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STUDENTS' EXPERIENCES OF 2D AND 360° VIDEOS WITH OR WITHOUT A LOW-COST VR HEADSET: AN EXPERIMENTAL STUDY IN HIGHER EDUCATION

Ari Alamäki*	Haaga-Helia University of Applied Sciences, Helsinki, Finland	ari.alamaki@haaga-helia.fi
Amir Dirin	Haaga-Helia University of Applied Sciences, Helsinki, Finland	amir.dirin@haaga-helia.fi
Jyrki Suomala	Laurea University of Applied Sciences, Espoo, Finland	jyrki.suomala@laurea.fi
Cheul Rhee	Ajou University, Suwon, South-Korea	crhee@ajou.ac.kr

* Corresponding author

ABSTRACT

Aim/Purpose	This case study examines students' affective responses to and relationships with two-dimensional (2D) and 360° videos that were experienced with or without low-cost virtual reality (VR) headsets.
Background	The prior research on low-cost VR technology is scant. Schools and universities are not financially able to purchase tens or hundreds of expensive inbuilt VR headsets. Therefore, we recommend an alternative, low-cost solution.
Methodology	We conducted the experiment with students' (*N*=100) responses to videos and VR technologies used in a higher education setting. We also applied a quantitative research approach examined in light of media richness and affective experience theories.
Contribution	This study provides evidence of the integral role that VR technologies and 360° video content play, because using low-cost VR headsets potentially decreases the initial affective experiences of 360° videos among students. Although VR headsets improve media richness, they might simultaneously weaken students' overall affective experiences if they experience usability challenges.
Findings	The results showed that using low-cost VR headsets decreased positive user experiences when they were watching 360° videos. The 360° video experience was

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noted to be better without low-cost VR headsets. Low-cost VR headsets with a smartphone and 360° videos were found to be complicated to set up and use among first-time users. However, 360° videos created a more positive affect than did 2D videos. We also found that the positive affect of videos enhanced the social sharing intention.

Recommendations for Practitioners: Educational institutes and teachers with limited financial budgets need to plan and manage courses that increases their need to adopt low-cost VR headsets. However, a poor initial user experience of low-cost VR technology usability might create negative student attitudes, which might hinder VR's adoption rate in higher education.

Recommendations for Researchers: This study provides a new understanding about students' affective experiences of 2D videos and 360° videos with and without low-cost VR headsets. The results show that positive user experiences of 2D and 360° videos enhance students' interest in sharing and collaboration in digital learning environments.

Impact on Society: The results help educators to predict possible usability challenges in selecting the proper rich media for different learning situations. Additionally, the results assist educators to design VR assisted courses that motivate students.

Future Research: The experimental comparison of different VR solutions and traditional learning technologies merits further examination. Additionally, more research is needed to determine the relationship of VR technologies, video content and learning methods, because technological features and content are tightly integrated in VR.

Keywords: 360° video, VR technologies, higher education, affective user experience

INTRODUCTION

The popularity of virtual reality (VR) and 360° video panoramas has driven researchers to look at the utilization of these technologies in an educational context. Investigation into the role of virtual reality technologies for different levels of education could help educational institutes anticipate potential drawbacks to using these technologies. Martín-Gutiérrez et al. (2017) believed that VR technologies can break down boundaries in education and assist educators in exploring topics that are difficult to present in classrooms, such as machines' performances or medical processes. The adoption of VR in higher education is a natural continuum for the use of instructional 2D videos in education. Videos have been a popular educational technology for decades because they improve student engagement and active learning (Bétrancourt & Benetos, 2018; Brame, 2016). Despite that, little prior research exists that compares 2D videos to VR technologies, although VR is a richer medium.

VR is gradually gaining popularity (Gudoniene & Rutkauskiene, 2019), and it is already being utilized for adult education and training (Harvie et al., 2020) and teaching disabled children (e.g., Cheng et al., 2017; Freina & Ott, 2015). Most researchers believe that using VR technologies for teaching is a positive initiative (e.g., Tichon, 2012); however, there are also challenges, such as the cybersickness felt by some students (Beadle, 2019) and the association of VR with gaming, which sometimes causes students not to take it seriously (Velev & Zlateva, 2017). Nevertheless, previous comparative research into low-cost VR and other media technologies is scarce. The literature currently lacks defined guidelines for the development and utilization of low-cost VR technologies in education. Such guidelines would help educators design VR-assisted courses that motivate students and provide rewarding learning experiences. The mainstream VR user experience research has also been focusing on the expensive VR headsets. However, the role and the impact of low-cost VR are not yet investigated thoroughly. Therefore, the user experience research gaps are self-evident and justify why we have conducted this study. Additionally, the financial burdens for purchasing VR technologies is yet another challenge for educational institutes and training organizations (e.g., Huang et al., 2010; Panchuk et al., 2018).

Student experiences related to VR are important because they support a learner's active participation, inner motivation, immersion, individualization and first-order experiences (Kavanagh et al., 2017; Mikropouls & Natsis, 2011). These properties of a learning environment optimally support users' learning according to the constructivist learning model. Therefore, it is no wonder that the constructivist learning model is the most commonly used approach to using VR in pedagogical contexts (Kavanagh et al., 2017; Mikropouls & Natsis, 2011).

Our findings are yet another effort to encourage educators to try and utilize VR technologies cost effectively in their educational offerings. Educational institutes and teachers who need to plan and manage courses with limited financial budgets have increased need to adopt the low-cost VR headsets. The COVID-19 pandemic will set new limitations on sharing the same VR headsets by several students in the same classrooms. However, studies on the user experiences with 360° videos and low-cost VR headsets are scant. The low-cost VR headsets are "cardboard style"; for example, plastic or cardboard VR headsets that use a smartphone as the display terminal. They are simple VR viewers that anyone can build and buy (see, e.g., Google, 2020). The low-cost VR technology is also known as 360° VR or immersive video (Kittel et al., 2020; Panchuk et al., 2018). A low-cost method for VR-based education is to use cardboard classes because everyone has their own smartphones (Román-Ibáñez et al., 2018). Thus, the devices used in this study differed from "real" integrated and inbuilt VR devices, such as Oculus Go or Sony PlayStation VR. Statista's report (Vailshery, 2021) shows that the leading "real" VR headset prices range from $249 to $999.

This study conducted a general examination of how the media features of digital applications affected students' experiences when watched with a conventional video format and 360° videos with or without low-cost VR headsets (low-cost VR technologies). The media features of VR technologies, such as interactivity, immersion and virtual presence, are an integral part of the digital usage experience. The study's aim was to increase understanding of current higher education students in relation to their affective experiences as users of conventional videos and low-cost VR technologies. Students currently consume a lot of digital content through various digital technologies, and understanding their preferences related to those technologies could help educators and curriculum designers to utilize more computer-assisted methods. Prior research (e.g., Hallikainen et al., 2019; Jahanmir & Cavadas, 2018) on this topic has shown that understanding users' experiences can assist designers in developing technological solutions that diffuse more quickly. Additionally, previous research findings have pointed out that understanding users' preferences can provide hints about potential opportunities for and obstacles to future technology adoption.

This study aimed to research students' experiences when they adopted VR technologies and compared them to conventional video experiences. The results will contribute to pedagogical planning and curriculum design in higher education and help teachers identify opportunities and predict the challenges of adopting low-cost VR technologies to their teaching practices. We put special focus on the usage differences between conventional videos, 360° videos, and "cardboard style" low-cost VR headsets. Thus, the main goal of this study was to examine the differences between students' experiences with two-dimensional (2D) videos and with 360° videos, both with and without low-cost VR headsets.

RELATED WORK

CHARACTERISTICS OF VIDEOS AND VR TECHNOLOGIES IN LEARNING AND TEACHING

Videos have been largely used in education and learning during the last two decades (e.g., Fokides et al., 2019; Gouia & Gunn, 2016). 2D videos have been found to be effective educational tools for higher education when they improve student engagement and promote active learning (Brame, 2016; Thompson et al., 2021). Videos support students in self-directed learning and tutoring and they are complements in classroom learning or "flipped classroom" trend (Bétrancourt & Benetos, 2018). The 360° videos and other virtual reality (VR) technologies have become important elements in education in recent years (Hebbel-Seeger, 2017; Laine et al., 2016; Nguyen et al., 2018) as the most common mobile and social media platforms have started to support to viewing of 360° videos.

Virtual reality (VR) refers to a three-dimensional (3D) computer-generated virtual environment in which a person can become immersed in and interact with an object (Bowman & McMahan, 2007). VR has created many opportunities in education (e.g., Chen et al., 2021; Hamilton et al., 2021; Pirker & Dengel, 2021). VR has been used to support students' learning according to a constructivist pedagogical model. In those cases, VR supports the learner's active role, situational awareness and individuality (Chen, 2010; Kavanagh et al., 2017; Mikropoulos & Natsis, 2011). VR creates a virtual experience for users (Fegely & Cherner, 2021) that makes it possible to experience affective feelings and cognitive information similar to those that a person could have in actual physical experience. The technologies of 360° or panorama have become feasible and popular in recent years, and 360° videos and images have become important elements of Augmented Reality (AR) and VR application offerings (Hebbel-Seeger, 2017). Hebbel-Seeger's (2017) and Toet et al.'s (2020) experiments demonstrate that 360° videos have an emotional and physiological influence on users.

Several studies show that VR technologies enhance and enrich learning and teaching (Nguyen et al. 2018), but the adoption of VR in teaching may also cause challenges or negative outcomes for teaching arrangements (Huang et al., 2010; Lan, 2020). Teaching is a complex phenomenon because it integrates formal learning, students' tacit knowledge, socio-constructive knowledge creation and practical hands-on activities and experiments (Alamäki, 2018). The existing research also emphasizes the importance of students' engagement in VR-assisted learning and teaching (Christopoulos et al., 2018). Thus, teaching requires dynamic and complex interpersonal skills (Ke et al., 2016), the ability to mix virtual and physical environments in teaching (Garrison & Kanuka, 2004; Zilka et al., 2018) and competencies to integrate VR into teaching arrangements (Lan, 2020). The literature on VR provides a rather broad review of its educational advantages (Freina, & Ott, 2015), yet research is scarce on students' experiences in adopting low-cost VR. This knowledge would assist teachers in predicting possible usability challenges and technological disadvantages in planning teaching arrangements in adopting low-cost VR technologies.

The previous research related to VR technologies in education (e.g., Huang et al., 2010; Vesisenaho et al., 2019) shows that teachers need to understand the principles of VR technologies, their pedagogical opportunities and models and challenges that students might meet when adopting VR technologies. Huang et al. (2010) point out that cost effectiveness is an important factor in designing and adopting VR-assisted learning and teaching, and high costs are still a major challenge for education and training organizations. The previous research shows (Román-Ibáñez et al., 2018; Panchuk et al., 2018) that low-cost VR is able to meet the needs of virtual reality and is able to create an enhanced, realistic experience to students.

The literature on VR technologies provides a rather broad review of its opportunities to education, but research on the role of low-cost VR technologies in students' experiences is scant. Research studies exist on users' affective experiences when they adopt VR for the first time in their life (Dirin, 2020), but the role and impact of low-cost VR technologies are not investigated thoroughly. The financial burden of purchasing VR equipment is yet another challenge for educational institutes.

Virtual Presence Evoking Affective Experiences

Virtual presence refers to the extent to which an individual feels the existence of virtual objects or space (Lee, 2004). The concept of virtual presence was initially introduced without the word "virtual" or as "telepresence" (Schubert, 2009). According to Schubert (2009), presence was initially defined and studied from the late 1990s to the early 2000s, and most studies focused on space. Terms such as "telepresence" and "physical presence" are widely used for a similar concept. Scholars subsequently began to take an interest in cognitive-faceted processes (Lee, 2004), which encompass an unconsciously acquired feeling of presence through a mental process when faced with a virtual environment (Wirth et al., 2007). For example, we may experience the feeling of "being there" even though we are merely visiting a website and navigating it.

Virtual presence has been examined for its efficacy in a virtual environment related to business in the forms of telepresence and social presence (Khalifa & Shen, 2004). Moreover, the more users feel connected to a virtual environment, the greater the behavioral effects, depending on the users' personalities (McCreery et al., 2013). The question of which factors increase the feeling of being connected to virtual environments has been studied for over a decade (Banos et al., 2008). Studies have also combined avatars with presence (McCreery et al., 2012). Other studies have investigated the negative side of telepresence pertaining to VR settings. For instance, McCreery et al. (2013) argued that users can experience feelings of disorientation, headache, dizziness, and tiredness. VR technologies are strongly related with telepresence, which helps to present remote locations or situations in learning and teaching settings in higher education.

Virtual presence and users' affective and behavioral responses have a strong relationship (Kisker et al., 2019; Riva et al., 2007). Virtual presence also influences users' first impressions (Bergmann et al., 2012; Cafaro et al., 2016). Mania and Robinson's (2004) study pointed out that the media features of VR technologies have a relationship to the users' impression. However, the causality and relationship between virtual presence, the VR technologies' features and users' affective responses is complex and still require further examination (Gromer et al., 2019).

Media richness theory

More knowledge is needed about the underlying theories of media effects because of the high media richness of VR applications and their potential ability to affect student behavior in order to understand the phenomenon of virtual presence in an educational context. Media richness, as an essential feature of media, indicates the extent to which media can facilitate a shared understanding within a time interval (Sun & Cheng, 2007). Media richness (Daft & Lengel, 1983, 1986) provides a theoretical framework by which to understand the potential value that students gain from using different media. Media richness does not directly impact the media effects of videos and VR applications, yet it forms a technological enabler to build digital media solutions. Media richness (Alamäki et al., 2019; Daft & Lengel, 1983, 1986) also creates the framework by which to evaluate the potential ability of conventional 2D videos and VR applications to elicit affective responses. Media richness demonstrates the potential value of digital media from the perspective of the media's ability to simultaneously deliver audio-visual cues and information and to promote engagement and understanding (Alamäki et al., 2019).

Videos are rich multimedia presentations that convey semantically rich information by using several symbolic systems (Lim & Benbasat, 2000; Mayer, 2009). The richer media facilitate understanding, make information less ambiguous and convey verbal, non-verbal and visual messages (Lim & Benbasat, 2000; Salomon, 1979). Thus, 360° videos as richer media are able to make more logical connections between symbolic systems by presenting richer information, interactivity and visual effects than the leaner media of 2D videos. The latest advancements in VR-based media technologies enable an almost real sense of social or physical presence. VR-based applications also provide new ways to view real-feeling experiences. VR media technologies thus provide a higher level of communication than digital text, images, or video, and this capacity increases its media richness. Media richness explains how much information or visual, verbal, or social cues videos and VR applications are able to deliver within a selected timeframe (Alamäki et al., 2019) and illustrates how these cues create logical connections for meaningful and effective communication.

The media richness theory thus suggests that VR technologies create potentially richer media experiences than conventional 2D videos (cf. Daft & Lengel, 1983, 1986; Lim & Benbasat, 2000; Salomon, 1979). Yeo et al. (2020) pointed that CG-VR (computer generated VR) performed better than 360-VR and TV in the creation of perceived presence, but they did not find a difference between affective outcomes. VR technologies improve interactivity and deliver simultaneously more visual, verbal and social cues and their symbolic systems than conventional media technologies. Therefore, VR technologies as richer media should potentially evoke a stronger virtual presence and affective user experiences among users than learner media.

Affective user experience

We need to understand, when designing VR-assisted learning environments, the students' cognitive and affective processes when they adopt VR technologies (Vesisenaho et al., 2019). Behavioral studies have pointed out that affective evaluation plays a crucial role in a user's experience (Dirin et al., 2018; Knutson & Greer, 2008), and VR technologies are an effective medium for evoking affective experiences, such as impressions (Bergmann et al., 2012; Cafaro et al., 2016; Ghanbarzadeh & Ghapanchi, 2020). Video technologies provide a sample of affective visuals from real-life experiences (X. Liu et al., 2018), whereas VR technologies create not only samples from real-life experiences but also the sense of a real-life environment with stronger impressions among users (Yeo et al., 2020).

The first impression is a human process that represents how users perceive and process interactions to form positive or negative judgements (Gronier, 2016). According to Gronier (2016), humans begin to perceive informational elements from the very first moments of interaction that they use to form impressions from the parties to the interactions. The literature of VR technologies (e.g., Cafaro et al., 2016) shows that humans form impressions from both physical and virtual experiences. For example, when users access the digital environment, they first form an overall impression before they begin to observe details and examine detailed information (Kim & Fesenmaier, 2008; C. Liu et al., 2010). Kim and Fesenmaier (2018) explain that users form first impressions from several perceived elements right after they have selected and entered a new webpage. Those perceived elements are inspiration, usability, credibility and informativeness among other elements that users observe, experience and perceive on a webpage. This process seems to align with the cognitive appraisal theory (Lazarus, 1991) that explains that users form affective responses through their cognitive evaluation of observed information. Venkatesh et al. (2012) similarly show in their unified theory of acceptance and use of technology (UTAUT2) that hedonic motivation plays an essential role when people consider using new technologies. The UTAUT2 model combines cognitive, behavioral and social variables, in addition to hedonic motivation as an affective variable, that influence users' behavioral intentions to use new technologies (Venkatesh et al., 2012).

Prior studies (e.g., Filippou et al., 2018; Park et al., 2017) show that positive affective experiences create a stronger media effect than cognitive information alone. Thus, impression, cognition and affection are not separate or exclusive concepts; they are often interrelated in human behavior, yet the individual character affects the human perceptions that influence individual affective experiences (e.g., Alamäki et al., 2019; Kulviwat et al., 2014). A goal of video- or VR-based instruction is to change or facilitate students' cognitive and affective processes (Vesisenaho et al., 2019). According to the cognitive appraisal theory (Lazarus, 1991), students cognitively observe and interpret digital content or reflect their usage experiences in ways that potentially influence their initial impression and affective outcomes. Additionally, positive affective user experiences influence users' intentions to share online content on social media (Berger & Milkman, 2012). Thus, affects, in addition to cognitive processing, seems to be a significant factor influencing student behavior. For example, digital learning content that creates strong positive experiences will be more likely to make the student act in accordance with the instructions. The learning content or user experience of educational technologies that creates a strong negative affect will likewise make the student act contrary to the instructions.

Prior research shows that VR technologies might also cause negative outcomes in addition to positive experiences (McCreery et al., 2013). The previous research indicates that positive affective experiences enhance students' learning motivation (Huang et al., 2010) and their intention to share digital content on social media (Berger & Milkman, 2012). We believe that the intention to share videos on social media indicates the degree of the users' affective experiences, but there is no prior research on that in the VR technologies literature. The previous literature has emphasized the importance of positive user experiences, but less is known about user experiences in adopting low-cost VR technologies. Hence, the relationship between affects, 2D videos, 360° videos and the use of low-cost VR headsets and social sharing intentions calls for more research.

Predictions

Media richness studies (e.g., Alamäki et al., 2019; Lim & Benbasat, 2000; Mayer, 2009), the literature of affective experiences (Gronier, 2016; Kim & Fesenmaier, 2008), VR-related learning studies (Chen, 2010; Kavanagh et al., 2017; Mikropoulos & Natsis, 2011), and the UTAUT2 model (Venkatesh et al., 2012), along with the previous research on virtual presence (e.g., Yeo et al., 2020) and social sharing intention (e.g., Berger & Milkman, 2012), created the framework by which to evaluate and compare the students' affective experiences of conventional 2D videos, 360° videos and VR headsets. We predicted, on the basis of previous research on VR technologies, media richness, literature of affective experiences and social sharing intention, that 360° videos provide a stronger positive experience than conventional 2D videos and that using VR headsets further enhances positive experiences. We also predicted that positive user experiences enhance social sharing intentions in the context of 360° videos. We formulated the following specific predictions: 360° videos with low-cost VR headsets create more positive experiences than 2D videos or 360° videos without VR headsets, and positive 360° video experiences trigger social media sharing intentions. Additionally, we examined how students express their first impression of low-cost VR technology with an explorative research approach.

RESEARCH METHODS AND DATA

STUDENTS AND DESIGN

The methodology of this research is a case study that includes features of experimental research settings (Cohen et al., 2013). Students used video applications and virtual reality (VR) headsets before responding to the questionnaire that enabled us to collect authentic user experiences. The students were 100 undergraduate students enrolled in bachelor's degree programs in Finland. They were mainly recruited to the experiment from two courses, digital business and user experience, and the experiment was conducted during their classes. The selection criterion was that the students should represent potential real-life users of online videos and VR applications in higher education, because this study aims to contribute to video and VR technologies usage as a part of learning and teaching in higher education. Table 1 presents the students' socio-demographic profiles. The socio-demographic profiles show that 39 % of the students were female and 61 % were male, most students were 21-30 years old, and 33 % of the students had no previous user experience with VR headsets. The goal of this research was to increase our understanding about the factors that cause differences in students' experiences, not to generalize the findings. We expect that the socio-cultural context of VR usage is similar across continents among higher education students. Additionally, we expect similar results although students were from business information technology programs and might have more familiarity with advanced technologies than other students with similar socio-demographic backgrounds. VR applications represent an audio-visual medium that creates 3D-based, computer-generated virtual environment in which a student can become immersed and interact with a significant object (Bowman & McMahan, 2007; Hebbel-Seeger, 2017; Toet et al., 2020). Thus, it creates virtual experiences rather than work as a complicated software system.

Table 1. Students' socio-demographic data and prior experiences

		Number (*N*)	Percent (%)
Gender	Female	39	39.0
	Male	61	61.0
Age (years)	18–20	7	7.0
	21–30	77	77.0
	30+	16	16.0
Previous experience of VR headsets	Yes	67	67.0
	No	33	33.0

Design and Procedure of Experiment

We employed a conventional video and 360° video with or without VR headsets. The students interacted with both videos and VR headset in the same testing situation, which provided a similar social situation and physical context. The experiments occurred in classrooms with 20–25 students. The students watched both the conventional video and a 360° video. All students (N=100) watched first the conventional 2D video without low-cost VR technologies. They watched a 360° video after this, but the student population was divided into two groups: those with and without low-cost VR headset. Seventy percentage (N=70) of the students watched 360° videos with the VR headsets and interacted with them through the combination of VR headset and smartphone display. Thirty percent of the students (N=30) watched 360° video without VR headset, and they interacted with it though the keyboard. We intentionally gave minimum technical guidance and instructions to set up the VR headsets to simulate the real usage situation in higher education. We also allowed students to select how they interacted with the 360° videos (with or without VR headsets). The VR headsets used were "Google cardboards," meaning either plastic (VR Box for 4-6" smartphones) or cardboard headsets (cardboard headset for 4-6" smartphones). The VR headsets required a smartphone as the display terminal, and students used their own smartphones as the end terminal. Thus, the devices used in this study differed from "real" integrated VR devices, such as Oculus Go, Sony PlayStation VR, that are significantly more expensive.

The experiment began with an orientation in which the researcher explained the purpose and procedure of the experiment. The researcher also distributed written instructions for the experiment that included the QR code and TinyURL of the test content and applications. The conventional video was not interactive, unlike the 360° video. Thus, the media formats differed in terms of interactivity, media richness, and virtual presence. The content included a conventional (2D) stand-up paddling (SUP-paddling) video (40 seconds), a conventional video on skiing in Alberta (32 seconds), a SUP-paddling 360° video (1 min 55 seconds), and a 360° video on skiing in Alberta (2 min 16 seconds). Thus, the fields of view were related to outdoor exercise with similar activities and views. The videos were public videos on YouTube. Students were asked to first watch the SUP-paddling conventional video and then the 360° SUP-paddling video, followed by the conventional skiing video and the 360° skiing video. The view control methods of the 360° videos were the smartphone's inbuilt gyroscope based on the user's motion and mouse if they watched it directly from the computer screen. There were no other view direction control methods (see Stebbins & Ragan, 2019). Students were advised to click on the VR mode on the YouTube platform to watch the 360° videos in VR headsets. The students accomplished the experiment alone or shared their devices with two or three other students when using the VR headset. The students answered the questionnaire's research items immediately after watching the videos and completing all three required experiments. The researcher supervised the experiment's procedure, which lasted for one hour on average, including the briefing, the experiments, and the completion of the questionnaire. Based on the content and the angle of the presented content, we had a low chance of users experiencing cyber sickness. Furthermore, the duration of the experiment was less than 10 minutes. Based on the prior literature on VR (e.g. Beadle, 2019), the researchers were aware of ethical concerns related to the experiment, such as potential cyber sickness. The researcher was ready to stop the experiment with any student who visibly began to suffer cyber sickness. The questionnaire was filled in and the data were handled anonymously.

MEASURES

The users' subjective affective experiences can be examined with the self-reported questionnaire in experimental media research (see, e.g., Falk et al., 2016; Mandryk et al., 2006; Vesisenaho et al., 2019). Aligned with this, we constructed affective measures based on the previous studies (Falk et al., 2016; Venkatraman et al., 2015) to examine the users' positive and negative affect. The questionnaire was constructed to determine the students' experiences with the conventional video and VR 360° video with or without VR headsets. Paper questionnaires were handed to the students after they had finished the experiments. The item "The video helped me to feel the following feelings" (asked separately about the use of conventional 2D video and 360° video) was accompanied by eight 5-point Likert multiple-choice statements (ranging from 5 = strongly agree to 1 = strongly disagree), of which four were positive ("exciting, encouraging, inspiring, relaxing") and four were negative ("boring, negative, depressing, unpleasant"). We asked the students to answer the following open-ended questions: "Verbally describe your first impression of 360 & VR" and "What things surprised in 360 & VR?". The willingness to share the videos on social media was assessed with the following statement measured on a 5-point Likert-scale: "I would love to share similar 360 video on social media." There were also three questions concerning the students' age, gender and prior experience with VR applications. The gender differences have been presented in another report (Dirin et al., 2019) and have been excluded from this study.

DATA ANALYSIS

The dataset comprised 100 completed questionnaires. Data from the open-ended questions were analyzed quantitatively by applying open coding without predefined coding categories (Strauss & Corbin, 1998). The coding of users' responses involved marking all comments that mentioned something related to the users' experiences. The analysis revealed that the users reported their experiences in synonymous terms, which allowed for the constructions of meaningful categories. The quantitative data analysis was conducted using IBM® SPSS® Statistics 23. We tested the validity of all original experience variables in each scale and included them in the analysis, because the Cronbach's alpha level was high (between 0.82 and 0.902). We also used sum variables concerning affective measures. We conducted independent sample t-tests to find the differences between groups of VR headset users and non-users. We also conducted a paired sample t-test to find the differences among participants relating to the conventional video and 360° video. We also ran a correlation analysis to understand the connections between all variables.

RESULTS

STUDENTS' INITIAL, LOW-COST VR TECHNOLOGY EXPERIENCES

We asked the students whether they had prior experience with virtual reality (VR) to analyze their initial experiences, and we only used the responses of those who were using VR headsets for the first time in the analysis. We categorized their positive and negative experiences from the open-ended responses in the questionnaire (Table 3) and grouped them as positive and negative themes. We counted all themes mentioned in each answer of the questionnaire's open-ended question. The findings showed that the students' first experiences of VR technologies were generally positive, although they also faced technical challenges and had dissatisfying experiences. According to the students, VR technologies provide visual experience about a place. A student (female, 20–30 years old) who had no prior experience with VR technologies described her first experience: "In watching the 360 and VR classes, I felt that I was in the place that was shown in the video, but it took a while before my eyes got used to the video." The students also faced technological challenges, quality problems, or bad physical experiences when watching a 360° video with a low-cost VR headset.

Table 2. Positive and negative experiences of using VR technologies for the first time (*N* = 33, those who had no prior experience about VR headsets)

Positive user experience themes	Frequency and percentage
Aroused positive affective experiences	28 (85%)
I felt like I was there	10 (30%)
Good idea	6 (18%)
Funny	5 (15%)
Visually promising	3 (9%)
Other	1 (3%)
Negative user experience themes	Frequency and percentage
Technical challenges	15 (46%)
Poor quality of VR headsets	11 (33%)
It hurt my eyes	8 (24%)
Useless	4 (12%)
I felt sick or got a headache	2 (6%)

Regarding the technology, the 360° view and atmosphere surprised the students the most when watching 360° videos with VR headsets for the first time (Table 3). For example, a student (female, 20–30 years old) stated, "The atmosphere made me feel as though I was in the middle of a lake in summer, even though it was mid-winter in reality." However, the VR technology experiences also created negative experiences. The students had some technological challenges or poor physical experiences, although some students indicated that VR technology did not provide any surprising experiences.

Table 3. Surprising experience themes when using VR technologies for the first time (*N* = 33, those who had no prior experience about VR headsets)

Surprising experience themes	Frequency and percentage
360° view or atmosphere	16 (49%)
No surprising issues	8 (24%)
Quality	7 (21%)
The technology itself	10 (30%)
Made user to feel sick or it hurt the eyes	7 (21%)
Technological difficulties	6 (18%)
Engaging	3 (10%)
Accessibility	1 (3%)

Comparison Between Students' Experiences with Conventional Video and 360° Video

A paired sample t-test showed that the students (n = 95) experienced the 360° video as more positive (x = 14.01) than the conventional video (x = 12.98), t(95) = 2.12, $p < .05$. Similarly, the t-test showed more negative user experiences related to the conventional video (x = 9.46) than the 360° video, although the result was not statistically significant in the negative constructs. The results of the negative user experiences confirmed these results because the conventional videos were experienced as more negative among the students.

Differences Between the Experiences of VR-Headset Users and Non-Users

We examined the differences in the students' experiences when watching 360° videos with and without low-cost VR headsets. We asked them to indicate whether they watched 360° videos with a VR headset or directly on a PC or mobile screen (without VR headsets). A significant difference was observed in the negative 360° video experience score between VR-headset users (x = 9.31) and non-users (x = 7.72), t(94) = 2.19, $p < .05$. The VR-headset users reported more negative experiences ("boring, negative, depressing, unpleasant") overall than the students who watched 360° video without VR headsets. The use of VR headsets did not notably increase positive statements. It is important to note that the participants used "cardboard" headsets with smartphones as a display, not real VR headsets with integrated display and computer technology.

User Experience Score and Social Sharing Intention

Table 4 presents the Pearson correlations and the coefficient of determination between user experience and willingness-to-share variables. Willingness to share the 360° video showed a statistically significant correlation at the 0.01 level between positive (r = 0.381, R2 = 0.15) and negative (r = -0.27, R2 = 0.07) user experiences relating to 360° videos. Willingness to share a conventional video also had a statistically significant correlation at the 0.01 level to positive (r = 0.323, R2 = 0.10) and negative user experiences (r = -0.314, R2 = 0.10) relating to conventional videos. Finally, a statistically significant correlation at the 0.01 level was found between willingness-to-share conventional videos and positive (r = 0.275, R2 = 0.07) user experiences relating to 360° videos. The willingness to share had a strong relationship overall to positive user experiences.

Table 4. The relationships between social sharing intention and user experience

			User experience variables			
			Neg conv. video	Pos conv. video	Neg 360° video	Pos 360° video
Social sharing intention	2D Video	r	-.314**	.323**	-.153	.275**
		R^2	0.10	0.10	0,02	0,07
	360° video	r	-.178	.150	-.270**	.381**
		R^2	0.03	0.02	0.07	0.15

r Pearson correlation
R^2 The coefficient of determination
** Correlation is significant at the 0.01 level (2-tailed)

DISCUSSION

We predicted on the basis of the literature review (e.g., Gronier, 2016; Kim & Fesenmaier, 2008; Lim & Benbasat, 2000) that 360° videos provide stronger positive affect than conventional 2D videos, and using virtual reality (VR) headsets enhances and enriches the user's experience when watching 360° videos. The findings showed that the 360° videos created a stronger positive affect than conventional video. Media richness does not always have a causal connection to the actual performance of communication (Dennis & Kinney, 1998), but it seems to improve affective experience in the context of 2D and 360° video formats.

Unlike what we predicted, using low-cost VR headsets did not improve the positive affect in watching 360° videos compared to non-users of low-cost VR headsets. This finding is aligned with the findings of Yeo et al. (2020) in which CG-VR and 360-VR invoked positive affects similar to a TV screen, although VR technologies improved the feeling of presence. This indicates that mere richer technology does not improve the user experience; therefore, enhancing new technology needs to be as smooth in usage as the existing digital solutions. Furthermore, new technology is important for providing additional features and capabilities that create a stronger effect for affective experiences. Our study differs from the experimental comparison of Yeo et al. (2020) because we found a difference between technologies in affective measures. Additionally, we showed that that the positive affect of 360° videos also have a connection to social sharing intentions.

The results support the prior findings of VR's effect on enhancing a learner's active role and situational awareness (e.g., Chen, 2009; Kavanagh et al., 2017; Mikropoulos & Natsis, 2011), but they do not necessarily improve students' affective experiences. This study provides evidence of the integral role of VR technologies and 360° video content, because using VR headsets potentially decreases the initial affective experiences of 360° videos among students. VR headsets improve media richness by increasing interactivity and immersion, yet they might simultaneously weaken users' overall affective experiences if they experience usability challenges. The poor initial user experience of low-cost VR technology usability might create a negative student attitude that hinders the general adoption rate of other more advanced VR technologies toward the mainstream technology. *The Economist* (2020) wrote in its pragmatic analyses of the VR industry that it is still awaiting the fulfillment of 40 years of promise for VR to become a mainstream media technology. Thus, these findings provide new insights into this important phenomenon of technology adoption and fill a research gap by creating a new understanding of students' affective experiences between low-cost VR headsets, 360° and 2D videos.

Students' Initial Impression of Low-Cost VR Technology

We examined the students' experiences with using VR technologies for the first time. The findings showed that 33% of the students had no prior experience with VR headsets. The media characteristics of low-cost VR technologies created positive impression in the students who were using VR technologies for the first time (see Tables 2 and 3). The most common responses (85%) were categorized as "it aroused positive affective experiences". This finding shows the importance of hedonic motivation to users' positive behavioral intention to use new technologies (Venkatesh et al., 2012). However, while the affective responses were positive, the use of a low-cost VR headset also caused some physiological problems (see Table 2). For example, some students reported eye pain or headaches, while others felt nauseous when watching 360° videos with VR headsets. This finding aligned with prior research about real VR headsets (Cobb et al., 1999; Rebelo et al., 2012), and we found this also with the "cardboard-style" headsets. Unlike VR, augmented reality (AR) applications have not caused similar negative physiological experiences among students (Alamäki et al., 2021). Furthermore, the adoption of VR technologies caused more technical challenges, because the VR headsets were more complicated to use (46%) or had perceived poor quality (33%). The positive experiences of the technology most frequently reported as surprising were the 360° view and the overall atmosphere of low-cost VR technologies. However, the onset of eye pain and technological difficulties were also reported as surprising outcomes. These findings align with the technology acceptance model (Venkatesh & Davis, 2000) that emphasizes the role of easiness and usefulness in adopting new technologies. It should be noted, again, that the students did not use actual VR headsets but rather cardboard or plastic low-cost VR headsets that they inserted into their smartphones, and it was necessary to select the VR-setting of a video clip to enable the 360° video to play on the two separate windows on the smartphone screen.

Differences in the Affective Experiences of Conventional Video and 360° Videos

This study found that the 360° videos create a stronger positive affect than does 2D-video content. The findings showed that the students had statistically more positive experiences with 360° videos ($p < .05$) than with conventional videos. It can be concluded that a 360° video is an affectively stronger experience than a 2D-video. Additionally, the richness of the conventional video's media was scored the weakest, indicating that richer media are related to stronger positive experiences. This study points out that user experiences are important to consider when selecting the proper learning technologies. Positive affective experiences create a stronger media effect than cognitive information alone (e.g., Park et al., 2017). This study also shows that media richness positively influences user experiences in the context of low-cost VR technologies. According to prior research (Alamäki et al., 2019; Daft & Lengel, 1983; Sun & Cheng, 2007), the effect of media richness on user experience is contextual. This study extends the understanding of user experiences and media richness in the context of low-cost VR technologies among higher education students.

The Effect of Low-Cost VR-Headset Usage on User Experiences

We found that the low-cost-VR-headset users reported more negative experiences than the students who watched the 360° video without VR headsets ($p < .05$). It is important to note that low-cost VR headsets require users to set up their smartphones to connect to the VR headset and select the video settings for the 360° videos. In our experiment, 33% of students did not have prior experience in the use of VR, which evidently affected their technical skills in adopting VR technologies in real-life settings. This might also have affected their prior expectations, thereby influencing the level of user experiences. Qualitative results also showed that some users experienced physiological problems, such as sickness. This probably also affected user experiences when using low-cost VR headsets.

Social-Sharing Intention and User Experiences

We also aimed at increasing understanding of the relationship between user experiences and social-sharing intentions. This is significant because students learn in social settings, such as project teams, in which they collaboratively define and solve problems (Alamäki, 2018). We compared the students' willingness to share normal videos and 360° videos and its relationship with the affective responses to examine this relationship. The findings (see Table 4) showed a clear correlation between user affective experience and social-sharing intentions related to conventional videos and VR content ($p < .01$). This supported our prediction. We concluded that the more the students liked the applications, the greater their intention to share them through social media. We also found a similar effect in terms of both positive and negative constructs of affective experiences: negative affective responses decreased their willingness to share, while positive affect increased their willingness to share. Prior research has provided evidence for this in the context of online newspaper articles (Berger & Milkman, 2012) and AR applications (Alamäki et al., 2021), whereas this study provides evidence of VR technologies in higher education.

Practical Implications for Teaching Arrangements

Assistance and hands-on support are required when using VR technologies for the first time, because watching 360° videos with low-cost VR headsets caused technological challenges for some students, thus creating a negative experience from an education perspective. A presentation should not last for a very long period of time because low-cost VR technologies caused physiological problems for some students. A long period of using VR technologies can make users uncomfortable, create cybersickness, and distract them from the topic (Rebenitsch & Owen, 2016; Saballe et al., 2018).

The findings also suggest that teachers should consider using 360° videos without VR headsets if students do not have prior experience installing and using low-cost VR headsets and there are limited support resources available to them. Unlike conventional 2D videos, low-cost VR headsets require students to take a more active role, because they must set up their smartphones to connect to the headsets and select the video settings for the 360° videos. Thus, more technical problems can be expected with low-cost VR headset usage than with conventional video usage or 360° videos alone. Conventional 2D videos might just "pop-up" on the screen, but the use of low-cost VR technology requires more interaction by the user. Thus, students need to have an interest in or motivation to engage with VR applications that may not capture users' attention as quickly as conventional videos do. VR-based applications are not suitable for all topics; however, they are especially suitable for situations in which a physical demonstration is unfeasible (e.g., Mantovani et al., 2003; Rizzo et al., 2013; Zajtchuk & Satava, 1997). Low-cost VR is a technology that can overcome the existing gaps in educational offerings. Therefore, identifying these gaps is important for the sustainable usage of the learning application. This is related to the usefulness of educational technology (e.g., I. F. Liu et al., 2010).

This study reveals that a positive user experience can increase students' intention to share 360° videos on social media. We conclude that positive experiences enhance sharing and social collaboration, whereas negative experiences decrease students' interest in sharing and collaboration in digital learning environments. We also conclude that conventional 2D or 360° videos that do not require the use of VR headsets are a better fit for fast learning needs or simple tasks, because they are significantly easier and faster to watch than digital content delivered through low-cost VR headsets. Low-cost VR technology requires greater user engagement, so its role could be useful in more complicated or larger-scale learning situations.

Conclusions

Virtual Reality (VR) is an effective learning technology that activates students with situational awareness. This study emphasizes putting more attention on students' usage experiences with VR. VR headsets improve media richness by increasing interactivity and immersion, but they might simultaneously weaken students' affective experiences if they experience usability challenges. A poor initial user experience with VR technologies might create negative side effects that hinder students' learning results. Additionally, there was not causal connection between richer media and affective measures. This confirms our understanding that the effects of VR technologies are contextual. Thus, we need more comparative research to discover where VR technologies perform better compared to the traditional media and how different VR technologies perform. For example, conventional videos are easier to create, share, and use, because they do not require any additional devices, such as low-cost VR headsets. We conclude that conventional video is a better fit for self-study when technical support is unavailable. The low-cost VR technology provides more value in situations where stronger impressions or other affective effects are needed. This study contributes to the discussion of technology selection in higher education.

Limitations and Future Research

This study has several limitations. First, in studies on media effects, any additional issue may affect students' experiences, just as conventional video and VR technologies might provide different usability experiences. Furthermore, this study was a one-shot experiment with a short intervention. Thus, we are not able to make long-term claims for experiential learning and information retention. Additionally, the findings should not be directly connected to the effectiveness of all VR, because we used low-cost Virtual Reality (VR) technologies. VR technologies are developing rapidly. Thus, the results of this study apply to the user experiences with 2D and 360° videos and cardboard VR headsets but not to the affective experiences of more advanced VR. Second, this study used a small target group, which influenced the generalizability of the results. Third, the students used the application for a relatively short period in a laboratory-type research setting, which did not provide a long enough time to learn to use new VR headsets or VR technologies. Fourth, the results of this experimental study should not be generalized. Additionally, the focus on students' learning outcomes were not examined, which should also be considered as a limitation. The fast-developing and advancing technologies in VR and in general educational technology mandate that we all utilize the experience we gained from our previous research studies and findings to compliment and develop robust solutions. Therefore, the findings of this paper are valuable for academicians, practitioners and low-cost VR solution developers. However, a part of our findings is limited to the near future due to the increasing and widespread use of advanced VR solutions and applications.

Nevertheless, the experimental comparison of different VR and traditional technologies merits further examination in the contexts of learning and teaching. Additionally, more research is needed to determine which specific features of low-cost VR technologies create an actual media effect on students' cognitive and affective processes in learning situations.

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AUTHORS

Ari Alamäki, PhD, is a principal lecturer at Haaga-Helia University of Applied Sciences and an adjunct professor at University of Turku, Finland. His current research focuses on the applications of artificial intelligence and VR in education, business services and human behavior. His academic work has been published in journals such as *Information Processing & Management*, *International Journal of Information Management* and *International Journal of Technology and Design Education*.

Dr. Amir Dirin is an adjunct professor in educational technology at the University of Helsinki and lecturer at Haaga-Helia University of Applied Sciences. His main research area is in immersive experience, machine learning, and user experience design. Dr. Dirin additionally is a keynote speaker in immersive experience and user experience design in different international conferences and seminars. As a latest activity, Dr. Dirin is active in organizing MOOC courses such as Data Mining, Immersive Experience, and Artificial Intelligent.

Jyrki Suomala, PhD (adjunct professor), is a principal lecturer at Laurea University of Applied Sciences in Finland. He has research interests in human decision making and learning in different contexts from universities and companies to marketplaces. He has published papers in journals such as *PLOS ONE*, *European Journal of Innovation Management* and *Journal of Neuroscience, Psychology and Economics*.

Cheul Rhee is a professor of e-business department at Ajou University in Korea. He has research interests in human factors & HCI, VR & AR, knowledge management, metaverse, enterprise systems and e-business strategies. He has published papers in journals such as *Communications of the ACM, Virtual Reality*, *International Journal of Hospitality Management*, and many others.