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ORIGINAL RESEARCH ARTICLE

Holographic teaching presence: participant experiences of interactive synchronous seminars delivered via holographic videoconferencing

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This study seeks to identify potential advantages of using holographic videoconferencing to deliver seminars within higher education as compared to the use of alternative non-holographic videoconferencing. Holographic videoconferencing offers opportunities to enhance attendees' experience of remotely delivered seminars but has not been widely researched. Data were collected from 127 attendees attending one of three seminars, each of which featured a combination of physically present presenters and remote presenters participating via holographic videoconferencing. In this study, the holographic representations were three-dimensional and life-size. Monitors and holographic images were calibrated in a manner such that the remote presenters were able to point to and achieve eye-contact with members of the audience. Results indicate that the use of holographic videoconferencing can enhance the teaching presence of remote presenters, the engagement between participants and attendees' enjoyment of a seminar. Almost all participants reported this to be their first experience of a holographic event and the positive results are partly explained by a sense of novelty. This suggests that the benefits of holographic videoconferencing may reduce over time. However, we argue that some benefit, resulting from an enhanced degree of teaching presence, will be sustained. The relative impact on learning gain is not explored in the current study. We believe that this would likely require a more controlled experiment in future research.

Keywords: holographic teaching presence; telepresence; online learning environments; holography in higher education; community of inquiry framework

Introduction

Digital technology continues to evolve at a rapid rate and present opportunities to enhance the delivery of education. One of the benefits of digital technology is that it is able to remove geographical barriers to learning. Teachers and students can interact via the virtual learning environment of an educational institution regardless of their proximity to its physical location. One of the technologies that facilitates such interaction is videoconferencing that enables parties in different physical locations to communicate simultaneously through the transmission of video and audio signals.

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Non-holographic videoconferencing, in which the video image is two dimensional, enables instructors and students to participate in a live class from different physical locations and has become commonplace within higher education. For example, this technology enables instructors to invite 'real-world' practitioners from industry into the classroom and has enabled institutions to simultaneously host classes across multiple physical and virtual locations.

The present study reports on the use of holographic videoconferencing (HVC) technology. HVC differs from non-holographic videoconferencing in that the instructor appears as a three-dimensional hologram rather than a two-dimensional video image.

Literature review

The use of holography in education

The term 'hologram' is a combination of two Greek terms *holos*, meaning the whole view, and *gram*, meaning to be written down (Ghuloum 2010). Holography, a technique for creating and displaying holograms, was invented by the physicist Dennis Gabor in 1947 (Elmorshidy 2010). However, the holographic technique was only practically utilised from 1962 onwards when scientists from the United States and the Soviet Union created a 3D holographic technology. Since the 1980s, the technology enabling the production of 3D holograms has advanced notably, largely due to the availability of low-cost solid-state lasers developed for common consumer goods such as DVD (Ghuloum 2010; Sudeep 2009).

Educators have started to adopt holographic technology for use in teaching and learning; however, this practice is still at an exploratory stage and most frequently occurs within the field of medical education, specifically in the teaching of anatomy (Freeman 2010; Hackett 2013; Jamali *et al.* 2015). Hackett (2013) performed a study with medical students aiming to identify possible benefits for the use of holograms in cardiac anatomy training and found that the use of holograms increased students' learning outcomes. Jamali *et al*. (2015) conducted a study investigating the use of mobile-augmented reality to render 3D holograms for use in studying the human skeletal structure. The results from this pilot test with 30 undergraduate students as subjects indicated that students were satisfied with the 3D holographic technology as a learning tool, with its usability and features and that this may have a positive impact on students' learning process. Freeman (2010) demonstrated that it was possible to use hologram technology in a pharmacology class to demonstrate the manner in which pharmaceuticals moved through the internal organs of the human body. Orcos and Magreñán (2018) focused on the use of recorded holograms to represent objects within a class on cellular biology. They found that the use of a hologram to portray cellular division enhanced students' learning of the process, that the students had a greater sense of the recorded object being 'present' and that they were more predisposed towards learning as a result.

Research to date has focused on the use of pre-recorded holograms in an experimental lab or in other science learning contexts (Barkhaya and Halim 2016). The use of HVC, that is, the use of holograms as a synchronous communication tool, within education has received less attention. Luevano, DeLara and Castro (2015) report on the development of a number of technologies, including an HVC system, aiming to improve the students' sensation of telepresence of a remote instructor.

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In an experiment involving 43 students attending classes on the topic 'Accounting and Costs', 93% of the students stated they 'felt' the presence of the instructor when HVC was used.

Notions of 'presence'

One aim of the present research is to investigate whether use of HVC engenders a greater sense of the 'presence' of the presenter as compared to the use of non-holographic alternative tools.

Various conceptualisations of presence have been defined. Witmer, Jerome and Singer (2005) define presence to be 'the subjective experience of being in one place or environment, even when one is physically situated in another'. This notion has also been termed 'telepresence' which Minsky (1980) used to describe two different phenomenon: (1) a technology that enables the projection of a person to or from a remote environment; and (2) a personal experience of either being present in the remote environment or being present in a mediated environment (Bailenson and Beall 2006; Minsky 1980). Lombard and Ditton (1997) describe telepresence as 'the perceptual illusion of non-mediation', and is determined by the characteristics of the media and of the user.

In practice, the terms 'presence' and 'telepresence' often refer to the same concept. Sheridan (1992a, 1992b, 1996) built on Minsky's original definition of telepresence and used the shorter term 'presence' to refer to the effect felt when controlling real-world objects remotely and also the effect people feel when they interact with, and immerse themselves in, virtual reality or virtual environments.

A more specific term 'spatial presence' can be defined as 'the subjective experience of being in one place or an environment, even when one is physically situated in another' (Witmer, Jerome and Singer 2005; Witmer and Singer 1998). The relationship between a sense of special presence and learning within a virtual environment was explored by Tichon (2007) who found a relationship between participants' sense of spatial presence within a virtual environment and the effectiveness of a programme aiming to train drivers in the operation of complex heavy machinery.

'Teaching presence' and the Community of Inquiry (CoI) framework

In the context of educational research, the notion of presence has been widely adopted and used in frameworks for online or blended learning (Baker 2010; Dunlap, Verma, and Johnson 2016; Garrison, Anderson, and Archer 2000; Kozan and Caskurlu 2018; Nagel and Kotzé 2010; Shea, Li, and Pickett 2006). A prominent example can be seen in Garrison, Anderson and Archer's (2000) application of the Community of Inquiry (CoI) (Figure 1) framework to online learning, originally within the context of text-based communication. This has been widely adopted as a theoretical model to explain and explore concepts in both online and blended learning experience (Chandler *et al.* 2013; Chen, Zydney, and Patton 2017; Díaz *et al.* 2010; Evans, Ward, and Reeves 2017; Nagel and Kotzé 2010, Katz and Halpern 2015). In this context, 'community' refers to 'a community of learners' which is claimed to be 'at the heart of a meaningful educational experience' in higher education (Garrison and Arbaugh 2007). Garrison, Anderson and Archer identified three distinct notions of presence: social presence, cognitive presence and teaching presence.

Figure 1. The community of inquiry framework.
Note: Garrison, Anderson, and Archer 2000.

'Teaching presence' as referred to by Garrison, Anderson, and Archer (2000) refers to two distinct activities in online education. First is the design of the educational experience. Second is the facilitation of the learning experience. In subsequent work, usage of the term has evolved to incorporate a broader range of teaching roles (Daspit and D'Souza 2012; Scagnoli, Choo, and Tian 2019; Scagnoli, McKinney, and Moore-Reynen 2015). The critical role played by teaching presence within students' learning experiences and level of satisfaction is supported in a number of studies (Chen and Wu 2015; Evans and Cordova 2015; Garrison 2017; Holland 2014; Scagnoli, Choo, and Tian 2019; Scagnoli, McKinney, and Moore-Reynen 2015; Schrader and Bastiaens 2012). As Garrison (2017) argues 'there should be no doubt of the essential role teaching presence plays in integrating the various elements of an educational experience' (2017, p. 71).

In such research, the notion of 'teaching presence' focuses on the actions taken by the teacher rather than the student perception of the instructor being physically present. However, this latter notion is explored by Scagnoli, Choo, and Tian (2019) who investigated the impact of placing video recording of an instructor within a course on students' sense of that instructor being 'present' in the course. This and related research found that students believe that their interaction with videos increases their motivation and engagement due to perceived personal connection with the instructor (Evans and Cordova 2015; Giannakos, Jaccheri, and Krogstie 2016; Hughes 2009; Scagnoli, Choo, and Tian 2019; Tichon 2007).

In the present research, the term 'teaching presence' refers to attendees' sense of a presenter being physically present in a seminar.

Research questions

This study sought to identify any potential advantages in the use of HVC compared to non-holographic videoconferencing. Specifically, the research questions were the following:

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Compared to non-holographic videoconferencing, does the use of HVC enhance:
presenters' degree of teaching presence?
attendees' engagement with a seminar?
attendees' enjoyment of a seminar?
Do presenters consider HVC to be a valuable and practical technology?

Research methods and design

The seminars

In the present study, data were collected from attendees of one of three live seminars, each featuring a presenter participating via HVC. Each seminar featured an audience physically located in London and was facilitated using the HVC technology described above. Each seminar also included a host who was physically in the same place as the audience.

The first seminar on the topic 'Women in Technology', comprised three parts: a synchronous presentation from a presenter physically located in Los Angeles, a pre-recorded holographic presentation and a live panel debate comprising a combination of two physically present panellists and two panellists participating via HVC from New York. The second seminar comprised a student-led seminar on the topic of technological disruption and featured a keynote speaker participating from a different location in London via the HVC technology. The third seminar titled 'International Perspectives on Sustainable Finance' contained two presenters, physically located in Canada, participating via the HVC technology.

The holographic technology

The HVC technology enabled presenters to appear as 3D, life-size entities and to interact with the audience in real time. Monitors and holographic images were calibrated so that presenters were able to point to and achieve eye-contact with members of the audience. As such, they were able to respond to audience reactions and take questions in a manner similar to being physically present in the lecture theatre.

The equipment comprised a 'capture studio' and a 'display studio'. The capture studio (Figure 2) comprises a video production studio containing a high-definition camera, lighting, audio equipment and set dressing. In addition, the set contains replicas of any furniture that appears in the display studio, a black curtain as a backdrop and one or more reference monitors for the presenter showing a live feed of the audience.

The video footage captured in the 'capture studio' is transmitted to the 'display studio' via an internet connection using proprietary software supplied by a commercial vendor. A projector projects this footage onto a transparent mesh screen. A black curtain backdrop together with lighting effects create the illusion of a three-dimensional holographic image (Figure 3).

Data collection and analysis

Data collection comprised a questionnaire delivered to attendees and semi-structured interviews with presenters. The same data-collection instruments were used for each of the three seminars. The questionnaire, comprising closed and open questions, was

Figure 2. An example of a capture studio.

Figure 3. An example of a display studio.

sent to all attendees following their attendance at a seminar and focused on research question 1. Questions asked attendees to compare their experience of the HVC conferencing technology with non-holographic videoconferencing.

As shown in Table 1, of the 221 attendees across the three seminars, 127 (57%) completed and returned the questionnaire. A total of 54% of these respondents were female and 46% male.

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Table 1. Participants and response rate.

	Seminar 1	Seminar 2	Seminar 3
Attendees	100	46	73
Attendees responding	68 (68%)	30 (65%)	29 (40%)

Semi-structured interviews were conducted involving four of the six presenters, who participated via the HVC technology, and focused on research question 2. Quantitative data analysis comprised univariate descriptive statistics. The qualitative data were explored using thematic content analysis.

Results

1 a) Did the use of holographic videoconferencing enhance presenters' degree of teaching presence?

As shown in Table 2, attendees strongly agreed with the premise that the use of HVC enhanced their sense of the remote presenter being present. A total of 84% of respondents agreed with this premise, 2% disagreed.

The following indicative responses to the open questions within the questionnaire suggest the reasoning behind this result: respondents frequently referred to a sense of the presenter being physically present in the seminar

'The wow factor derives from the presence of the speaker, who looks almost on stage'. (Attendee S)

'The speaker beamed in from New York who looks "being there" physically on stage, the experience was truly amazing, holograms were like out of Star Wars!' (Attendee Q)

'It's kind of surreal, I feel the presence of the speaker as she is in the same lecture theatre here when she listens to, looks at and talks to me, but she is in Canada!'. (Attendee A)

Respondents also stated the event to have a greater sense of 'realism' compared to experiences of non-holographic videoconferencing.

'The event was good and very interesting with the hologram, which offer realistic face-to-face presence breakthrough that could not be provided by a Skype call… because the images on a 2D flat screen with Skype calls is less realistic'. (Attendee H)

1 b) Did the use of holographic videoconferencing enhance attendees' engagement with a seminar?

As shown in Table 3, the respondents in this study strongly agreed that the use of HVC enhanced their sense of engagement in the seminar.

The majority of respondents (78%) agreed that the use of HVC is more likely to facilitate attendee engagement and 73% of respondents stated a belief that holograms enhance the effectiveness of interaction between attendees and remote presenters. Respondents commented that the enhanced sense of the presenter being physically present resulted in more sustained attention during the seminar.

Table 2. Teaching presence.

	Minimum	Maximum	Mean	Std. deviation	Variance
Holograms *offer more realistic in-person presence* of speakers who are based remotely	7	10	9.22	0.750	0.562

Note: Perceived comparison with non-holographic videoconferencing, 1 = strongly disagree, 10 = strongly agree.

Table 3. Engagement.

	Minimum	Maximum	Mean	Std. deviation	Variance
Holograms enhance *effectiveness of interaction between students and speakers* (both locally and remotely).	7	10	9.16	0.855	0.731
Holograms *offer much more efficient communication* among participants.	7	10	8.89	0.739	0.546
Holograms enable speakers to *address participants in different locations simultaneously*.	7	10	8.66	0.872	0.760

Note: Perceived comparison with non-holographic videoconferencing, 1 = strongly disagree, 10 = strongly agree.

'I find it's very easy to get distracted with webinar or video-lectures but with hologram lecturers, they are in front of you as in the same room, it's very different experience'. (Attendee J)

'The experience is interesting, I'd pay more attention when the instructor appears as holograms than if he is only present in video-lectures, the realistic presence-in-person is more powerful I guess…'. (Attendee T)

A total of 22% of respondents stated a neutral view on whether holograms enhanced attendees' engagement. However, the majority stated this was due to technical issues experienced during the set-up of the seminar.

> 'There were some sound issues at one point of the lecture with some of speakers that took away the feel of the holograms, I'd be more engaged with speakers if the sound is better from back'. (Attendee B)
>
> 'The event was good and very interesting with the holograms, however (perhaps because of the backlight) the 3D feeling was not perfectly captured. I did not feel like it was a lot different from live streaming'. (Attendee M)
>
> 'When two hologram speakers presented, at the one point, one of the holograms kept looking in the wrong direction – the opposite to the speaker, although she realised later on'. (Attendee C)

1 c) Did the use of holographic videoconferencing enhance attendees' enjoyment of the seminar?

In this study, attendees strongly supported the statement that the use of HVC enhanced their enjoyment of the seminars (Table 4).

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Table 4. Enjoyment.

	Minimum	Maximum	Mean	Std. deviation	Variance
Holograms make *the lecture much more fun*.	7	10	9.22	0.910	0.829
Holograms make the lecture *much more enjoyable*.	7	10	9.11	0.895	0.800

Note: Perceived comparison with non-holographic videoconferencing, 1 = strongly disagree, 10 = strongly agree.

Of relevance here is the fact that only 12 of the 127 respondents reported that they had previously attended an HVC-facilitated event. The majority of participants were therefore experiencing HVC for the first time and comments suggested that a sense of novelty was a factor promoting the reported sense of enjoyment.

'The lecture was very well put together. It was enjoyable and a delight to attend for the first time'. (Attendee A)

'The whole experience was truly magical! I felt extremely proud as an MSc IHM student to have the opportunity to be part of this pioneering lecture'. Student J)

2. Do presenters consider holographic videoconferencing to be a valuable and practical technology?

Four of the six presenters who participated in the seminars via HVC were interviewed. All stated their experience to be positive, supporting the premise that HVC can be a practical technology to facilitate and enhance the delivery of seminars. The primary advantage offered by the presenters was that the HVC technology provided an experience closer to that of a face-to-face presentation in that they were able to interact with the audience in a more realistic manner.

'I was part of an amazing discussion with impressive women that allowed for two-way audience interaction from thousands of miles away. It was a bit surreal to see myself projected on a stage between three live humans, but I felt much more engaged and part of the discussion than if it were a video chat. The conversation flowed freely, and I think the audience at times forget we were being beamed in from New York'. (Presenter physically present in New York)

Discussion

The respondents in this study were not ambiguous in their enthusiasm for the HVC format adopted. The results suggest that the use of HVC, when compared to alternative non-holographic conferencing formats, may enhance the teaching presence of remote presenters, enhance engagement between participants and increase attendees' enjoyment of a seminar.

Attendees suggested that these concepts are linked in that it was the more realistic in-person presenter presence afforded by the HVC that fostered engagement which made the seminar more engaging and enjoyable. Of particular interest is the fact that attendee responses also suggest that use of the HVC technology may help to sustain attendee attention to a presenter.

Almost all attendees reported that this was the first time they ever attended a holographic event and a sense of novelty was present. This suggests that the benefits of HVC may reduce over time. However, we argue that some of the benefits relating to the enhanced degree of teaching presence will be sustained. In particular, the use of HVC increased attendees' sense of 'teaching presence', a component of the CoI framework shown to aid motivation and engagement (Chen, Zydney, and Patton 2017; Dunlap, Verma, and Johnson 2016; Garrison, Anderson, and Archer 2000; Garrison and Arbaugh 2007; Kozan and Caskurlu 2018; Nagel and Kotzé 2010).

This research also found that the effectiveness of the HVC depends on appropriate technical set-up, participants reported that better sound and lighting would have significantly improved their experience. In addition, it is necessary for presenters to be appropriately trained in the nature of delivering presentations through HVC due to the novel nature of presenting involved.

Conclusion

The adoption of HVC within higher education is at an early stage; however, the results of this study offer encouragement that this technology may offer value with regard to the student learning experience. This study does not make claims regarding any positive effects on learning gain or knowledge retention; however, the impacts on attendees' sense of teaching presence, engagement with the seminars and level of enjoyment in themselves seems valuable and worthy of further exploration.

Limitations of the study

This study does have limitations. There is potential bias arising from the selection of the participants in that the attendees for each of the three seminars were self-selected. The topics of seminars 1 and 2 both had a technology focus and, in addition, the topic of seminar 1 had a gender focus. Therefore, female students were slightly overrepresented and technology-inclined individuals were also likely to be overrepresented. In addition, this relies heavily on attendees self-reporting on their experience following an event. Studies adopting more observational methods would provide more robust support for the results.

A further limitation is that a range of HVC and non-holographic technologies exists, with varying functionality. This study investigated the use of one HVC with particular characteristics. Further studies comparing alternative technologies would be valuable. For example, this study did not directly compare the HVC technology to non-holographic videoconferencing systems that render the participants in life size. Such a study would provide further insight on effects directly attributable to the holographic representation.

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