment modules, participants completed the zPresence survey to assess the perceived level of presence in the virtual reality environment. Teachers were interviewed following their completion of the four sessions to document their perceptions of the virtual reality system.

2.4 Virtual Reality Technology

The zSpace® technology employs a haptic enabled stylus and a full stereoscopic display that allows the user to feel, view and manipulate 3-D images in real-time. The 3-D experience is enhanced by the addition of full motion parallax as well as the binocular parallax depth cue. The zSpace® system uses infrared cameras that track the viewing angles of the student using the system and adjusts the perspective of the virtual environment to match the view point of the student. The 3-D eyewear has infrared reflectors

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that are detected by the zSpace® system. The images are displayed on a high definition (1080p, 120Hz) 3-D monitor (Figure 1). Students can navigate and select objects with a 3-button haptic feedback enabled stylus whose motion is tracked by the cameras.

Figure 1. The zSpace Virtual Reality System

2.5 zPresence Survey

The items for the zPresence survey were modified from the presence survey developed by Whimer & Singer (1998) for assessing presence in a virtual environment. The original items have been found to be highly reliable and positively correlated with task performance [19]. Items developed for the present study were adapted to specifically address presence factors during a 3-D, VR, haptic enabled [zSpace®] investigation. The survey included 61 total items for the 4 constructs of presence (control n=21; sensory n=14; distraction n=11; and realism n=15).

2.5.1 Validity

A panel of 10 science educators, 2 middle school students, 1 zSpace® educator, and 1 zSpace® computer programmer reviewed the items for clarity, developmental appropriateness, coherence, and validity for zSpace® program for middle school students. The survey included questions designed to assess students' and teachers' perceived presence during the zSpace® investigation for four presence factors: control, sensory, distraction, and realism.

Study participants were asked to indicate their level of agreement for each item ("I felt that I was in control of the zSpace® 3-D environment during the session) on a Likert scale of 1-6 (i.e. strongly disagree to strongly agree) after they completed 4 sessions using zSpace® to learn science.

2.5.2 Reliability

The students' and teachers' zPresence survey construct scores were compared across treatment groups using the Mann-Whitney U test (2-tailed, alpha = 0.002, 0.003, 0.005, 0.003, respectively) to ascertain significance between control and experimental respondents. Cronbach's alpha was calculated with a reliability value of 0.943, 0.829, 0.869, 0.775 and an overall value of 0.922 for student responses and 0.959, 0.532, 0.897, 0.830 for an overall value of 0.926 for teacher responses. Values for both groups demonstrate a strong internal consistency of items and responses (see Table 1).

Table 1

Reliability Measures (Cronbach's Alpha) by Control, Sensory, Distraction, and Realism Items

zPresence Category	Students	Teachers	Reliability
Control Items ($N = 21$)	.943	.959	Excellent
Sensory Items ($N = 14$)	.829	.532	Good / Poor
Distraction Items ($N = 11$)	.869	.897	Good
Realism Items ($N = 15$)	.775	.830	Good
Whole Test ($N = 82$)[a]	.922	.926	Excellent

Note: $\alpha \geq 0.9$, Excellent; $0.7 \leq \alpha < 0.9$, Good; $0.6 \leq \alpha < 0.7$, Acceptable, $0.5 \leq \alpha < 0.6$, Poor; $\alpha < 0.5$, Unacceptable

[a]Contains items from other categories not reported here.

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As seen in Table 2, there were no significant differences in the mean rank scores between students' and teachers' control zPresence scores.

Table 2

Differences in Student and Teacher Responses by Control Construct

zPresence Item	Student Mean Rank	Teacher Mean Rank	Mann Whitney U	*p* value
1. I felt that I was in control of zSpace® 3-D environment during the session.	8.05	9.25	25.5	0.584
2. zSpace® 3-D environment would respond to my actions.	8.20	9.00	27.0	0.703
3. zSpace® 3-D environment did what I wanted it to do.	8.80	8.00	27.0	0.715
4. The interactions I had with the zSpace® 3-D environment were natural.	9.05	7.58	24.5	0.514
5. I felt that the stylus allowed me to control what was / occurring in the 3-D environment.	8.80	8.00	27.0	0.720
6. The stylus would do what I wanted it to do in the 3-D environment.	9.20	7.33	23.0	0.394
7. The interactions I had with the stylus to interact with the 3-D / environment were natural.	8.95	7.75	25.5	0.596
8. The stylus would respond to my actions when I interacted with the / 3-D environment.	8.80	8.00	27.0	0.720
9. The stylus allowed me to control the movement of objects in the / environment.	9.10	7.50	24.0	0.450
10. I was able to predict what would happen if I moved an object in the / 3D environment.	8.80	8.00	27.0	0.730
11. I could move objects easily in the 3D environment.	8.35	8.75	28.5	0.855
12. I could manipulate objects easily in the 3D environment.	9.30	7.17	22.0	0.339
13. There was a delay between what I wanted to do and what happened on / the screen.	7.30	10.50	18.0	0.180
14. I adjusted quickly to the screen during the zSpace® session.	8.80	8.00	27.0	0.720
15. I could easily move objects in the 3D environment.	9.20	7.33	23.0	0.414
16. I could easily interact with different objects in the 3-D / environment.	9.30	7.17	22.0	0.339
17. I could manipulate objects with a stylus in ways that I could not / in the real world.	8.05	9.25	25.5	0.519
18. I could easily zoom in on objects.	7.60	10.00	21.0	0.282
19. I could easily zoom out from an object.	8.20	9.00	27.0	0.730
20. I could navigate inside of objects using the stylus.	8.50	8.50	30.0	1.000
21. I was able to navigate behind objects that I could not do normally / in a 2-D simulation.	8.60	8.33	29.0	0.893

There were no significant differences in the scores between students' and teachers' perceptions of sensory items (Table 3).

Table 3

Differences in Student and Teacher Responses by Sensory Construct

zPresence Item	Student Mean Rank	Teacher Mean Rank	Mann Whitney U	*p* value
1. My sense of sight was highly engaged during the session.	9.40	7.00	21.0	0.225
2. My sense of hearing was highly engaged during the session.	9.70	6.50	18.0	0.185
3. My sense of touch was highly engaged during the session.	10.00	6.00	15.0	0.093
4. I was convinced that the objects I viewed with zSpace® were moving through space.	8.75	8.08	27.5	0.777
5. I was able to explore all of the 3D environment with my / sight.	9.25	7.25	22.5	0.361
6. I was able to explore all of the 3-D environment with my sense of / touch.	10.20	5.67	13.0	0.060
7. I was able to closely examine objects during the zSpace® session.	9.40	7.00	21.0	0.225
8. I was able to closely examine objects from multiple viewpoints / during the zSpace® session.	9.10	7.50	24.0	0.439
9. I was aware of other events in the classroom during the zSpace® session.	9.65	6.58	18.5	0.203
10. I was aware of sounds outside of the zSpace® session.	9.45	6.92	20.5	0.290
11. I was aware of the stylus I used to control objects in zSpace®.	9.40	7.00	21.0	0.267
12. I was aware of the 3D glasses I used to view objects in zSpace®.	9.00	7.67	25.0	0.574
13. I was aware of the zSpace® monitor I used to view objects in zSpace®.	8.55	8.42	29.5	0.954
14. I was aware of the zSpace® camera during the session.	9.55	6.75	19.5	0.247

Note: Mann-Whitney U: Differences in two independent groups, Alpha 2-tailed, .003.

As seen in Table 4, there were no significant differences in the scores of students and teachers for distraction.

Table 4

Differences in Student and Teacher Responses by Distraction Construct

zPresence Item	Student Mean Rank	Teacher Mean Rank	Mann Whitney U	*p* value
1. I was very involved during the zSpace® session.	8.90	7.83	26.000	0.564
2. The 3D glasses were distracting.	9.00	7.67	25.000	0.560
3. The stylus was distracting.	9.00	7.67	25.000	0.566
4. The 3D objects in the environment were distracting.	9.00	7.67	25.000	0.546
5. Other students were distracting me during the zSpace® session.	8.70	8.17	28.000	0.705
6. The stylus interfered when I moved objects in the 3D / environment.	8.10	9.17	26.000	0.653
7. The glasses interfered when I moved objects in the 3D / environment.	8.40	8.67	29.000	0.895
8. I was able to concentrate easily during the zSpace® session.	8.15	9.08	26.500	0.670
9. I was comfortable using the stylus during the zSpace® session.	8.65	8.25	28.500	0.851
10. I was comfortable using the 3D glasses during the zSpace® session.	8.90	7.83	26.000	0.568
11. I felt comfortable viewing the objects in the 3D environment.	8.20	9.00	27.000	0.703

Note: Mean Rank Mann-Whitney U: Differences in two independent groups, Alpha 2-tailed, .005.

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There were significant differences in students' and teachers' responses for the item that stated "Using zSpace® to view objects is more realistic than participating in lab at school" (see Table 5). Because repeated tests of significance were conducted, a Bonferroni correction was applied resulting in a p value for significance of $p < .003$.

Table 5

Differences in Student and Teacher Responses by Realism Construct

zPresence Item	Student Mean Rank	Teacher Mean Rank	Mann Whitney U	*p* value
1. The zSpace® 3D objects were not realistic.	9.45	6.92	20.500	0.257
2. I felt disconnected during the zSpace® session.	9.45	6.92	20.500	0.262
3. My experiences during the zSpace® session were similar to real laboratory experiences.	8.90	7.83	26.000	0.650
4. The 3-D environment was realistic.	9.55	6.75	19.500	0.223
5. I felt disoriented when I put the stylus down.	8.55	8.42	29.500	0.953
6. I felt confused when I put the stylus down.	8.75	8.08	27.500	0.739
7. I felt disoriented when I removed the 3-D glasses.	8.55	8.42	29.500	0.952
8. I felt confused when I removed the 3-D glasses.	8.30	8.83	28.000	0.802
9. I lost track of time during the zSpace® session.	9.15	7.42	23.500	0.448
10. I could transition from the real world to using zSpace® easily.	8.75	8.08	27.500	0.765
11. The illusion of the 3-D environment was very real to me.	9.65	6.58	18.500	0.190
12. The object appeared to jump out of the screen.	8.85	7.92	26.500	0.679
13. Using zSpace® to view objects is more realistic than using a simulation on a / computer.	8.10	9.17	26.000	0.564
14. Using zSpace® to view objects is more realistic than watching a video.	8.20	9.00	27.000	0.703
15. Using zSpace® to view objects is more realistic / that participating in lab at school.	11.25	3.92	2.500	0.002*

Note: Mann-Whitney U: Differences in two independent groups, Alpha 2-tailed, .003.

2.5.3 Interview Results

Post-treatment interviews with the teachers and students revealed there were differences in how the teachers and students viewed the realism of the virtual reality instruction. For example, when asked, "Did you think the experience felt realistic?", students tended to find the experience genuinely realistic as seen in this students' response:

Student: Yea, totally. It looked really 3D and detailed.

Interviewer: So, what made it seem real? Was it that...yea what about your experience seemed real?

Student: The details. The more you looked closer the more lines and details and your like oh I never knew this, I

> never knew how it looked like and like the heart I was just like whoa what is this, I never knew it looked like this. And the fly it was really, really weird. The eyes looked really different and it had a lot of hair on its legs. If you look at it far away you can see anything you just say oh it's just a fly.
>
> Interviewer: So do you look at flies differently?
>
> Student: Yes.

However, teachers reported their experience as less realistic than the students. For example, when asked if the experience felt realistic this teacher commented, "Sometimes." The interviewer probed and the teacher clarified, "For example, when we just took the friction it showed me that you used the different materials such as rubber or carpet or something like that. I think I would rather the students to do that in real materials."

When teachers and students were asked, "if they had a chance to use the virtual reality system to learn science most of the time would they prefer to use the zSpace® system or more traditional ways to learn science," nearly all students noted a preference for using zSpace®. Teachers expressed more skepticism about using virtual reality as noted by this teacher: "There is something to the actual physical touch and feel of being able to do a lab, and also there is something to learn with an actual lab with unseen variables that can be, that can occur in a classroom."

2.5.4 Limitations

These findings should be interpreted with care. This exploratory study had a limited number of participants and the results should be interpreted as tentative until the study can be replicated with a larger sample and in other contexts.

3 Discussion

The results found here support the findings of Whimer and Singer (1998) that maintain that dimensions of presence can be reliably assessed. The present study shows that this reliability holds for both adults (teachers) and for youth (middle school students) for use with zSpace® virtual reality. The significant difference between students' and teaches' responses for the item regarding the level of realism to the 3-D, VR sessions raises questions about whether prior experiences or development may frame their use and perception of the experience. It is possible that middle school students have had more experience using virtual reality technology with gaming and other applications. As a result, they experience a greater degree of presence in the virtual environment than their older counterparts. Another interpretation of the differences in students' and teachers' ratings of realism could reflect the teachers' views of the technology as a teaching tool. To teachers, virtual reality did not fully represent the physical objects that they provide during science experiments. In a study done by Childers (2014), high school teachers whose students completed a remote electron microscope investigation were less likely than students to describe the investigation as being real. The high school teachers stated during semi-structured interviews that the realness of the experience was diminished because the students were not located in the same area as the research lab, electron microscope, and the scientists. In comparison, the high school students reported the remote electron microscope investigation as being very real, suggesting that the high school students were immersed during the investigation.

Another interpretation of the differences in students' and teachers' reports of realism in virtual reality could be differences in development. Schifter, Ketelhut and Nelson (2012) used virtual reality with a group of middle school students and reported that the seventh grade students were more likely to report a sense of presence than the sixth grade students. These researchers question whether the older students were more developed and as a result more engaged and immersed in the virtual environment. Further research is needed to examine the impact that both development and prior experience may have on the perception of learning in virtual environments.

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