Assessing the applicability of 3D Hologram Technology as an Enhanced Technology for the Distance Learning

Pradeep Kalansooriya, Nagaoka University of Technology, Japan
Ashu Marasinghe, Nagaoka University of Technology, Japan

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Abstract
Distance learning has provided an excellent platform for students in geographically remote locations while enabling them to learn at their own pace and convenience. A number of technologies are currently being utilized to conceptualize, design, enhance and foster distance learning. Teleconferences, electronic field trips, podcasts, webinars, video conferencing and online courses are among such technologies used in providing distance learning opportunities. However limitations in those existing technologies have affected to the increase of distance learners dropout rates. As an attempt to overcome the limitations in the currently adopted distance learning practices, the study aims to utilize 3D Hologram Technology (3DHT) in the Engineering discipline. 3D hologram facilitates live and life size 3D telepresence that can interact with remote audiences. A survey had been conducted, using Delphi Technique to gather data from the experts in the field to evaluate the potential of 3DHT over existing technologies. Results of the survey suggested that 3DHT as a good distance learning technology and have the potential of overcoming existing limitations. Lack of infrastructure, High initial cost of infrastructure and Lack of technical know how are the main encounters identified by the experts in the sample. It is expected to develop a classroom environment with 3DHT and to evaluate its effectiveness for the distance learning in the next stage of the study.

Keywords: Distance learning, 3D Hologram technology

Introduction

Distance Education

Distance Education or Distance Learning is a field of education that focuses on teaching methods and technology with the aim of delivering teaching, often on an individual basis, to students who are not physically present in a traditional educational setting such as a classroom (Subrahmanyam & Ravichandran, 2013). Fundamentals of distance education are that teachers and students are in different places for all or most of the time that they teach and learn. Hence it requires some form of communication technology to connect the teacher and the student. Accordingly, Bratt (1977) stated that history of distance education dates back to the early 18^{h} centaury, nonetheless conclusive evidences were found in1833 in the form of advertisement by old Swedish university city of Lund, which offered opportunities to study through the medium of the post. Another early attempt to provide distance education was made in England by Isaac Pitman who taught shorthand on postcards (Holmberg , 2005).

Distance Education has progressed in leaps and bounces due to the fast evolution of communication technology allowing faster and convenient opportunities for the students and teachers. Webinar, Teleconference, Podcast, Virtual world and Blogs are some of the modern communication technologies used in Distance Education. Some of the modern communication technologies and their advantages and disadvantages had been summarized in Table 1. Accordingly, difficulty of interacting between teacher and student was noticeable in different levels on almost every technology compared to the conventional classroom interaction with teacher and student. Hence developing innovative communication technology, which eliminates difficulties of interacting between teacher and student, will be exciting area of research.

Table 1: Advantages and Disadvantages of exiting communication technologies of Distance Education

Communication Technology	Description	Advantages	Disadvantages
Webinar	Instructor leads the learning, and all learners are logged on simultaneously and communicate directly with each other (Shi & Morrow, 2006)	• Ability of real time sharing of knowledge and learning • Opportunity for immediate access to the instructor to ask questions and receive answers	• Only 2D communication can be possible, hence good interaction cannot be possible • Requires quality bandwidth and computing power
Virtual world	Computer simulated environment that enables users to interact with each other without geographical confines. An avatar represents each user.	• Ability of interacting large number of communities • Ability of cost effective and robust simulation for	• Avatar or graphical representation is not real, so that the interaction between the parties are artificial • Requires quality

	(Harris & Rea, 2009)	educational activities	bandwidth and computing power
Podcast	It involves downloading a series of audio or video broadcasts (files) onto a digital media player, via a computer, over a period of weeks (Evans, 2008)	• Ability of using the materials repeatedly • Ability of using any time user want	• Only one sided interaction is possible • They are stagnant. Once created, they cannot be changed or modified
Text based materials		• No special facilities or equipment are needed to use it • Ability of easy navigating; random access of specific portions is convenient and fast	• Interactivity is more difficult to achieve with print than with some other media
Electronic field trip	Use digital and computer visualization techniques based on the personal computer and internet (Qiu & Hubble, 2002)	• Ability of presenting trips to inaccessible areas • Provide an alternative of fieldwork, when time, expenses, and/or logistics are real issues	• Do not convey the true three-dimensional nature of objects • Do not convey the non-visual and aural feelings of touch, smell etc

Among all these technologies, Virtual Environments (VE) have been subjected to many researches over the years for its potential of facilitating for education in many disciplines, such as, learning sciences, computer science, psychology, communication, etc… (Bailenson et al, 2008). There are number of learning opportunities provided by VEs as learning modules stems from their ability to implement contexts and relationships not possible to achieve in a traditional learning setting.

Embodiment of Agents that Teach and Learn

In recent studies many efforts have been made to create intelligent virtual agents who teach a learner about a specific domain. Rickel and colleagues' work (1998) on evaluating the possibility of using virtual agents in performing complex mechanical tasks in a learning VE, the creation of a virtual tutor for teaching the fundamentals of hardware and operating systems developed based on the natural language processing interface (Hill et al., 2003), the digitally augmented dollhouse that encourages children to tell stories as a way of promoting literary competencies (Cassell, 2004) are some of the noteworthy examples of such. Virtual agents not only allow a user to enter into a learning experience at his or her own convenience, but they can also provide personalized one-on-one learning experiences tailored to the individual that would be prohibitively expensive otherwise (Baylor & Kim, 2005).

Existence of Co-learners

There is a factual reality on the success rate of students learning in groups outperform students in individualistic conditions (Johnson, Johnson, & Skon, 1979; Wood, Willoughby, Reilly, Elliot,&DuCharme, 1995). Therefore, in the reality, it is a substantial shortcoming of the typical individualized learning environments with virtual teachers. However the introduction of co-learners in VEs, as a solution for the aforementioned issue, have been thoroughly studied and confirmed conceivably better than a traditional classroom since virtual co-learners can be programmed to behave specifically to enhance each user's learning process (Bailenson et al, 2008). Studies conducted to evaluate the credibility of having virtual co-learners in the process of learning suggest that co-learner's positive behavior can enhance a user's increased performance (Ju, Nickell, Eng, & Nass, 2005).

Visualizations

Visualization is one of the salient features of VEs. It helps the users with visual, haptic and auditory cues to enhance and swift between different perspectives of a given set of complex information. For an example, the study conducted by Perdomo and the team in 2005 concluded that abstract concepts such as architectural settings, engineering setups, or chemical structures can be conveniently understood by the user, if they were enabled to create, alter, and rotate in real time three dimensions. In addition enabling users with multiple perspectives on the same situation -central, peripheral, bird's-eye view, and so on, assist them in the learning process through allowing them to understand different aspects of the situation clearly (Ellis, Tharp, Grunwald, & Smith, 1991).

Synthesis of Archived Behaviors

One of the strong suits of VEs, which was highly noted by many scholars, is that every single action that is rendered must be formally represented in order to appear to the users. Subsequently every action carried out by the users can be constantly recorded over time, and assimilation of such data can be used to evaluate behavioral profiles (Bailenson et al, 2008). For example, Rizzo and colleagues (2000) automatically collected the gaze behavior of students in a virtual classroom via head-tracking devices and used patterns of attention and gaze to diagnose deficits in attention among children. Bailenson and team (2008) clearly mentioned that when the behavioral tracking systems become more elaborate, the ability to use this information to track student performance and consequently improve learning systems should become a major advantage of using virtual classrooms.

3D Hologram Technology

Evolution of 3D Hologram Technology (3DHT)

Holography can be referring to as a method of obtaining photographic image in three dimensions (Ahmad, 2014). It involves the use of a laser, interference, and deflection, light intensity recording and suitable illumination of the recording. (Upadhye, 2013) specified that the term hologram be composed of the Greek terms, "holos" for "whole view" and gram for "written". However the technical term for the holography is wave front reconstruction.

Dennis Gabor Hungarian Physicist is considered as the father of Holography as he invented this technique when he was working on to improve his electron microscope. However

(Chavis, 2009) noted that the technique was not fully exploited till 1960s, as the laser technology had not been improved to standards. Records indicate that by the time of 1962 scientists in both in United States and Soviet Union had developed 3D holographic technology. Today Holograms is expanding its boundaries from science fictions to one of world's attractive communication method. Live and realistic 3D hologram representations can now interact with their distance audiences whether they are a band or artist performing on stage, a politician delivering a keynote speech, announcers broadcasting a live program simultaneously from different places or a CEO holding an interactive meeting with colleagues around the world.

Process of 3DHT

As per the following figure 1 the two laser beams reach the recording medium, their light waves intersect and interfere with each other. Those interferences are imprinted on the recording medium and can be considered an encrypted version of the scene. In order to view its contents require a laser beam identical to the original light source used to record the hologram. When such laser is beamed at the developed film, it illuminates the hologram and it is diffracted by the hologram's surface pattern. This phenomenon produces a light field identical to the one originally produced by the scene and scattered onto the hologram. The image this effect produces in a person's retina is known as a virtual image.

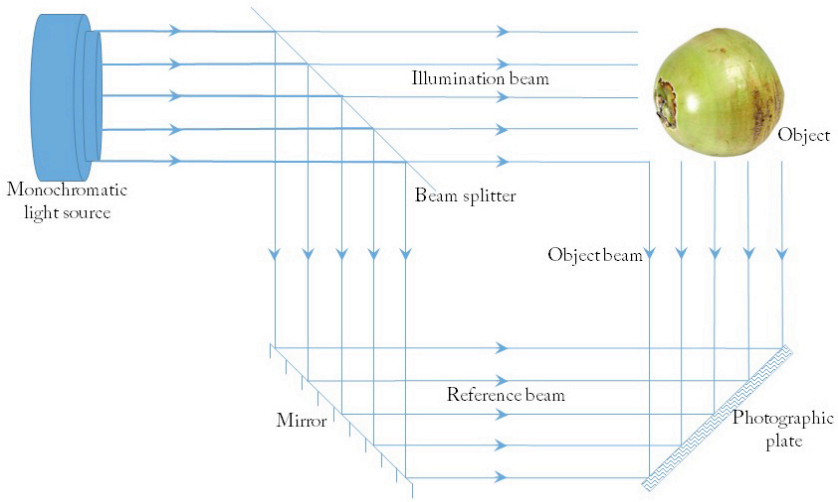

Figure 1: Recording a hologram

About some of the famous examples, which are recognized as implications of 3DHT, there are some contradictive opinions expressing that those are truly not 3DHT implications. Narendra Modi's election campaign and Michael Jackson performance on the 2014 Billboard Music Awards are two such events that commonly considered implications of 3DHT but have contradictive opinions. Some expertise argues that those events are advancement of Pepper Ghost Technology. "Pepper's Ghost" occurs when a semitransparent image appears in front of a background and it involves reflecting an image from a beam splitter placed in front of a scene. "Pepper's Ghost" provides only a single reflection. It does not allow multiple planes of transparent images. Furthermore, it cannot produce images that pass through each other in a direction parallel to the optical path to the viewer. Figure 2 simply graphically demonstrates the process of Pepper's Ghost.

Table 2: Recent real-world implications of 3DHT

Example	Description	Features
Narendra Modi's election campaign	The prime minister of India, Modi used holographic technology in his election campaign 2012. He Addressed the voters in different locations simultaneously through filmed speeches by broadcasting them live via a satellite uplink to the stages. (Musion, 2014)	Offered a 3D convincing view of the president. Addressed different locations simultaneously
Election result broadcasting on CNN - 2008	At the election coverage program 2008 in America announcer in Chicago was beamed up into Wolf Blitzer's studio in New York with a very realistic display. This event attracted millions viewers to watch the hologram effect via a YouTube clip.	Sensed that two announcers were at same place. Interaction between announcers were attractive and efficient Realistic view of the announcer
Michael Jackson performance on the 2014 Billboard Music Awards	Beaming Michel Jackson's performance on to the stage commenced billboard Music Award 2014. (Gallo, 2014)	Performance was creative and attractive as the famous character brought to life again.

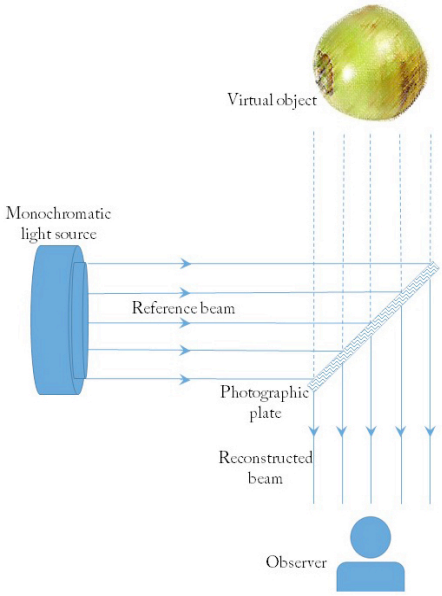

Figure 2: Reconstructing a hologram

Despite the contradictive arguments most of those implications are considered as implications of 3DHT. To conclude appropriate definition and process requires deep review of literature, which is not in the scope of this study. Hence both those processes are considered under 3DHT and implications from both processes are taken in to consideration in latter parts of this study.

Implications of 3DHT

Currently 3DHT is 3DHT has been used in many fields due its increasing popularity. Some of the recent implications are summarized in the table 2. "Narendra Modi's" election campaign by using 3DHT was noteworthy example. As India is a very large country successful election campaign is a challenging task. Using 3DHT for the election campaign helped the speakers to address different locations simultaneously through filmed speeches by broadcasting them live via a satellite uplink to the stages. Those views of the politicians were very convincing, thus it was very attractive and touched the people who had never seen a politician addressing them so close to them. Another example of 3DHT, which attracted millions of YouTube viewers, was Election result broadcasting on CNN – 2008. It allowed two announcers in two different places to broadcast the results with better interaction and creativity. Michael Jackson performance on the 2014 Billboard Music Awards was another exciting example 3DHT. It was a fascinating and creative performance for the fans of Michael Jackson as the famous character brought to life again. In addition to above examples, some of Museums using 3DHT to bring world-renowned masterpieces to life again.

The Importance of 3DHT on Education

It may possible to take advantages of some of the features mentioned in the table 2. Those features in the table 2 can be review and summarized as follows;

Ability of offering convincing and realistic view of the user

- Ability of communicating users in different locations
- Ability of attractive and efficient communication
- Ability of bringing famous characters back to life

Students and teachers can afford to communicate and interact each other's even they were in very far from each other as its ability of communicating from different places. Students might be benefited by the realistic and convincing views of the study materials. The hologram teacher appears to be in the classroom, and can see and speak to the students as if they were all in the same room, which enables attractive and efficient interaction between student and teacher. Further to that it can enhance the educational process by bringing famous characters to life again from the past, and they speak about themselves and/or explain something as an assistant teacher would be attractive for the students. However those potentials have not been testified realistically yet. Thus this study attempts to provide and initial groundwork for the above purpose.

Methodology

Questionnaire and Sampling Procedure

The questionnaire adapted in this study comprised with three parts with an objective of evaluating experience and ideas in a distance-learning environment. First part of the questionnaire aimed to compare important factors in teaching environment and evaluate the level of importance of video based education and hologram based education. Important factors in teaching environment which were used in the questionnaire is shown in figure 1. Second part of the questionnaire focused on the evaluation of the applicability of hologram technology in classroom environment by identifying major barriers and technical difficulties in implementing a hologram based classroom. Finally, the third section comprises of general

information of the responder. Qualitative responses were quantified through a 1 to 5 Likert scale where 1 indicated the strong disagreement while 5 indicated the strong agreement level.

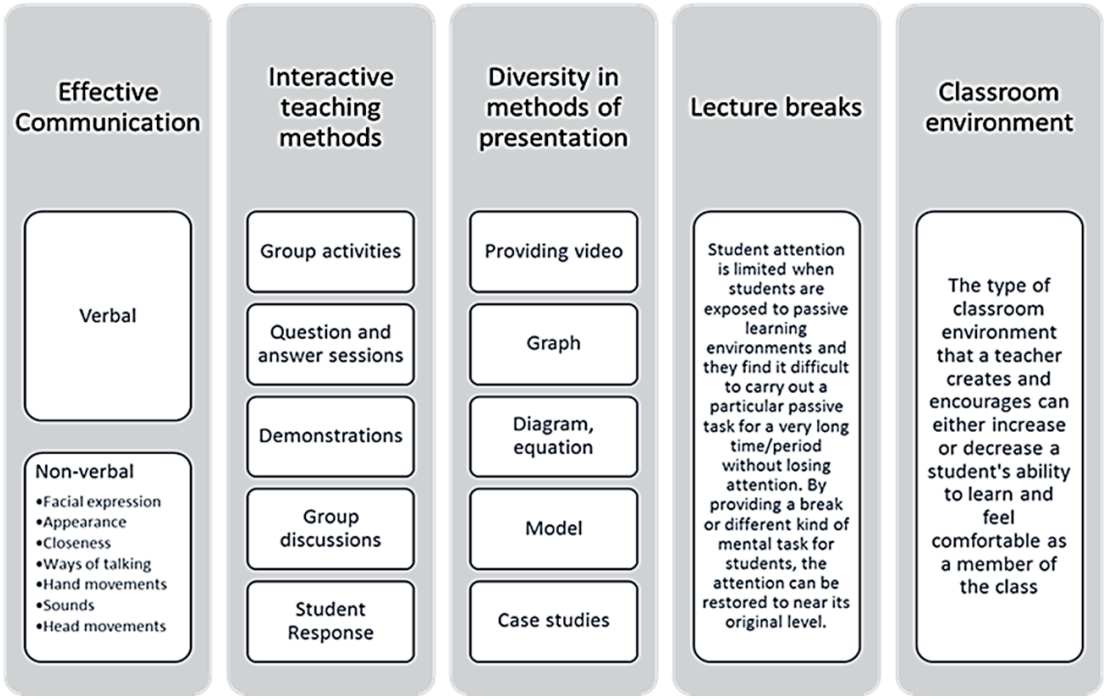

Figure 3: Factors and indicators of effective teaching environment

Since, 3DH is a developing technology therefore the awareness about 3DHT is at a lower point among general public, experts' views were considered for the study. The Delphi technique [1] was used in selection of the sample of 25 each from two categories; University Academia, and IT related professionals. Only 17 (43.6%) and 22 (56.4%) participants have responded and considered valid for the analysis of the study respectively.

Analysis Procedure

Data obtained from the survey had been analyzed in three stages using Analytic Hierarchy Process (AHP), Descriptive analysis, and Analysis of Variation (One-Way ANOVA) consecutively. AHP was used to conduct a pairwise comparison of factors of effective teaching environment and thereby to evaluate the suitability (according to the perceptions of participants) of Video technology based education and Hologram technology based education. Means and Standard Deviations of the dependent variables; Likability to use 3DHt, Cost effectiveness, and Students' active involvement, were used to describe the behavior of the sample. Finally, the mean differences of groups within separate categories; gender, experience, Profession/ Expertise were calculated using Analysis of Variation (One-Way ANOVA)

[1] "The Delphi technique is well suited as a method for consensus-building by using a series of questionnaires delivered using multiple iterations to collect data from a panel of selected subjects. "(Hsu, & Sandford, 2007).

Analysis

Pairwise Comparison of Importance 0f Factors Related to Teaching and Learning Environment

Each respondent in the sample was given an opportunity to make pair wise comparison between 'Effective communication', 'Interactive teaching methods', 'Diversity in method of presentation', 'Lecture breaks', and 'Classroom environment' and requested to give weights according to the level of importance. According to AHP 'Interactive teaching methods' and 'Effective communication' are the factors rated highly with generalized weights of 26.58% and 24.13% respectively.

Table 3: Results of pairwise comparison of factors related to teaching and learning environment

Factor	Weights (%)
Interactive teaching methods	26.58
Effective communication	24.19
Diversity in method of presentation	19.88
Classroom environment	16.71
Lecture breaks	12.65

Comparison of Video Based Education and Hologram Based Education for The Factors Related to Teaching Environment

The participants were asked to rank the level of importance on a scale of 1 to 5 where 1 is the lowest and the 5 is the highest. The Figure 2 and Table 3 illustrate the level of importance that each factor received for both teaching mechanisms. Almost all the factors were recorded important other than for lecture breaks for both categories. Additionally Hologram based distance education was recorded important for factors other than 'Lecture breaks' in relation to video based education. Further it was statistically proven by the generalized mean of 3.892 (Standard Deviation : 0.453).

Table 4: Comparison of video based education and hologram based education

	N	Minimum	Maximum	Mean	Std. Deviation
Video based distance education	39	1.608	4.355	2.948	0.710
Hologram based distance education	39	2.759	4.747	3.892	0.453

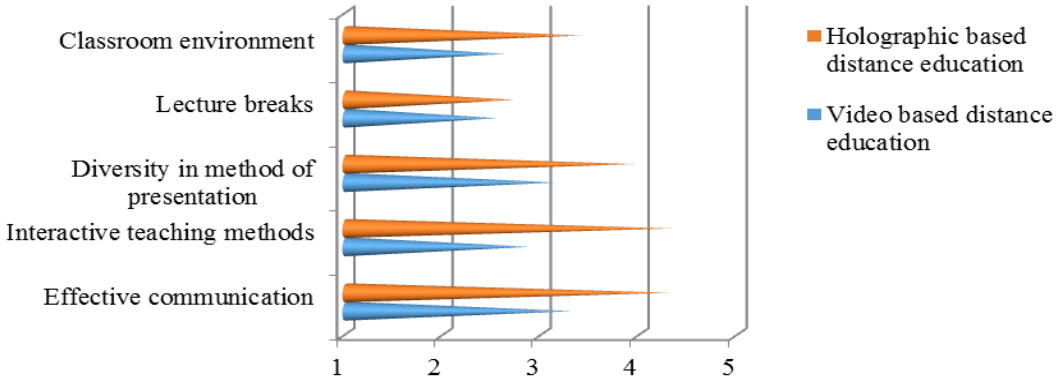

Figure 4: Comparison of video based education and hologram based education for the factors related to teaching environment

Perceptions on 3D Hologram Based Classroom Environment

One –way ANOVA statistical test was performed to test whether there are differences between independent variables; gender, experience, and employment groups.

Likability To Engage

Table 5: Perceptions on likability to engage in 3D Hologram based classroom environment

	N (%)	Mean	Std. Deviation	Minimum	Maximum
Male	61.5	3.96	1.429	1	5
Female	38.5	4.47	0.640	3	5
≤10 year experience	48.7	4.42	0.607	3	5
>10 year experience	51.3	3.90	1.553	1	5
University Academia	43.6	3.59	1.583	1	5
IT related professionals	56.4	4.59	0.503	4	5
Total	100	4.15	1.204	1	5

There is a statistically significant difference between University academia and IT related professionals ($F(1,37) = 7.851$, $p = 0.008$). No other groups have indicated heterogeneity within groups mentioned above. Tukey post-hoc test was not possible, since there is no any group consists with at least three sub categories.

Cost Effectiveness

Table 6: Perceptions on cost effectiveness of 3D Hologram based classroom environment

	N (%)	Mean	Std. Deviation	Minimum	Maximum
Male	61.5	3.33	0.868	1	4
Female	38.5	3.40	0.910	1	4
≤10 year experience	48.7	3.53	0.841	1	4
>10 year experience	51.3	3.20	0.894	1	4
University Academia	43.6	3.18	1.015	1	4
IT related professionals	56.4	3.50	0.740	1	4
Total	100	3.36	0.873	1	4

There is no statistically significant difference between groups mentioned above.

Students' Active Involvement

Table 7: Perceptions on active involvement of students in 3D Hologram based classroom environment

	N (%)	Mean	Std. Deviation	Minimum	Maximum
Male	61.5	3.38	1.279	1	5
Female	38.5	3.60	1.183	1	5
≤10 year experience	48.7	4.11	0.937	1	5
>10 year experience	51.3	2.85	1.182	1	5
University Academia	43.6	3.24	1.348	1	5
IT related professionals	56.4	3.64	1.136	1	5
Total	100	3.46	1.232	1	5

There is a statistically significant difference between experience groups ($F(1,37) = 13.417$, $p = .001$). No other groups have indicated heterogeneity within groups mentioned above. Tukey post-hoc test was not possible, since there is no any group consists with at least three sub categories.

Major Barriers in Implementing 3D Hologram Based Classroom

Participants responded vividly to the question regarding major barriers in implementing 3DH based classroom. 'Lack of infrastructure' and 'High initial cost of infrastructure' have been identified as the main two barriers with Mean values reached more than 4.00. Additionally 'Limited bandwidth' was also identified as a secondary roadblock in the process of implementing 3D Hologram based classroom (Table 7, Figure 3).

Table 8: Major Barriers in Implementing 3D Hologram Based Classroom

	Minimum	Maximum	Mean	Std. Deviation
Lack of infrastructure	2	5	4.36	0.811
High initial cost of infrastructure	2	5	4.23	0.872
Bandwidth limitations	2	5	3.46	0.854
Backwardness in adapting to new trends	1	5	3.08	1.265
Lack of technical know-how	1	5	3.92	1.178

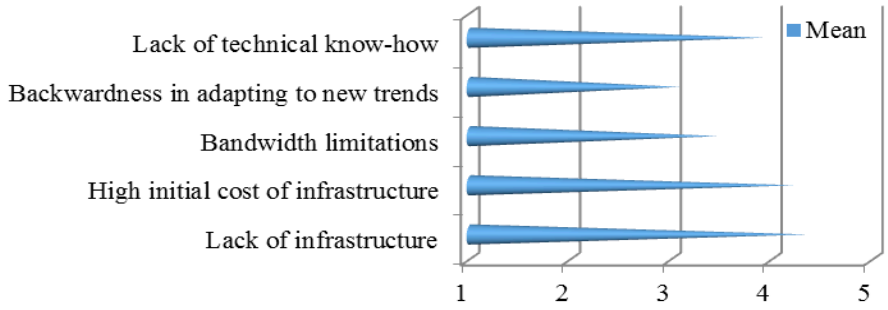

Figure 5: Graphical representation of major barriers in implementing 3D Hologram based classroom

Perceived Benefits of 3D Hologram Based Classroom

At least 30% of the respondents believed that 3DH classrooms enhance the real time experience of students through 3D perceptual effects and effective in both theoretical and practical subject content delivery. Fifteen percent of the sample believed that 3DH classrooms in distance learning have the power to enhance effective interaction between student and teacher while reaching out for mass audiences regardless of distance and time barriers (Figure 5).

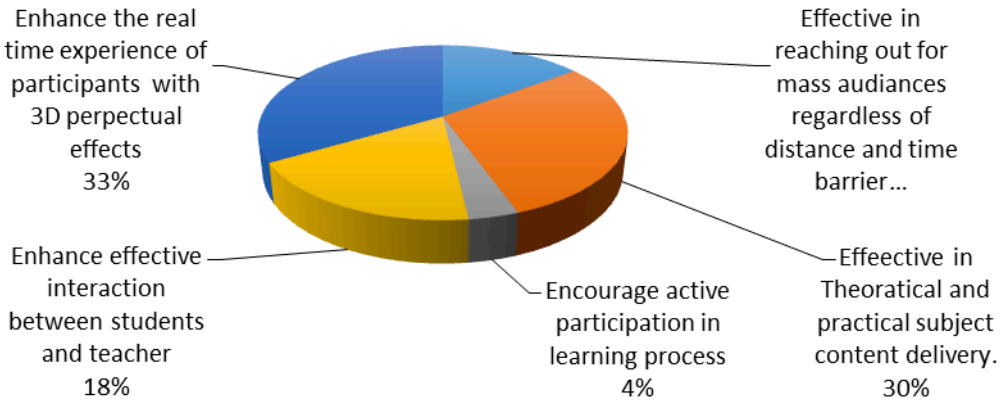

Figure 6 : Perceived Benefits of 3D Hologram Based Classroom

Discussion and Conclusion

3DH is an applicable and strongly appreciated technology for distance education. However, the experts have no clear cut idea about the cost effectiveness and active involvement of students in 3DH classroom. There is a significant difference in perceptions between University academia and IT related professionals on likability to engage 3DHT based classroom. The perceptions on cost effectiveness of 3DHT based classroom does not show a significant difference under any group classification selected in this study. There is a significant difference in perceptions between experience level groups on active involvement of students in 3DHT based classroom. 3DH is an applicable and strongly appreciated technology for distance education.

Lack of infrastructure, High initial cost of infrastructure and Lack of technical know how are the main barriers identified by the experts in the sample. However, respondents believed that 3DH classrooms enhance the real time experience of students through 3D perceptual effects and is an effective mode of delivery in both theoretical and practical subject content.

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Contact Emails: Pradeep Kalansooriya (lpkalan@gmail.com)
Ashu Marasinghe (ashu@kjs.nagaokaut.ac.jp)
K.M.D.N. Bandara (dumindatcp@gmail.com)