Perceptions of Presence in 3-D, Haptic-enabled, Virtual Reality Instruction

M. Gail Jones, Rebecca Hite, Gina Childers, Elysa Corin, Mariana Pereyra, and Katherine Chesnutt

***Abstract*—**This exploratory case study evaluated perceived presence of students and teachers after learning science topics on a 3-dimensional, haptic-enabled, virtual reality system. Twenty students and teachers completed four, one hour sessions with the instructional technology exploring biology and physical science content. Participants were interviewed and surveyed to evaluate their perception of presence via four constructs: control, sensory, distraction, and realism. Additional questions assessed changes in participants' acquired skills from sessions. Results indicated the survey had high reliability for all constructs. Differences between students' and teachers' responses showed students perceived their virtual experience as more realistic than teachers. Students more than teachers reported improved gains science process skills (analyzing data, reporting results, recognizing error) and understandings of the nature of science (tentativeness and sociocultural context of science). When asked how this technology was regarded as a viable instructional option for learning science, students ranked the virtual technology higher than teachers as more interesting and increasing their understanding. Results showed students ranked zSpace as the most preferred instructional option and teachers ranked hands-on activities with materials as their most preferred instructional option.

***Keywords*—**3-D, Haptics, Instructional Technology, Science Education, Virtual Presence, Virtual Reality

I. 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 [6, 8, 10]. 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.

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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) [4, 11, 14]. Presence has been described as involving participation [19] or perceptions of being in another environment [21]. Early in the development of virtual reality, presence was described as a perception of being in a location at a distance [15]. Researchers have also defined presence as a perception of being in an environment with other people (i.e. social presence) [7]. In other cases, the focus of presence is on objects where presence is the perception of virtual objects as actual objects [11]. 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, 18].

According to Witmer and Singer (1998), early pioneers of virtual presence, both involvement and immersion are necessary for experiencing presence. Involvement is mediated by the users' ability to control the virtual environment and hold the users attention within the virtual realm. Therefore, the display and hardware of 3-D, VR, haptic-enabled technology should ensure the user is comfortable wearing and using the equipment; if such hardware is cumbersome or confining, the users involvement in the virtual environment will diminish considerably [24].

Immersion gauges the quality of the virtual environment compared to the real world. Continuous or deep immersion relies on sensory engagement and realistic features within the virtual realm. Essentially, the sensory experience shapes how real the environment appears to the user [22]. Among the senses, visual information may most strongly influence presence yet research into haptics has found that body interactions increase the sense of presence for the user [20].

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 extent to which students are able to interact with virtual environments. First, the degree 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 [22]. 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 [3, 22].

Vividness is often associated with reports of being present in the virtual environment [22]. 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 [7]. 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 the 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 sophisticated 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. Since 3-D, virtual reality systems are crafted to couple involvement with immersion into a simulated world, these systems have a great potential to produce presence [24].

The perception of presence is also highly dependent on the individual experiencing the virtual environment [13, 24]. 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 [11, p. 47]. Research suggests that individuals with high empathy and active imaginations reported greater presence than others in the same virtual realms [23]. 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 [14].

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 [7], researchers are only beginning to examine how to measure the degree of presence students feel in learning contexts [17]. 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, distraction refers to external stimuli outside of the virtual technology. Thus, the level of presence has a relationship to the learner's willingness to disregard those external distractions 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 [5].

There is developing recognition of virtual presence as a field of research since users may become more engaged in learning activities due to the realistic contexts these systems provide [2]. Understanding how students' and teachers' perceptions of presence differ may provide important information regarding how these technologies may be implemented in the K-12 science classroom, ultimately increasing student interest in science and understanding of scientific processes and procedures.

II. Methodology

A. Research Questions

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

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

B. Participants

This study is an extension of preliminary results presented previously by Jones, Hite, Childers, Corin, Pereyra, Chesnutt, and Goodale (2015). Study participants included 10 middle school students (aged 12-13 years; 5 males and 5 females; 2 Hispanic and 8 Caucasian) and 10 middle school teachers (9 females, 1 male; 1 Asian, 9 Caucasian) from two different public middle schools in the southeastern 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 a balanced number of in-service (experienced) middle grade teachers and pre-service (novice) teachers.

C. Instruction

Each participant (teachers and students) completed four separate instructional sessions, approximately three hours total on the zSpace® system. The first two 45-minute 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).
Researchers elected for more extensive 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. During the third and fourth 45-minute sessions, participants were presented with information on the human heart and electrical circuits, respectively. 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 and students were interviewed following their completion of the four sessions to document their perceptions of the virtual reality system.

D. Virtual Reality

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 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 four stereoscopic cameras.

Figure 1. The zSpace® Virtual Reality System

E. 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 [24]. 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 4 constructs of presence (control n=21; sensory n=14; distraction n=11; and realism n=15).

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.

III. Validity and Reliability

A. 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 using the 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.

B. 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 examine possible differences 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 0.958, 0.737, 0.899, 0.749 for an overall value of 0.948 for teacher responses. Values for both groups resulted in strong internal consistency of items and responses as seen in Table I.

Table I

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

zPresence Category	Students	Teachers	Reliability
Control Items (*N* = 21)	0.943	0.958	Excellent
Sensory Items (*N* = 14)	0.829	0.737	Good
Distraction Items (*N* = 11)	0.869	0.899	Good
Realism Items (*N* = 15)	0.775	0.749	Good
Whole Test (*N* = 82)[a]	0.922	0.948	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.

IV. Results

A. zPresence Survey

Students' (*N*=10) and teachers' (*N*=10) responses were compared by item and construct for level of agreement to each statement. Reverse coding was performed for uniformity of responses. Mean ranks for each group were calculated to view the level of agreement for each group. A Mann-Whitney U value compared the amount of variance between the mean ranks of each surveyed group. A p-value was calculated to indicate possible statistical significance between groups at the threshold value of 0.003.

Table II shows differences between students' and teachers' responses by control items. There were no significant differences in the mean rank scores between groups.

Table II

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.	9.75	11.25	42.5	0.522
2. zSpace® 3-D environment would respond to my actions.	9.70	11.30	42.0	0.483
3. zSpace® 3-D environment did what I wanted it to do.	10.70	10.30	48.0	0.865
4. The interactions I had with the zSpace® 3-D environment were natural.	10.95	10.05	45.5	0.707
5. I felt that the stylus allowed me to control what was occurring in the 3-D environment.	10.95	10.05	45.5	0.702
6. The stylus would do what I wanted it to do in the 3-D environment.	11.35	9.65	41.5	0.461
7. The interactions I had with the stylus to interact with the 3-D environment were natural.	10.90	10.10	46.0	0.737
8. The stylus would respond to my actions when I interacted with the 3-D environment.	10.50	10.50	50.0	1.000
9. The stylus allowed me to control the movement of objects in the environment.	11.40	9.60	41.0	0.435
10. I was able to predict what would happen if I moved an object in the 3-D environment.	11.25	9.75	42.5	0.551
11. I could move objects easily in the 3-D environment.	10.25	10.75	47.5	0.831
12. I could manipulate objects easily in the 3-D environment.	11.85	9.15	36.5	0.259
13. There was a delay between what I wanted to do and what happened on the screen.	8.45	12.55	29.5	0.109
14. I adjusted quickly to the screen during the zSpace® session.	10.50	10.50	50.0	1.000
15. I could easily move objects in the 3-D environment.	11.30	9.70	42.0	0.515
16. I could easily interact with different objects in the 3-D environment.	11.40	9.60	41.0	0.450
17. I could manipulate objects with a stylus in ways that I could not in the real world.	10.00	11.00	45.0	0.618
18. I could easily zoom in on objects.	9.00	12.00	35.0	0.208
19. I could easily zoom out from an object.	9.50	11.50	40.0	0.417
20. I could navigate inside of objects using the stylus.	10.50	10.50	50.0	1.000
21. I was able to navigate behind objects that I could not do normally in a 2-D simulation.	10.65	10.35	48.5	0.888

Note: Mann-Whitney U: Differences in two independent groups, Alpha 2-tailed, .002.

Table III shows differences between students' and teachers' responses by sensory items. There were no significant differences in the mean rank scores between groups.

Table III

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.	11.50	9.5	40.0	0.342
2. My sense of hearing was highly engaged during the session.	11.90	9.10	36.0	0.281
3. My sense of touch was highly engaged during the session.	12.45	8.55	30.5	0.123
4. I was convinced that the objects I viewed with zSpace® were moving through space.	10.75	10.25	47.5	0.843
5. I was able to explore all of the 3-D environment with my sight.	11.00	10.00	45.0	0.675
6. I was able to explore all of the 3-D environment with my sense of touch.	12.50	8.50	30.0	0.122
7. I was able to closely examine objects during the zSpace® session.	11.50	9.50	40.0	0.342
8. I was able to closely examine objects from multiple viewpoints during the zSpace® session.	11.00	10.00	45.0	0.648
9. I was aware of other events in the classroom during the zSpace® session.	12.05	8.95	34.5	0.232
10. I was aware of sounds outside of the zSpace® session.	12.70	8.30	28.0	0.088
11. I was aware of the stylus I used to control objects in zSpace®.	11.85	9.15	36.5	0.251
12. I was aware of the 3-D glasses I used to view objects in zSpace®.	11.35	9.65	41.5	0.506
13. I was aware of the zSpace® monitor I used to view objects in zSpace®.	10.40	10.60	49.0	0.936
14. I was aware of the zSpace® camera during the session.	11.90	9.10	36.0	0.282

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

Differences between students' and teachers' responses by distraction items are shown in Table IV. There were no significant differences in the mean rank scores between groups.

Table IV

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.	11.10	9.90	44.0	0.549
2. The 3-D glasses were distracting.	11.15	9.85	43.5	0.590
3. The stylus was distracting.	11.00	10.00	45.0	0.684
4. The 3-D objects in the environment were distracting.	11.30	9.70	42.0	0.503
5. Other students were distracting me during the zSpace® session.	11.00	10.00	45.0	0.542
6. The stylus interfered when I moved objects in the 3-D environment.	9.70	11.30	42.0	0.521
7. The glasses interfered when I moved objects in the 3-D environment.	11.00	10.00	45.0	0.664
8. I was able to concentrate easily during the zSpace® session.	10.75	10.25	47.5	0.836
9. I was comfortable using the stylus during the zSpace® session.	11.20	9.80	43.0	0.556
10. I was comfortable using the 3-D glasses during the zSpace® session.	11.40	9.60	41.0	0.399
11. I felt comfortable viewing the objects in the 3-D environment.	10.30	10.70	48.0	0.861

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

Differences between Realism scores for students' and teachers' responses are shown in Table V. There was a significant difference in students' and teachers' responses for the item that stated "Using zSpace® to view objects is more realistic than participating in lab at school." Because repeated tests of significance were conducted, a Bonferroni correction was applied resulting in a p-value for significance of $p < 0.003$.

Table V

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®® 3-D objects were not realistic.	12.55	8.45	29.5	0.085
2. I felt disconnected during the zSpace®® session.	12.00	9.00	35.0	0.218
3. My experiences during the zSpace®® session were similar to real laboratory experiences.	11.25	9.75	42.5	0.551
4. The 3-D environment was realistic.	12.90	8.10	26.0	0.056
5. I felt disoriented when I put the stylus down.	10.75	10.25	47.5	0.837
6. I felt confused when I put the stylus down.	11.65	9.35	38.5	0.313
7. I felt disoriented when I removed the 3-D glasses.	11.35	9.65	41.5	0.493
8. I felt confused when I removed the 3-D glasses.	10.70	10.30	48.0	0.866
9. I lost track of time during the zSpace® session.	11.75	9.25	37.5	0.293
10. I could transition from the real world to using zSpace® easily.	11.15	9.85	43.5	0.590
11. The illusion of the 3-D environment was very real to me.	12.05	8.95	34.5	0.205
12. The object appeared to jump out of the screen.	12.15	8.85	33.5	0.184
13. Using zSpace® to view objects is more realistic than using a simulation on a / computer.	11.15	9.85	43.5	0.557
14. Using zSpace® to view objects is more realistic than watching a video.	10.50	10.50	50.0	1.000
15. Using zSpace® to view objects is more realistic / that participating in lab at school.	14.50	6.50	10.0	0.002*

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

A. Interviews

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. Here is an example of a students’ response as he explores a fly using zSpace®:

> Student: Yea, totally. It looked really 3-D 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.”

Students and teachers were asked to rank their preferences learning science with various instructional modalities. Table VI displays differences between students’ and teachers’ preferences for instruction that was “more interesting.” Table VII displays differences between students’ and teachers’ preferences for instruction that was “increased their understanding.”

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Note: A score of 1 indicates the most agreement with the statement, 8 the least.

Table VI

Students' and Teachers' Perceptions of Instructional Options, Ranked by "More Interesting."

	Students (n=6)		Teachers (n=9)		Students to Teachers
	Mean	SD	Mean	SD	*p* value
Teacher Instruction	5.833	1.472	5.556	1.667	0.810
Hands-on Activity with Materials	2.833	1.722	1.333	0.500	0.039*
Model	4.833	1.330	4.444	1.424	0.596
Simulation	3.333	1.751	3.667	1.225	0.478
Textbook	7.500	1.225	7.667	0.500	0.772
Videos	4.333	1.211	5.000	0.866	0.317
Internet Reading	6.167	1.602	6.556	1.130	0.857
zSpace®	1.000	0	1.778	0.667	0.039*

Four students were not given this question during the interview.
One teacher was not given this question during the interview.
P-values were calculated using Mann-Whitney U: Differences in two independent groups, Alpha 2-tailed, .05.

Table VII

Students' and Teachers' Perceptions of Instructional Options, Ranked by "Increases my Understanding."

	Students (n=6)		Teachers (n=9)		Students to Teachers
	Mean	SD	Mean	SD	*p* value
Teacher Instruction	4.500	2.098	3.444	1.424	0.772
Hands-on Activity with Materials	5.250	2.258	1.889	1.965	0.052
Model	4.750	1.378	5.778	1.986	0.726
Simulation	5.000	1.633	4.333	1.500	0.289
Textbook	5.750	2.429	5.111	1.965	0.516
Videos	3.250	2.066	6.222	1.093	0.021*
Internet Reading	6.250	1.975	6.444	2.455	0.904
zSpace®	1.333	0.516	2.778	1.394	0.052

Note: A score of 1 indicates the most agreement with the statement, 8 the least.
Four students were not given this question during the interview.
One teacher was not given this question during the interview.
P-values were calculated using Mann-Whitney U: Differences in two independent groups, Alpha 2-tailed, .05.

Students ranked the virtual (zSpace®) option of instruction much higher than teachers for both a more interesting experience (Table VI) and increasing their understanding of the science topic (Table VII). Students ranked less immersive and interactive experiences (using models, teacher instruction, textbooks and internet reading) as least interesting for science instruction, yet teachers had almost similar results with the exception for a stronger preference for hands-on activities with materials (Table VI). However, when asked what modality increased their understanding, students strongly preferred virtual options (Videos, zSpace®) over other types of instruction (Table VII). Teachers, however, preferred hands-on activities as their preferred methods for increasing their understanding of science content (Table VII). Table VIII displays the paired differences between students' and teachers' responses based upon science instruction that was "more interesting" and "increased their understanding." There were significant differences in students' responses involving how they perceived the benefits of simulations to their learning as "more interesting" as compared to "increased their understanding." The statistical test could not produce values for zSpace® among students, indicating they provided matching values in both inventories. Based upon values in Tables VI and VII, it is likely each student reported the same high level of agreement for zSpace® as being "more interesting" and "increasing my understanding." Teachers' responses were more varied between inventories, indicating significant differences between their perceptions of instructional preferences in teacher instruction, use textbooks and videos. Moreover, teachers provided matching responses in the categories of hands-on activities with materials and simulations (Table VIII). This suggests that the teachers as a group had similar preferences for this modality as both "more interesting" and "increasing their understanding" based upon previous results from Table VI and VII.

Table VIII

Comparison of Students' and Teachers' Perceptions of Instructional Options by "More Interesting" versus "Increases my Understanding."

	Student to Student *p* value	Teachers to Teachers *p* value
Teacher Instruction	0.053	0.006*
Hands-on Activity with Materials	0.058	
Model	0.173	0.064
Simulation	0.014*	
Textbook	0.069	0.006*
Videos	0.112	0.022*
Internet Reading	0.250	0.458
zSpace®		0.053

Note: A score of 1 indicates the most agreement with the statement, 8 the least.
Four students were not given this question during the interview.
One teacher was not given this question during the interview.
P-values were calculated using Wilcoxon Signed Rank Test: Differences in paired groups, Alpha 2-tailed, .05.
Missing values indicate same value for both items.

VI. 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.

VII. 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 and Jones (2015), 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.

Although the mean ranks did not reach the significance threshold, other realism constructs related to including user involvement (questions 1, 2, 4, 9) and immersion (question 11, 12) suggested there may be differences between student and teacher groups (Table V) if the study included a greater sample size.

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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