The effect of VR and traditional videos on learner retention and decision making

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Abstract

Virtual reality (VR) as computer-mediated 3-D environments including real-life situations presented via different tools in which users can interact effectively with visuals. This study is significant as it primarily aimed to investigate effects of VR on retention by comparing it with traditional 2-D videos. The main aim of this study is to compare the effect of VR and 2-D videos on learner retention and decision making. About 18 students from the Department of English language teaching in an age range of 18–20 (nine males and nine females) voluntarily participated in this study and took course credits. As all participants were tested under the same two conditions in different time periods; repeated measures were chosen for statistical analysis. It can be inferred that both technologies have similar effects on short-term retention and VR does not provide any extra retention performance. However, VR was found to have a significant effect on long-term retention.

Keywords: Virtual reality, eye tracking, retention, decision making.

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1. Introduction

The use of new technologies in learning environments has long been a hot research topic. Especially, in recent years, the benefits of practicing technological trends in educational settings and its possible effects on learning gains have been a research trend. One of these technologies is virtual reality (VR), which started to be quite popular. Although it is commonly believed to be a recent technology, VR technologies date back to 1980s. The initial examination of VR for educational settings concluded that the use of VR was unsuitable for learning gains due to its expensive and fragile nature, especially for crowded classrooms (Tax'en & Naeve, 2002). These cons of VR hindered the fruitful use of VR in learning environments until the 2010s. Today, due to recent technological developments, VR became more popular and less expensive, which paved the way to the implementation of VR in classrooms (Jung, Tom Dieck, Lee & Chung, 2016).

Although VR technologies had different definitions in literature, these definitions have common points. In this respect, VR technologies can be defined as the tools enabling 3-D environments via a computer, a database or Internet in which users go through a virtual experience, involve actively in this 3-D environment and interact with visual stimuli (Carrozzino & Bergamasco, 2010; Cavas, Cavas & Can, 2004; Rheingold, 1991). Additionally, Burdea and Coiffet (2003) defined VR technologies as 3-D environments, which densely include imagination and interaction. Moreover, Kayabasi (2005) refers to VR as computer-mediated 3-D environments, including real-life situations presented via different tools (e.g., goggles) in which users can interact effectively with visuals.

Due to its interactive and creative nature, today VR technologies are popular in various fields such as tourism, health and entertainment (Basaran, 2010). When the definitions and beneficial practice of VR in several fields are considered, VR can also be effective in educational environments as proposed by a number of related studies (Basaran, 2010; Chavan, 2016; Nooriafshar, Williams & Maraseni, 2004; Steuer, 1992; Youngblut, 1998). Possible benefits are as follows:

- VR may lead real-life experience for learners.
- VR environments may provide comfortable and easy learning by promoting cognition.
- Learners may feel involved in complex scientific experiments in a virtual environment.
- As VR enables learners to feel involved in a virtual environment which may promote learner motivation.
- VR provides learning environments which may be impossible, dangerous and expensive in real life classrooms such as a trip to the Louvre museum.
- VR may provide high-quality interactive environments.

In sum, VR technologies in classroom settings may provide a realistic, entertaining and motivating learning experience which can promote retention of learning gains. However, despite its advantages, some limitations of VR technologies were also listed in related literature (Chavan, 2016; Nedas, Challacombe & Dasgupta, 2004).

- Designing and developing VR software are challenging and require advanced software knowledge.
- To enable a feeling of involvement, VR visuals should be high in quality; low-quality visuals cannot provide a realistic feeling.
- It is totally virtual.
- Real life learning is always superior to virtual learning.

When the pros and cons of VR are regarded, it can be inferred that there are still some points to overcome to benefit VR in learning environments. In addition, most common types of media used with VR are videos rather than pictures. Different from traditional video interface which is 2-D, VR enables exposure to 3-D videos some of which are also interactive.

As VR has long been developed as a technology, investigating its use in education is also possible. Previous research on the use of VR as an educational tool is not limited but has a large spectrum

ranging from military training to health education. In their research within the scope of health education, Huang, Liaw and Lai (2016) examined the attitudes of health students towards VR. Their results revealed that VR videos can be effective as an educational tool in several ways. Webster (2016) used VR in military education and concluded that VR-based multimedia enabled more effective learning when compared to 2-D slideshows. In addition, Kal (2017) developed a VR application to overcome various limitations for cinematic storytelling education. Similarly, Sahinler Albayrak (2015) revealed that learning new words in a foreign language is easier with VR videos as it promoted learner motivation. In their research with language learners, Dolgunsoz, Yildirim and Yildirim (2018) also concluded that VR videos promoted long-term vocabulary retention in a foreign language and increased vocabulary intake.

VR technologies can provide both 3-D images and 3-D videos. This study used 3-D videos as related literature showed numerous benefits of videos in educational settings. Videos provide better retention, lead more joyful and meaningful learning along with learning motivation (Alkan, 1988; Cavanaugh & Cavanaugh, 1996; Chiu & Lee, 2009; Hagen, 2002; Kumar, Smith, Helgeson & White, 1994; Merkt, Weigand, Heier and Schwan, 2011; Pekdag, 2010; Simsek, 2010; Tan & Towndrow, 2009; Whatley & Ahmad, 2007; Zhang, Zhou, Briggs & Nunamaker, 2006). Some limitations for videos were also mentioned: They are harder to design and develop, require extra preparation, some technical problems may occur while playing them and low-quality videos may provide no desired effect (Caladine, 2008; Usun, 2006; Vertelney, 1989).

Making decisions mostly involve the processing of visual information. When people need to decide between two or more visual stimuli, they pay attention to them and use their eyes in the decision process. Thus, eye tracking as a tool to interpret decision-making dynamics has long been valued and used in various decision-making research (Glaholt & Reingold, 2011; Krajbich, Armel & Rangel, 2010; Krajbich & Rangel, 2011; Simion & Shimojo, 2006; Wedell & Senter, 1997). They primarily aimed to reveal how eye movements change and how participants decided in given conditions by scrutinising their attentional shifts and gaze plots. Similarly, the current research aims to use eye tracking to investigate decision-making behaviors of learners by measuring their total attention on correct visual items and analysing how many times these items are revisited.

VR is a new technology and its use in learning environments should be investigated to reveal its advantages along with its limitations. This study is significant as it primarily aimed to investigate the effects of VR on retention by comparing it with traditional 2-D videos. The main aim of this study is to compare the effect of VR and 2-D videos on learner retention and decision making. In this respect, the following research questions were addressed:

1. What is the effect of VR and 2-D videos on learner retention? Can VR promote learner's retention of visuals?
2. What is the effect of VR and 2-D videos on decision making regarding total time and revisit counts?

2. Method

2.1. Participants

Eighteen students from the Department of English language teaching in an age range of 18–20 (nine males, nine females) voluntarily participated in this study and took course credits. Non-random sampling method was used for sampling as it is cost effective and practical (Yildirim & Simsek, 2008). All participants have normal or corrected eyesight.

2.2. Materials and visual stimuli

For VR condition, Samsung VR Goggles with Samsung S7 Edge Mobile Phone was used. Two VR videos were presented: First video was about Chernobyl and another one was about bears and their

habitat. Duration for each video was about 5 minutes in 800 × 600 resolution. For 2-D traditional video condition, mp4 formats for the same videos were downloaded from YouTube and presented in a classroom setting via a computer and a projector.

For immediate post-tests and delayed post-tests, 20 images from the related video and 20 unrelated images downloaded from Google were used. Forty images were given in slideshows in which each slide included two images from the related video and two unrelated images. Participants were asked to choose the image taken from the video they watched.

2.3. Apparatus

To collect eye-tracking data, GP3 eye tracker with 60 hz speed was utilised. GP3 is a remote eye tracker, which can register a sample in every 16 ms with 0.5–1 degree of visual angle accuracy and 25 cm (horizontal) × 11 cm (vertical) head movement flexibility. An 18-inch monitor was used to present visual stimuli.

2.4. Data collection

All participants watched both VR and 2-D video in different time periods. In both VR and 2-D video conditions, participants immediately took an unannounced post-test asking them which two images were correct (taken from the video watched). After a month, the same procedure was applied as the delayed post-test by randomising images.

2.5. Data analysis

As all participants were tested under the same two conditions in different time periods, repeated measures were chosen for statistical analysis. Some of the data was observed to have been slightly skewed and kurtic with significant Shapiro Wilk values. For the analysis of these data, the Friedman Test was used as the non-parametric equivalent of Repeated measures ANOVA (Field, 2009).

2.6. Procedure

While VR group individually watched a VR video 'Chernobyl' with VR Goggles seating on 360° rotating chairs, the other group collectively watched the same video in 2-D format projected on the wall in a traditional classroom setting. After watching the video, participants were taken into immediate post-test asking them to choose correct images taken from the video they watched. In this process, their eye movements were recorded while they try to decide. Calibration process was done through nine grid calibration setting before starting the session. Same procedure was applied after a month.

3. Findings

The data obtained were analysed in accordance with the research questions as follows.

3.1. What is the effect of VR on retention capacity of learners?

Retention test scores were analysed to reveal any effect of VR on learner retention in comparison with 2-D videos. Normality tests showed that retention scores did not distribute normally with significant Shapiro Wilk values. Thus, Friedman Test as the non-parametric equivalent of repeated measures (Kilmen, 2015) was performed. The results were given in Table 1.

Table 1. Friedman test results for retention scores

Group	Condition	N	Mean	Mean Rank	Sd	χ^2	p
VR	First	18	17.83	1.67	1	2.250	0.134
	Delayed	18	16.17	1.33			
2B	First	18	18.50	1.81	1	9.308	0.002
	Delayed	18	16.72	1.19			

According to Table 1, both groups remembered a similar number of visuals. In the condition of VR, no significant change was observed between first and delayed test (χ^2 (1) = 2.250, $p > 0.05$). In this respect, it can be inferred that no significant loss of retention occurred in VR condition after 4 weeks; learners remembered most visuals they remembered in the first test. For traditional 2-D video condition, a significant change was obtained regarding retention performance after 4 weeks; (χ^2 (1) = 9.308, $p < 0.05$). This finding showed that in 4 weeks' time, learners in 2-D video condition significantly forgot visuals they remembered in the first test.

3.2. What is the effect of VR and 2-D videos on decision making regarding total time and revisit counts?

Eye movement analysis showed that in VR condition, learners revisited correct visuals slightly more (*M* = 2,09, SD = 0.77) than they did in 2-D video (*M* = 1,72; SD = 0.54). However, results of repeated measures indicated no significant difference between 2-D video and VR conditions regarding revisiting correct test items; Wilks' Lambda = 0.87, F (1.17) = 2.323, $p > 0.05$. Thus, in both VR and 2-D video conditions, revisiting correct test items was similar and was not affected by the type of video watched.

In terms of total time, eye movement analysis indicated that learners paid more attention to correct visuals in test after watching VR (*M* = 1222; SD = 383) while their attentional span slightly decreased after 2-D video (*M* = 1189; SD = 328). Results of repeated measures indicated no significant difference between 2-D video and VR conditions regarding total fixation duration on correct test items; Wilks' Lambda = 0.04, F (1.17) = 0.065, $p > 0.05$. Hence, total time spent on correct test items was not affected by the type of video. A detailed table was given below:

Table 2. Eye movement analysis results

		Mean	Standard Deviation
Total Fixation (ms)	VR	1222	383
	2-D Video	1189	328
Revisit	VR	2,0941	0.77174
	2-D Video	1,7206	0.54085

Sample heat maps and fixation map were given below showing that visual test items were processed in similar attentional spans:
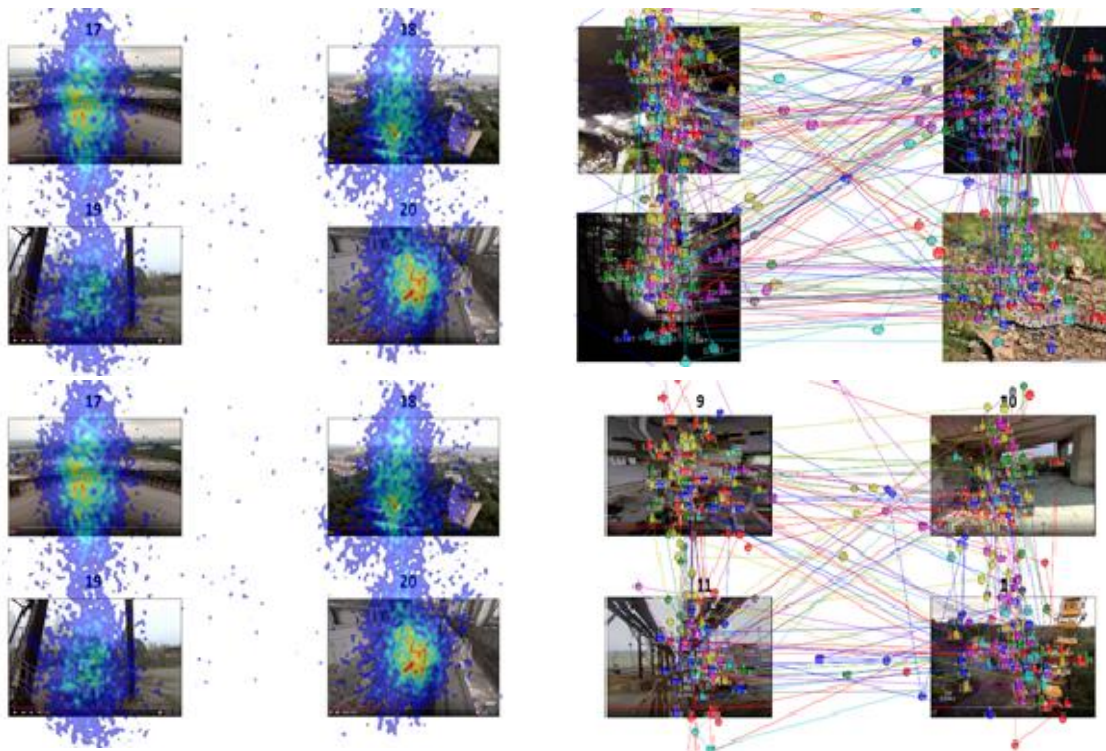
Figure 1. Sample heat maps and gaze plots

In general, eye movement results indicated no significant difference between VR and 2-D video conditions. Learners spent identical time spans over correct answers. Also, they revisited correct answers in a similar number of times.

4. Conclusion and discussion

This research aimed to scrutinise the effect of VR on retention capacity and decision making processes of students. For this aim, retention performances of learners were examined and no significant difference was found between VR and 2-D traditional video conditions. It can be inferred that both technologies have similar effects on short-term retention and VR does not provide any extra retention performance. Thus, teachers may safely use both VR and 2-D videos if they aim to promote short-term retention. However, this finding seems disadvantageous for VR technologies: Tax'en and Naeve (2002) clearly mention about the expense and limitations of VR which may cause VR to fall one step behind standard videos which are quite cheap and suitable for crowded classrooms. However, it should be noted that VR technologies are more motivating (Freina & Ott, 2015) and are getting cheaper and more practical every year.

Although no effect of VR was observed on short-term retention performance of students, VR was found to have a significant effect on long-term retention. Our results showed that students scored and remembered better in VR condition even after 4 weeks. These results confirmed the study by Merians, Poizner, Boian, Burdea and Adamovich (2006) who concluded that VR technologies not only promoted the motor skills of learners but also contributed long-term retention. The underlying rationale behind this effect may be highly associated with VR's being more motivating (Freina & Ott, 2015), more interesting (Dede, 2010), more entertaining (Burdea & Coiffet, 2003) and requiring students to be more active (Cavas, Cavas & Can, 2004; Dede, 2010; Kayabasi, 2005). Hence, teachers who aim to promote long-term retention may use VR technologies effectively in their classrooms. But our results also contradict with the study by Smith, Farra, Ulrich, Hodgson, Nicely and Matcham (2016) who

proposed that VR significantly affected short term-retention and did not have an effect of long-term retention. In addition, Moreno and Mayer (2002) argued that head-mounted display systems were also effective but they had similar effects on retention performance when compared to 2-D videos.

The results of the eye-tracking data showed no significant differences between 2-D videos and VR: Students processed visuals in similar time spans and revisited them identically during an immediate test conducted after both VR and 2-D video conditions. It can simply be inferred that VR did not affect decision-making processes of students. However, related literature proposed that VR enabled real-life experience and provided more focus on content (Dede, 2010; Shin, 2002; Yair, Schur & Mintz, 2003). Thus, we expected a difference between 2-D video and VR conditions regarding the processing of visual content during the immediate test. Indeed, learners were inexperienced about VR and it was their first exposure to VR videos. Thus, they may have missed some of the content which should be noted as a limitation of VR.

In conclusion, in terms of short-term retention and decision-making processes, VR yields no significant positive effect over 2-D videos, while VR significantly affects long-term retention performance. In this respect, teachers should keep the expense of VR in mind before using it in their classrooms and they are required to plan the lesson carefully, especially if their classrooms are crowded. When teachers want to design an entertaining lesson with high-motivational qualities and expect to have remarkable results, in the long run, VR is effective. For short terms effects, using VR may cause extra challenges.

5. Recommendations

In the current study, we utilised a 60 Hz device, which provided sufficient data for the purpose of the study. Using a 120 Hz device would slightly improve the data obtained. The researchers should be cautious before implementing eye-tracking sessions by considering calibration processes, illumination of the room and participant characteristics such as serious eye disorders and eye make-up (e.g., mascara). For VR goggles, we utilised Samsung VR Goggles with Samsung S7 Edge Mobile Phone which made the goggles heavier. Utilising goggles, which is directly attached to the computer through USB devices, would be much comfortable for the participants.

For further studies, a new design can be proposed with different age groups. In addition, a new study with a larger sample size can be conducted for a more detailed analysis. Also, a study can be designed in which researchers develop their own content on a longitudinal basis. For another study, mixed method approach may extend the horizon of the results.

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