Usage of Augmented Reality (AR) and Development of e-Learning Outcomes: An Empirical Evaluation of Students' e-Learning Experience

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Abstract

This study aims to examine students' experience of augmented reality learning applications (AR.LRP). Uses and gratifications theory was proposed as a theoretical foundation of the current study's conceptual model. Four dimensions of UGT benefits were proposed as key antecedences of the students' experience with AR.LRP: personal interactive benefits, social interactive benefits, affective benefits, and cognitive benefits. The model was also extended by considering the role of telepresence. Further, technostress was proposed on the current study to moderate the relationship between the aspects of UGT and e-learning experience. A sample size of 500 undergraduate students from the four largest Universities in Saudi Arabia was used in the current study survey. The statistical results largely support the significant impact of personal interactive benefits, affective benefits, and cognitive benefits, and telepresence on student experience with AR.LRP. Technostress was also found to significantly moderate the relationship between UGT dimensions and student experience with AR.LRP. Further, results support a significant relationship between student experience with AR.LRP and students' learning performance. This study has contributed to the perspectives of researchers and practitioners by highlighting the most important aspects and characteristics that ensure a distinctive and positive students' experience of the drum with applications with AR.LRP.

Keywords: augmented reality; e-learning experience; e-learning performance; uses and gratifications theory; technostress.

1. Introduction

Augmented reality (AR) technology has gained increasing global interest in recent years in a range of o different sectors: healthcare (i.e. Zhao et al., 2016), retailing (i.e. Caboni et al., 2019), digital marketing (i.e. Scholz and Duffy, 2018), travel and tourism (i.e. Yung and Khoo-Lattimore, 2019), manufacturing (i.e. Novak-Marcincin et al., 2013), and maintenance (i.e. Palmarini et al., 2018). In this respect, it is important to indicate that the international investment in AR applications has reached 12 billion dollars by the end of 2020 and this number is expected to double to 72.8 billion dollars by 2024 (Statista, 2020a). Conceptually, Klopfer and Squire (2008, p. 205) articulated AR as "a real world context that is dynamically overlaid with coherent location or context sensitive virtual information". According to Azuma et al. (2001), three key features of AR were reported to differentiate such learning systems from other ones. The first one is addressing of AR as a mixture of virtual and real objects in an actual environment. The second one pertains to human resources that work interactively and simultaneously. The third feature is related to the extent of alignment and compatibility between real and virtual things. To put it differently, an interaction between virtual objects and the physical environment could be provided by AR applications that accordingly help students to actively engage in the learning process (Azuma, 1997; Chang et al., 2016).

Learning and educational organisations have also invested considerable efforts and resources in AR applications as an innovative and smart solution to enhance learning outcomes and create an outstanding student learning experience (i.e. Alahmari et al., 2019; Arici et al., 2018; Chiu et al., 2015; Matsutomo et al., 2012; Peddie, 2017; Yen et al., 2013). This is evident in the widespread adoption of this technology extending from primary schools (i.e. Chiang et al., 2014; Kerawalla et al., 2006) to higher education institutions (i.e. Ferrer-Torregrosa et al., 2016; Ferrer-Torregrosa et al., 2015). For example, according to a recent report published by Statista (2020b), the volume of investment in the AR technology by educational organisations amounted to 1.6 billion dollars in 2018 and is likely to reach 12.6 billion in 2025 by the year 2025. This could be attributed to the fact that AR is easily assisted by simple technical facilities (i.e. smartphones, computers, laptops, and tablets) which are available at low cost for most students (Alahmari et al., 2019; Gervautz & Schmalstieg, 2012; Wu et al., 2013). Therefore, AR systems have represented a recent and increasing trend in all modern sciences (Cheng & Tsai, 2012). Such modern trends in the educational area has focused on the importance of observational learning, creative and critical thinking, multifaceted inquiries, skill development, and knowledge sharing (Van Zee & Roberts, 2006).

Practically, there are several reasons that have motivated educational organisations to expand their use of AR systems. For example, the interactive nature of AR gives students more opportunities to actively engage in the learning process, which in turns, help them to authentically discover the real world (i.e. Cai et al., 2014; Dede, 2009; Olsson et al., 2013; Wojciechowski & Cellary, 2013). This, in turn, will make the learning process more enjoyable and valuable from the students' point of view (i.e. Ab Aziz et al., 2012; Chang et al., 2016; Li, 2010; Yoon et al., 2012). Further, students, who use AR.LRP, are more attentive and motivated, which will be reflected in their performance level (Ab Aziz et al., 2012; O'Brien & Toms, 2005; Sumadio & Rambli, 2010).

On the other hand, using AR applications has not been as easy as expected and has involved a number of challenges. A level of complexity in using AR has been perceived by some students whose engagement and experience with such applications did not run smoothly due to technical problems (Chiang et al., 2014; Lin et al., 2011). The complicated student experience with AR was also observed by Squire & Jan (2007) who noted an absence of well-designed interfaces and clear guidance for the use of AR. Wu et al. (2013) argued that accessing AR applications through several platforms and devices could be another source of technical problems. One of the most important challenges hindering the success of AR applications was teacher and staff resistance to change, especially in the light of the fact that AR presents a new way of learning, completely different from the traditional learning methods with which those teachers are familiar (Kerawalla et al., 2006). One of the main obstacles for students was the size of the duties and additional burdens that they had to carry out which was negatively reflect in the learning experience and their overall understanding (Cheng & Tsai, 2013; Dunleavy et al., 2009). Therefore, it has been argued that AR.LRP can not fully substitute the traditional educational approaches as a large part of students would not cognitively, emotionally, and behaviourally engage in an AR-mediated learning environment (e.g. McCall et al., 2011).

Therefore, clearly understanding and carefully addressing these challenges will help to provide positive students experience with AR.LRP. However, there is a lack of studies that have tested the main factors and antecedences of the student's experience with AR learning applications (i.e. Olsson et al., 2013). In their systemic review study, Cheng and Tsai (2013) asserted the fact that little research and interest has examined the related issues of students' experience with AR applications over the educational area. Further, Cheng & Tsai (2013) and Wu et al. (2013) stressed the importance of continuing to conduct research and studies related to examining all aspects related to students' interaction and experience with augmented reality applications, since there is still a lot of ambiguity surrounding this area. Accordingly, this study attempts to fill this gap by proposing and empirically validating the main factors that could either positively or negatively shape the student learning experience with such innovative applications. This study will help both researchers and practitioners to better know the features and aspects that should be considered in designing and implementing AR.LRP applications in in a way that ensures improved learning outcomes.

2. Literature Review

Augmented reality has consistently received a significant attention from researchers over the educational area (i.e. Arici et al., 2018; Chang and Hwang, 2018; Georgiou and Kyza, 2018). According to Arici et al. (2018), about 62 studies addressing the related issues of AR educational applications have been published between 2013 to 2018. In fact, several issues pertaining to AR applications (i.e. purposes, learning experience, students' perception, opinions, adoption, challenges, benefits, effectiveness, productivity) have been covered by the main AR body of literature over the educational area (i.e. Arici et al., 2018; Chen and Tsai, 2011; Cheng et al., 2013; Ferrer-Torregrosa et al., 2016; Ozdamli and Karagozlu, 2018; Tom Dieck et al., 2018).

Noticeably, the largest part of these studies has focused on the value and benefits of using AR.LRP. For example, Hsiao et al. (2012) approved that students' learning via AR technology does not only contribute to the students' knowledge but also improves students' level of physical practice. Further, Hsiao et al. (2012) reported the role of AR mediated learning systems in shaping students toward learning ecosystems aspects. According to Wu et al. (2013), AR learning applications help students to notice and examine phenomena (i.e. airflow; molecular structure) that are difficult to observe or study in the real world. Other studies have also reported the usefulness of AR learning applications in comparison with conventional methods that could be attributed to the ability of AR systems to assimilate and mix virtual content and the physical learning environment (Azuma, 1997; Dunleavy et al., 2009; Hsiao et al., 2012; Kaufmann & Schmalstieg, 2003). This also creates an immersive learning experience for students (i.e. Tscholl and Lindgren, 2016).

Student understanding of space science was shown by Woods et al. (2004) to be considerably enhanced by using AR.LRP. Likewise, the results of Kerawalla et al. (2006) demonstrated that AR applications are able to improve students 'collaboration and interaction, comprehension and cognitive reactions, and accordingly students' educational fulfilment'. AR.LRP have also proven effective in the field of linguistics by enhancing reading, spelling, and pronunciation skills as reported by Kirner and Zorzal (2005).

Kye and Kim (2008) provided further evidence supporting the role of AR media features, namely, sensory immersion, navigation, and manipulation in shaping student's presence, which in turn, predicts the learning outcomes in terms of students' satisfaction, knowledge, and understanding. Similarly, Martín-Gutiérrez et al. (2010) supported the importance role of AR technology on students' learning satisfaction due to the ability of such emerging system to efficiently help students improve three-dimensional competences in designing and creating construction drawings for students of the College of Engineering. In the designing area, Wei et al. (2015) empirically assured that students who actively engage with AR.LRP, are more able to be creative, motivated, and have a high learning performance level. In their comparison study, Ibáñez et al. (2014) proved the capabilities of AR.LRP instead of traditional learning mechanisms in enhancing students' perception of usefulness, flow, and thus, their overall learning experience. Further, Chiang et al. (2014) found that AR mobile learning applications empower students' ability to ask new questions and to learn constantly. Chiang et al. (2014) added that AR mobile learning applications provide students with more useful information and allow them to share such information with their colleagues.

Other aspects (i.e. critical thinking, cognitive load and self-efficacy) were also reported as key consequences of using AR learning applications (Chao et al., 2016; Lin & Chen, 2015). In their experimental study, Chang and Hwang (2018) were also able to prove that students who actively use AR.LRP have better project performance along with enhanced critical thinking skills and self-efficacy. This according to Chang and Hwang (2018) significantly reflected on the student learning motivation. Iordache et al. (2012) found that using AR applications significantly contributed to the effectiveness and efficiency of the learning process. According to Wojciechowski & Cellary (2013) and Yoon et al. (2012), AR applications make the students learning experiences more enjoyable and entertaining. Therefore, students' attitudes were noticed to be positively affected by using AR.LRP (Cai et al., 2014; Chang et al., 2018; Sumadio & Rambli, 2010).

Another kind of AR outcomes for the learning experience was the ability of such applications to enhance students' feelings of reality and having a real learning experience in learning topics and issues related to the physical environment, which in turn, contributes to the learning outcomes and students understanding and performance (Shelton & Stevens, 2004; Sumadio & Rambli, 2010). In this respect, Georgiou & Kyza (2018) empirically proved how using AR.LRP would accelerate student feelings of involvement and immersion, and accordingly, contributing to their motivation and learning performance. Chang et al. (2016) argued that even though student attitudes and knowledge were noticed to be same for students who used AR learning applications and those who use interactive simulation technology, technology features were differently perceived by these two groups of students.

Even though this part of literature has contributed to the current understanding regarding the main aspects pertaining to AR.LRP, there is still a need to comprehend students' learning experience with AR and what are the main antecedences (factors that could shape such experience) and also the consequences of such experience in terms of the students' learning performance. Further, as a new and very novel technology, students could have an extent level of technostress which has never been covered in prior studies of AR, and therefore, testing technostress would add further understanding about the main challenges that could hinder students experience with AR. Furthermore, although telepresence is one of the main features of AR technology, prior studies have generally addressed the related aspects of presence, but not accurately telepresence. Moreover, there is a need to consider how students' characteristics and perception toward AR could shape the learning experience as asserted by Cheng & Tsai (2013). Therefore, this study will attempt to address the impact of such factors in shaping the students' experience with AR.

3. Conceptual Model

The current study aims to provide a comprehensive understanding of student learning experiences with AR applications. Therefore, there was a need to identify the main benefits that using AR applications could deliver, and accordingly, shape the students' experience toward such applications. Uses and Gratifications Theory (UGT) proposed by Katz et al. (1974) has been noticed to be among the most common models and theories that could clarify people's behaviour and perceptions toward new media and emerging information & communication technologies (ICTs) (Katz et al., 1973; Lariscy et al., 2011; Lee et al., 2020; McLean & Osei-Frimpong, 2019; Nambisan & Baron, 2007; Rubin, 2002).

The main assumption of UGT is that people seem to be more motivated to use particular kind of media and emerging communication technology if the results of using such media and technologies gratify their psychological needs (i.e. personal-integrative benefits; cognitive benefits; social integrative benefits; and affective benefits) (Palmgreen et al., 1981; Phua et al., 2017; Rauschnabel, 2018; Verhagen et al., 2015; Zollo et al., 2020). This assumption was attributed to people's rationality making them more goal oriented, and accordingly able to recognise their needs as well as the methods related to identifying the expected sources to satisfy those needs (Katz et al., 1973; Ko et al., 2005; Phua et al., 2017; Rauschnabel, 2018). Further, UGT has been successfully validated for different technologies [social media (i.e. Putzke et al., 2014), mobile shopping (i.e. Huang and Zhou, 2018), e-commerce (i.e. Luo, 2002), online games (i.e. Merhi, 2016), television (i.e. Logan et al., 2012), virtual reality (i.e. Gallego et al., 2016; Kim et al., 2020), wireless Internet (i.e. Shin, 2009) and from different perspectives: customers (McLean & Osei-Frimpong, 2019), citizens (Guo et al., 2016), and students (Mondi et al., 2008; Shin, 2011)]. However, there is a dearth of literature testing UGT in the area of augmented reality, especially these related to students' perspective (Lee et al., 2020; Rauschnabel, 2018).

According to Katz et al. (1973), four main benefits [personal integrative benefits (PIB); cognitive benefits (CGB); social integrative benefits (SIB); and affective benefits (AB)] were derived from UGT and proposed as key drivers of student learning experiences with AR.LRP. Such benefits have been widely reported as fundamental needs and motives predicting individual's behaviour toward new media and emerging information & communication technologies (ICTs) (Nambisan & Baron, 2007; Verhagen et al., 2015).

However, as discussed in the introduction section and the literature review, aspects associated to telepresence and technostress also need to be addressed to provide a fuller understating regarding the way that student's learning experience should be built and shaped. Moreover, literature that has integrated telepresence and technostress with UGT to address student learning experience with AR, is more limited. The current study attempts to expand the validity and theoretical horizon of UGT to new technologies (i.e. AR), new context (i.e. students), and by considering new factors (telepresence and technostress). In this respect, Rauschnabel et al. (2017) argued that the applicability and flexibility of UGT should be integrated and extended by other factors and models such as technology acceptance model as proposed by Shin (2011) and flow theory as proposed by Huang et al. (2014).

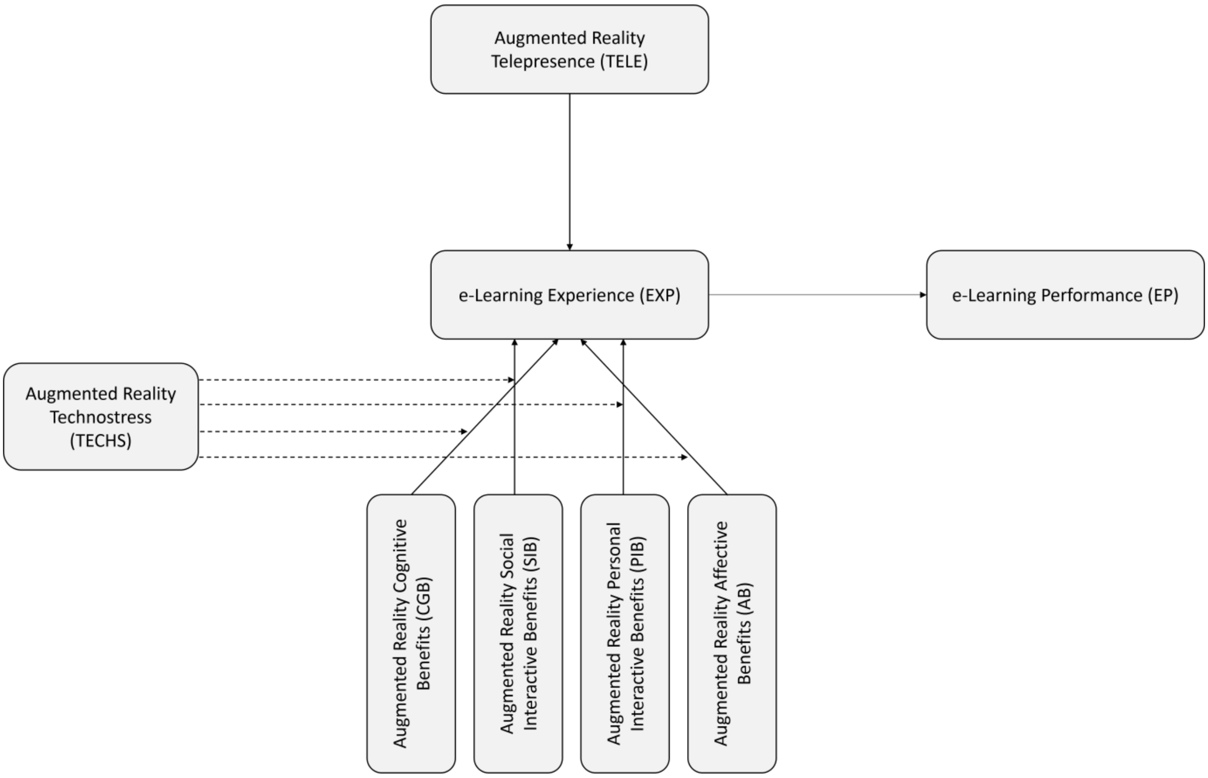

Figure 1. Conceptual Model - Adapted from Katz et al. (1974)

3.1 Cognitive Benefits (CGB)

According to Verhagen et al. (2015, p. 341), cognitive benefits could be defined as "the medium's ability to provide desirable information and fulfil the desire to learn". AR offers a high level of interactivity which enables students to control and retain what they learn, and accordingly, increasing their knowledge and academic achievement (i.e. Hsiao et al., 2016; Hwang et al., 2016; Liou et al., 2017; Squire et al., 2007). AR also contributes to the students' ability to better access and share the relevant updated knowledge and to receive feedback more effectively (i.e. Verhagen et al., 2015). This, in turn, contributes to improving the level of students' cognitive achievement, self-learning, and the educational process in general (i.e. Ha et al., 2015; Martin-Gutierrez et al., 2012; Verhagen et al., 2015). For example, in a situation where conducting the learning process is really difficult to undertake in the actual world (i.e. chemical experiment), AR helps students to have a learning experience similar to that of real ones without any risks (i.e. Chen and Wang, 2017; Klopfer & Squire, 2008; Wojciechowski & Cellary, 2013). AR has also been reported as a more effective learning technology empowering students to envisage particular concepts (i.e. airflow; magnetic fields) via exposing computer-generated elements over real objects (i.e. Dunleavy et al., 2009). Furthermore, students, who actively use AR applications, are more emotionally and cognitively immersed in the learning process (Dalgarno & Lee, 2010; Squire & Jan, 2007). Therefore, students' knowledge, critical thinking, problem solving skills, and learning efficiency are more likely to be accelerated by using AR systems, which will in turn, reflect on the student's learning experience and creativity (i.e. Cheng, 2017; ElSayed et al., 2011; Sotiriou & Bogner, 2008; Verhagen et al., 2015; Wang et al., 2013). Thus, the current study assumes that due to the innovative and interactive nature of AR, it considerably stimulates the cognitive benefits and students are more likely to have positive learning experiences from using such systems. In this regard, the important role of cognitive benefits in shaping the user's experience with emerging systems (i.e. virtual reality) has been empirically approved by Kim et al. (2020) over the tourism sector. Therefore, this study proposes that:

H1: Cognitive benefits attained from using AR.LRP will positively influence student learning experience.

3.2 Social Integrative Benefits (SIB)

Verhagen et al. (2015. P. 341) defined Social integrative benefits as "benefits related to the medium's capability to facilitate social interaction and connect users to one another". Social integrative benefits also pertain to the ability of a medium to empower users to initiate or preserve current relationships with others who use the same medium platform (Rauschnabel et al. 2017; Rossmann et al., 2016). In fact, AR has been widely reported as a mechanism that could accelerate the students' interaction and collaboration with other students as well as with their teachers (i.e. Billinghurst, 2002). This could be explained by the interactive nature of AR.LRP that helps students to share and discuss what they learn with other students along with the ability to have constant teacher feedback (i.e. Capps & Crawford, 2013; Chiang et al., 2014). In other words, AR is able to imitate the actual learning environment, and accordingly, AR applications could not be only considered as digital platforms of knowledge delivery but also as social platforms in which students could socialise and personally interact with each other (i.e. Huang & Hsieh, 2011; Merhi, 2016). AR learning applications empower students to jointly solve their learning problems, which in turn, sustain the social bonds among those students (Kollock, 1999; Nambisan & Baron, 2009; Verhagen et al., 2015; Wasko & Faraj, 2005). In general, the ability of virtual applications to shape and enhance social interactions has been commonly reported in prior studies (i.e. Chen et al., 2010; Han et al., 2015; Ji & Fu, 2013; Kim et al., 2020). For example, Chen et al. (2010) illustrated that using virtual games significantly contributes to the social interactions between users. More recently, Kim et al. (2020) demonstrated the significant impact of social integrative benefits attained from using virtual reality applications on the customers' experience in the tourism context. Therefore, this study proposes that:

H2: Social integrative benefits attained from using AR.LRP will positively influence student learning experience.

3.3 Personal Integrative Benefits (PIB)

According to Godey et al. (2016), Katz et al. (1973), Nambisan et al. (2016), Verhagen et al. (2015) personal integrative benefits (PIB) could be defined as the extent to which using a particular medium could enhance the user's sense of confidence, self-efficacy, and self-esteem. Hamilton (1998) also addressed PIB as the ability of a medium to consolidate the user's credibility and social status between his/ her peers. As discussed in the part related to social integrative benefits, AR.LRP enables students to share their own experience which gives them a greater chance to be seen and recognised by their peers (Chang & Chuang, 2011). This, in turn, reinforces students' sense of importance and status as well as their perception of self-efficacy (Verhagen et al., 2015; Wang et al., 2013). AR has been commonly confirmed to be efficient learning applications enriching students' academic performance and productivity, and accordingly, contributing to their personal development (Alahmari et al., 2019; Moro et al., 2017; Pan et al., 2017). This, in turn, clarifies the personal values that AR.LRP could add in terms of self-efficacy, self-esteem, and social status. In this respect, Karapanos et al. (2016) argued that using emerging systems and media (i.e. social media) is a way to express themselves and their personalities in a modern and desirable manner, and accordingly, to project the image that they want others to perceive. Further, AR.LRP was strongly proved to have a crucial role in contributing to the students self-learning which could also add to the students' feelings of self-reliance and self-efficacy (Martin-Gutierrez et al., 2012). In other words, students, who use AR.LRP, are more able to concurrently learn and train even in the absence of their teachers (Alahmari et al., 2019). Moreover, using AR.LRP does not only contribute to the long-term benefits (i.e. student's sustainable performance) as assured by Ayer et al. (2016). Therefore, it could be argued that as long as using AR.LRP could yield more personal integrative benefits, students are more likely to have positive learning experience with such applications. Therefore, this study proposes that:

H3: Personal integrative benefits attained from using AR.LRP will positively influence student learning experience.

3.4 Affective Benefits (AB)

Affective benefits are more related to the users' feelings of pleasure, joy, and entertainment which are accelerated via use of a particular medium (i.e. AR) (Rauschnabel et al., 2017; Verhagen et al., 2015). Such feelings have been largely supported to shape the users' perception and experience with medium (Gallego et al., 2016). In fact, the ability of new learning systems (virtual reality and augmented reality) in enhancing such feelings could be returned to the novelty seeking, and aesthetic appeal perceived in using such applications (Chitturi et al., 2008; Gallego et al., 2016; Kim et al., 2020; Nambisan and Baron, 2009). Further, as argued in the social integrative needs section, using more interactive learning systems like virtual reality and augmented reality helps students to have more exposure as they are able to share their own knowledge and information which gratifies their desire for status, and accordingly, gratifies their affective needs (Kim, 2020). The use of augmented reality technology also calls for full attention from the students' senses and mind in addition to physical movement. This, in turn, makes the educational process more dynamic and exciting than using traditional methods (Kerawalla et al., 2006). The significant role of affective and hedonic benefits have been reported by different studies that have tested the new emerging systems of e-learning (Ha et al., 2015) and potential travel (Gallego et al., 2016; Kim et al., 20120; Merhi, 2016; Rauschnabel et al. 2017). Therefore, this study proposes that:

H4: Affective benefits attained from using AR.LRP will positively influence student learning experience.

3.5 Telepresence (TELE)

According to Steuer (1992, p.76), telepresence can be explained as "the extent to which one feels present in the mediated environment, rather than in the immediate physical environment". Biocca (1992) also conceptualised telepresence as the extent to which the user is able to be cognitively and emotionally transported to the technology-mediated environment. More recently, Mollen and Wilson (2010, p.8) defined telepresence as "a psychological state of 'being there' in a computer-mediated environment, augmented by focused attention". In line with the present study context (AR.LRP), telepresence could be articulated as the students' sense of presence in the virtual world empowered by AR.LRP (i.e. Hyun and O'Keefe, 2012). One of the most exceptional features of AR applications is their ability to simulate the real learning environment (Azuma et al., 2001; Klopfer and Squire, 2008). This could be attributed to the high level of AR.LRP's interactivity and vividness which have been commonly reported as key levers of users' sense of telepresence (Algharabat et al., 2018; Faiola et al., 2013; Hyun and O'Keefe, 2012). Further, using AR.LRP empowers students with more skills and controllability which helps those students to have a sense of telepresence as reported by Faiola et al. (2016). Furthermore, telepresence is one of the most important facilitators helping students to focus mentally and in a sensory manner during education: this is reflected in their involvement and experience in a large and positive way (Finneran & Zhang, 2003). Therefore, telepresence becomes a particularly powerful tool for learning when it is paired with a group experience. Telepresence has been reported as a key driver of users' engagement and experience with augmented and virtual applications (Algharabat et al., 2018; Hollebeek, 2011; Pelet et al., 2017; Mollen and Wilson, 2010; Song et al., 2007; Wang et al., 2014). Kim and Hyun (2016) provided empirical evidences supporting the role of telepresence in shaping the users' continued intention to use AR mobile applications. More precisely, Faiola et al. (2013) argued that student's sense of telepresence "being there" is a key driver of their e-learning experience with virtual game-based learning. All things considered, it could be suggested that increasing a student's sense of telepresence would help students to have an outstanding learning experience with AR.LRP. Accordingly,

H5: Telepresence will positively influence student learning experience with AR.LRP.

3.6 Technostress (TECHS)

Tarafdar et al. (2010, p. 305) defined technostress as “the stress that users experience as a result of application multitasking, constant connectivity, information overload, frequent system upgrades and consequent uncertainty, continual relearning, the consequent job-related insecurities, and technical problems associated with the organisational use of ICT”. In other words, technostress seems to be a mental and psychological state that expresses the pressure caused by the discomfort and inability of the individual to deal with modern technology in a healthy and efficient way (Brod 1984; Fuglseth and Sørebø, 2014; Lee et al. 2016).

Technostress has been commonly reported to play a negative role that psychologically hinders new systems users' satisfaction and loyalty which in turn decreases their productivity and performance (i.e. Hung et al., 2015; Nisafani et al., 2020; Ragu-Nathan et al., 2008; Tarafdar et al., 2015; Tarafdar et al., 2010; Tarafdar et al., 2007; Wang et al., 2020a; Wang et al., 2020b). In spite of the main needs and benefits that could be gratified via using AR.LRP, there are many research evidences reporting that using AR.LRP comprises an extent of complexity which could make students’ engagement and experience unsatisfactory due to the technical problems (Chiang et al., 2014; Lin et al., 2011). For example, the absence of a well-designed interface and clear guidance for use of AR would cause more technostress for the targeted students. Accordingly, making them perceive that the use of AR.LRP is not as useful as it should be, and this in turn will reflect negatively on their overall experience with such applications. Another reason why technostress is associated with AR.LRP could be that AR presents a new and novel way of learning, completely different from traditional learning methods that both teachers and students are used to (Kerawalla et al., 2006). In the line with what has been discussed regarding the causes of technostress are the findings of a number of studies (i.e. Chen et al., 2019; Hwang and Cha, 2018; Oladosuet al., 2020; Özgür, 2020; Tarafdar et al., 2010; Upadhyaya, 2021).

Christian et al. (2020), Gaudron and Vignoli (2002), Grandhi et al. (2005), La Torre et al. (2019), Luqman et al. (2017), Pearson et al. (2009) and Qi (2019) also argued that the use of new technology may represent additional loads and duties, which may increase the stress on users of such technology and negatively affect their level of satisfaction and experience. In this respect, Cheng & Tsai (2013) and Dunleavy et al. (2009) asserted the fact that expanding the adoption of AR.LRP increases the amount of educational burdens and duties required of students and thus reduced the free time available to them.

All things considered, this study supposes that those students who experience a high level of technostress are more likely to underestimate the associated benefits of using AR.LRP, and accordingly, less likely to have a positive learning experience. Thus, technostress is proposed in the current study to moderate the relationship between the dimensions of UGT (cognitive benefits, social integrative benefits, personal integrative benefits, and affective benefits) and student's learning experience with AR.LRP. In this respect, Verkijika (2019) empirically supported the moderation impact of technostress on the relationship between usefulness and attitudes with students' intention to adopt digital textbooks. This study proposes that:

H6a: Technostress will moderate the impact of cognitive benefits on student learning experience with AR.LRP.

H6b: Technostress will moderate the impact of social integrative benefits on student learning experience with AR.LRP.

H6c: Technostress will moderate the impact of personal integrative benefits on student learning experience with AR.LRP.

H6d: Technostress will moderate the impact of affective benefits on student learning experience with AR.LRP.

3.7 e-Learning Experience (EXP)

According to Alben (1996) and Hassenzahl and Tractinsky (2006), user experience presents the overall user's assessment of using and trying a new system including the results of the influence of the person's internal factors (inclinations, expectations, needs, motives, moods, etc.), the nature of the system used and its features (such as ease of use, purpose, usefulness, function) and the sitting and environment in which the interaction takes place. The current study adopted the definition proposed by ISO (2009) and Olsson et al. (2013), and therefore, learning experience with AR.LRP could be articulated as the way that students perceive and react resulting from the use and/or expected use of such learning applications.

One of the key consequences of using AR.LRP is empowering students to have a unique and positive learning experience attributed to a high degree of interactivity, vividness, and personalisation (Beck and Cri´e, 2016; Chiang et al., 2014; Hilken et al., 2018; Rosenbaum et al., 2007). In other words, students, who actively use AR.LRP, are more able to build fruitful relationships with colleagues, have contactual efficiency and more interactivity. This, in turn, reflects positively on the students' motivation, immersion, and academic performance (Chiang et al., 2014; O'Shea et al., 2011; Rosenbaum et al., 2007). Practically, AR.LRP allows students to experience a real learning environment which is supported with virtual objects. Accordingly, AR.LRP helps students to have a learning experience similar to that of real ones without any risks (i.e. Chen and Wang, 2017; Klopfer & Squire, 2008; Kudryavtsev et al., 2012; Wojciechowski & Cellary, 2013). Further, Chang et al. (2018) argued the effectiveness of AR.LRP in increasing students' ability to think critically and make proper decisions, and thus improving their learning experience in particular and their academic performance in general.

AR.LRP could be launched in different disciplines of education (i.e. biology, physics, chemistry, and engineering) and help students to have unique learning experience by visualising, testing, and removing objects without causing any environmental harm or wasting resources (Alahmari et al., 2019). There are several studies that have tested the consequences of the learning experience with AR.LRP (i.e. Tom Dieck et al., 2018). For example, Tom Dieck et al. (2018) proved the crucial role of AR.LRP on student satisfaction and memory, and accordingly, their engagement. More recently, Mumtaz et al. (2017) suggested that students' learning experience is accelerated when using AR.LRP, and accordingly, enhances the students' confidence and motivation. Stoyanova et al. (2015) also noticed that students, who use AR.LRP, are more likely to have an attractive and entertaining learning experience. Likewise, Estapa and Nadolny (2015) found out that students who effectively experience AR.LRP are more motivated and have a higher academic performance. Therefore, this study proposes that:

H7: e-learning experience with AR.LRP will positively influence student e-learning performance.

4. Methodology

The current study nature is more to be positivist, and therefore, quantitative research approach was selected to test the current study model and verify the main research hypotheses. Thus, questionnaire survey design was applied to collect the main quantitative data for the purpose of the current (Bhattacherjee, 2012). The main population of the current study comprises undergraduate students from the four largest Universities (i.e. King Saud University; King Abdulaziz University; King Fahd University of Petroleum and Minerals; Umm Al Qura University) in Saudi Arabia. The total number of the undergraduate students of these four universities was about 245,904 as reported by the Saudi Ministry of Higher Education (2019).

A purposive sample size of 500 undergraduate students from the four largest Universities (i.e. King Saud University; King Abdulaziz University; King Fahd University of Petroleum and Minerals; Umm Al Qura University) in Saudi Arabia was approached in the current study's survey. These universities were chosen because they were the first to use augmented reality technology in the learning process, especially in scientific disciplines such as science, computer science, engineering, and medicine. Students, who were targeted in the current study, should be actively engaged in using AR.LRP. Those participants were approached using an online questionnaire between the periods extending from the first of February to the end of April. The collected valid responses were about 325 with a response rate of 65%.

Scale items of UGT constructs were derived from Nambisan & Baron (2009) which have been successfully validated by different studies over the related area of e-learning and augmented reality (i.e. Verhagen, 2015; Zollo et al., 2020). Four items were derived from Kim and Hyun (2016) to measure telepresence while items of technostress were adapted from Verkijika (2019) and Wang and Tan (2020). Four items proposed by Kim et al. (2020) were considered in the current survey to test student e-learning experience AR.LRP. Finally, Wang's et al. (2007) scale items were used to measure student e-learning performance. All of these items were tested in the current study questionnaire using the seven-point Likert scale ranging from strongly agree to strongly disagree. The questionnaire was also pre-tested prior the main survey with a sample of 30 students in King Abdulaziz University. All students emphasised the clarity and suitability of the language used in formulating the questions. Further, Cronbach's alpha test was conducted to assure the adequate level of reliability. In details, all constructs were able to have a value above 0.80 which is higher than the recommended value 0.70 (Nunnally, 1978).

5. Results

As presented in the methodology section, the valid responses of the current study sample were about 325 with a response rate of 65%. With regard to the demographic characteristics of the current study sample, about 59% of participants were males while about 41% were females. Their distribution according to academic level was as follows: first year students (19%); second year students (23%); third year students (26%); fourth year students (20%); more than four years (12%). In terms of students' usage experience with AR.LRP, about 36% of the current sample participants have more than 2 to 3 years using experience with AR.LRP; 39% of participants have more than three years' experience of using AR.LRP;

while about 25% of sample participants have less than one year of using experience with AR.LRP. Science students present the largest part (27%) of the current study sample followed by medicine students (23%); social science students (19%); engineering students (17%); and other backgrounds (14%).

Table 1. Demographic Profiles of Sample Participants

Demographic Profile	Number of Respondents (N= 325)	Percentage (%)
Gender		
Male	192	59%
Female	133	41%
Total	325	100%
Academic level		
First year	62	19%
Second year	75	23%
Third year	85	26%
Fourth year	65	20%
More than fourth year	38	12%
Total	325	100%
Academic major for students		
Science	88	27%
Medicine	74	23%
Social science	62	19%
Engineering	55	17%
Other backgrounds	46	14%
Total	325	100%
Usage experience with AR.LRP		
Less than one year	81	25%
2-3 years	117	36%
More than 3 years	127	39%
Total	325	100%

5.1 Descriptive statistics of the measurement items

As seen in Table 2, most constructs’ items have been valued positively by the students targeted in the current sample. The average mean of scale items used to measure CGB was 5.69 with a Std. deviation value of 1.04 which means that students largely value aspects related to cognitive benefits associated with AR.LRP. Likewise, sample respondents positively rate scale items used to measure PIB as the average mean value was 5.64 and Std. deviation value was 1.08. The average mean value accounted to SIB scale items was 5.55 with Std. deviation value of 1.10, and accordingly, indicating the participants’ positive evaluation for the aspects related to social benefits yielded from using AR.LRP. Students targeted in the current study were also noticed to positively appraise the hedonic aspects pertaining to AR.LRP as the average mean of AB scale items reached 5.48 with a Std. deviation of 1.05. AR.LRP seems to enhance students' feeling of being immersed in the virtual world as a high average mean value was accounted for telepresence (5.39) with a Std. deviation value of 1.08. Students targeted in the current study sample are more likely to positively value their learning experience with AR.LRP as the average mean value accounted to EXP scale items was about 5.85 and a Std. deviation value of 1.09. Similarly, most students in the current study sample see AR.LRP as enhancing their learning performance as the average mean value in this respect was about 5.55 with Std. deviation value of 1.00. Finally, students of the current study moderately value the aspects associated with technostress with an average mean value of 3. 27 and Std. deviation value of 0.982.

As seen in Table 2, skewness-kurtosis values for all scale items were inspected to guarantee that there is no concern regarding violation of normality (Byrne, 2010; Hair et al., 2010; Kline, 2005). Table 2 shows that all scale items do not have skewness value higher than 3 and kurtosis value higher than 8, which in turn, supports that the current study data are normally distributed (Kline, 2005; West et al., 1995).

As for the missing values and how were managed, both the amount of missing values and their distribution pattern were tested for the current study data prior conducting the main analyses. The yielded results in this respect showed that the amount of missing values for each construct were not higher than 5 per cent. This, in turn, means that there is no concern regarding the impact of missing values as reported by Churchill (1995). The p value of MCAR was also tested and noticed to be non-significant (p = .429). Accordingly, the missing data in the current study existed in a random manner and the missing values were allocating non-systematically (Little, 1988). However, the variable mean value was considered in the current study to replace all the missing values with the variable mean as suggested by Hair et al. (2006) and Tabachnick and Fidell (2007).

Table 2. Descriptive statistics of the measurement items

Construct		Mean	Std. Deviation	Skew	Kurtosis
CGB	CGB1	5.76	1.02	-.77	.17
	CGB2	5.77	1.05	-.97	.50
	CGB3	5.63	1.05	-.76	.05
	CGB4	5.63	1.05	-.76	.05
	Average	5.69	1.04		
PIB	PIB1	5.68	1.11	-.76	-.15
	PIB2	5.64	1.11	-.75	-.169
	PIB3	5.66	1.08	-.73	-.03
	PIB4	5.58	1.04	-.74	-.25
	Average	5.64	1.08		
SIB	SIB1	4.94	1.32	.002	-1.22
	SIB2	4.97	1.22	-.15	-.99
	SIB3	4.26	1.13	-.36	-.66
	Average	4.72	1.22		
AB	AB1	5.55	1.10	-.67	-.28
	AB2	5.82	0.88	-.84	.64

	AB3	5.79	0.90	-.68	.39
	AB4	5.48	1.05	-.69	.29
	AB5	5.77	1.00	-.38	-.58
	Average	5.48	1.05		
TELE	TELE1	5.37	1.09	-.41	-.46
	TELE2	5.67	0.99	-.82	.27
	TELE3	5.02	1.07	-1.18	.69
	TELE4	5.51	1.20	-.55	-.68
	Average	5.39	1.08		
TECHS	TECHS1	3.06	0.89	-1.21	1.77
	TECHS2	3.20	0.77	-.92	1.07
	TECHS3	3.44	1.13	-.41	-.62
	TECHS4	3.35	1.09	-.37	-.62
	TECHS5	3.30	1.03	-.38	-.47
	Average	3.27	0.982		
EXP	EXP1	5.84	1.10	-.83	-.12
	EXP2	5.71	1.18	-1.02	.50
	EXP3	5.91	1.07	-1.13	1.02
	EXP4	5.94	1.01	-.90	.38
	Average	5.85	1.09		
EP	EP1	5.98	1.03	-1.23	1.27
	EP2	5.95	1.05	-1.05	.62
	EP3	5.10	0.97	-1.21	1.17
	EP4	5.13	0.93	-1.33	1.89
	EP5	5.91	1.0	-.97	.76
	EP6	5.25	1.05	-1.25	1.65
	Average	5.55	1.00		

5.2 Structural equation modelling (SEM) analysis

Two stage SEM approach was applied in the current study to validate the current study model and test the research hypotheses. In the first stage: measurement model, a number of criteria were considered such as model fitness, construct reliability and construct validity while the main conceptual model was conducted to validate the current study model and test the research hypotheses. Regarding the parameter estimation method, the maximum likelihood estimators (MLEs) were computed as appropriate for parameter estimates especially in the light of the large sample size of the current study (325) (Anderson and Gerbing, 1988; Jöreskog and Sörbom, 1982). According to Hair et al. (1995), MLEs are also more suitable in the case of the latent constructs have less than five observed variables as noticed for the most constructs in the current study (see Appendix). Further, MLEs have "the desirable asymptotic, or large-sample, properties of being unbiased, consistent, and efficient" (Anderson and Gerbing, 1988, p. 413). The MLE enjoys with ability to decrease the divergence between the covariance and sample matrices; which in turn, enhances the estimated parameters (Hair et al., 2006). Accordingly, the current study adopted the to conduct an SEM analyses.

5.2.1 Measurement Model

Model fitness

Thirty four scale items were used in the current study to measure eight latent constructs as seen in Table 2. All of these items have been tested in the first stage of structural model analysis (measurement model: confirmatory factor analysis (CFA)). Thus, a group of fit indices (goodness-of-fit index [GFI]; adjusted goodness-of-fit index [AGFI]; comparative fit index [CFI]; normed chi-square [CMIN/DF]; normed-fit index [NFI]; and root mean square error of approximation [RMSEA]) were considered in the current study to test the goodness of fit for the measurement model. However, as noticed in Table 3, a number of indices (CMIN/DF = 4.214; GFI = 0.821; AGFI = 771; NFI = 0844; and RMSEA=0.082) of the initial version of the measurement model were not found to be within their suggested level (Byrne, 2010; Hair et al., 2010; Tabachnick & Fidell, 2007). Accordingly, the initial version of the measurement model was revised by removing the most problematic items (Byrne, 2010; Hair et al., 1995; 2006; Holmes-Smith et al., 2006). In this respect, six items (EXP1; CGB4; EP1; TECHS1; TECHS2; and PIB4) were observed to have factor loading less than 0.50, and accordingly, were all removed from the measurement model (Byrne, 2010; Hair et al., 1995; 2006; Holmes-Smith et al., 2006). Then, the revised version of the measurement model was tested and all fit indices were able to exist within their threshold level as such: CMIN/DF = 2.241; GFI = 0.918; AGFI = 0.876; NFI = 0.945; CFI = 0.973; RMSEA = 0.051).

Table 3. Measurement model fit indices

Fit indices	Cut-off point	Measurement model (Version 1)	Measurement model (Version 2)
CMIN/DF	≤3.000	4.214	2.241
GFI	≥ 0.90	0.821	0.981
AGFI	≥ 0.80	0.771	0.876
NFI	≥ 0.90	0.844	0.945
CFI	≥ 0.90	0.921	0.973
RMSEA	≤ 0.08	0.082	0.051

Construct reliability and validity

Three common criteria [composite reliability (CR), Cronbach's alpha (α) and average variance extracted (AVE)] were considered to assure adequate level of construct reliability and validity (i.e. Anderson & Gerbing, 1988; Fornell & Larcker, 1981; Hair et al, 2010). As shown in Table 4, CR values for all eight constructs had a value higher than 0.70 as suggested by Anderson & Gerbing (1988). Both TECHS and EXP were able to have the highest CR value (0.917) while CGB accounts for the lowest CR value (0.773).

Table 4. Construct reliability and validity

Construct	CR	AVE	Cronbach's alpha (α)
CGB	0.773	0.539	0.772
EP	0.914	0.726	0.915
EXP	0.917	0.736	0.916
PIB	0.869	0.693	0.869
TECHS	0.917	0.786	0.914
SIB	0.807	0.584	0.804
AB	0.843	0.573	0.841
TELE	0.842	0.572	0.841

Likewise, Cronbach's alpha (α) values for all eight constructs were above 0.70 (Nunnally, 1978). In this respect, CGB has the lowest Cronbach's alpha (α) (772) while EXP has the highest value (0.916) (see Table 4). AVE values ranged between 0.539 (CGB) to 0.786 (TECHS) which all are above 0.50 as recommended by Hair et al. (2010) and Fornell & Larcker (1981).

Table 5. Standardised Regression Weights

TELE1	<---	TELE	0.801
TELE2	<---	TELE	0.78
TELE3	<---	TELE	0.75
TELE4	<---	TELE	0.69
AB4	<---	AB	0.76
AB3	<---	AB	0.823
AB2	<---	AB	0.719
AB1	<---	AB	0.721
EP2	<---	EP	0.846
EP3	<---	EP	0.905
EP4	<---	EP	0.801
EP5	<---	EP	0.853
EXP5	<---	EXP	0.87
EXP4	<---	EXP	0.807
EXP3	<---	EXP	0.913
EXP2	<---	EXP	0.837
CGB1	<---	CGB	0.542
CGB2	<---	CGB	0.826
CGB3	<---	CGB	0.801
PIB1	<---	PIB	0.881
PIB2	<---	PIB	0.93
PIB3	<---	PIB	0.662
SIB1	<---	SIB	0.688
SIB2	<---	SIB	0.875
SIB3	<---	SIB	0.717
TECHS3	<---	TECHS	0.853
TECHS4	<---	TECHS	0.923
TECHS5	<---	TECHS	0.883

Convergent validity was tested by inspecting the Standardised Regression Weights (factor loading) for all unremoved items. As seen in Table5, all scale items were able to have a factor loading value higher than 0.50 (Hair et al., 2010). Furthermore, Table 6 shows that all latent constructs were able to match criteria related to discriminant validity as the inter-correlation values between the constructs were found to be less than the square root of AVE value for each construct (Fornell and Larcker, 1981).

Table 6. Discriminant validity

	CGB	EP	EXP	PIB	TECHS	SIB	AB	TELE
CGB	0.734							
EP	0.422	0.852						
EXP	0.397	0.804	0.858					
PIB	0.505	0.407	0.299	0.833				
TECHS	0.549	0.248	0.182	0.394	0.887			
SIB	0.322	0.378	0.533	0.226	0.335	0.764		
AB	0.412	0.557	0.648	0.254	0.325	0.643	0.757	
TELE	0.323	0.521	0.581	0.239	0.364	0.738	0.679	0.756

5.2.2 Structural Model

The structural model was also able to adequately fit the observed data as all goodness of fit indices exist within their recommended level: CMIN/DF = 2.391; GFI = 0.900; AGFI = 0.865; NFI = 0.933; CFI = 0.961; and RMSEA = 0.058. Further, five factors, namely: AB, PIB, CGB, and TELE account about 0.59 of variance in the student' experience with AR.LRP which, in turn, accounts about 0.43 of variance EP. In terms of pat coefficient analyses, AB was observed to be the most significant factor predicting the student experience with AR.LRP (γ=0.488, p<0.000) followed by CGB (γ=0.341, p<0.007) (see Table 7). Student learning experience with AR.LRP was also noticed to be predicted by the role of PIB (γ=0.149, p<0.012) and TELE (γ=0.308, p<0.048). Therefore, H1, H3, H4, and H5 were supported. However, SIB was not proved to have a significant impact on the student experience (γ=0.057, p<0.603), and accordingly, H2 was rejected. The highest regression weight value in the current structural model was noticed between students' experience and e-learning performance (γ=0.757, p<0.000). Therefore, H7 was accepted.

Table 7. Hypothesises Testing

			Estimate	S.E.	C.R.	P	Label
EXP	<---	AB	.488	.114	4.271	***	par_18
EXP	<---	TELE	.308	.101	3.049	.048	par_19
EXP	<---	CGB	.341	.127	2.678	.007	par_21
EXP	<---	PIB	.149	.059	2.519	.012	par_22
EXP	<---	SIB	.057	.110	.520	.603	par_25
EP	<---	EXP	.757	.059	12.886	***	par_20

The moderation results of technostress are presented in Table 8. Hayes (2017) process macro (model 58) was applied in the current study so as to validate the moderating impact of technostress on the relationships between UGT dimensions (CGB, SIB, AB, and PIB) with EXP. Table 8 illustrates that the interaction effect of technostress as a moderator with (a) CGB and EXP, (b) SIB and EXP, (C) PIB and EXP, and (D) AB and EXP. Findings reported that by incorporating the moderation role of technostress, the R^2 accounted in EXP increased to 0.65: formerly it was 0.59. The R^2 accounted in EP was also enhanced to be 0.51 while it was 0.43. This, in turn, supports the significant impact of technostress as a moderating factor on the relationships between CGB, SIB, PIB, and AB with EXP. Furthermore, the interaction effect of technostress on the proposed relationships between CGB, SIB, AB, and PIB was tested to see the direction of the moderation. The moderation results also illustrates that the interaction terms have significant regression coefficients. For example, it was noticed that that the path coefficient of the interaction Technostress★CGB→EXP=-0.14 (significant at 0.05 level), Technostress★SIB→EXP=-0.10 (significant at 0.05 level), Technostress★PIB→EXP =-0.12 (significant at 0.05 level), and Technostress★AB→EXP =-0.13 (significant at 0.05 level) all have negative directions. Thus, it could be concluded that technostress negatively moderates relationships between CGB, SIB, AB, and PIB with EXP, and accordingly, H6a, H6b, H6c, and H6d were all supported.

Table 8. Moderation Results

Hypothesis	Estimate	S.D	T-statistics	P	Hypothesis result
Technostress★CGB→EXP	-.14	.032	-3.125	.032	Supported
Technostress★SIB→EXP	-.10	.033	-3.03	.041	Supported
Technostress★AB→EXP	-.13	.042	-3.095	.029	Supported
Technostress★PIB→EXP	-.12	.039	-3.076	.031	Supported

6. Discussion

As presented in the prior section, the empirical results of the current study have been in line with the propositions set out in the conceptual model. All criteria pertaining to the measurement model (model goodness of fit, construct reliability, and construct validity) were supported, approving the validity and applicability of UGT and other factors (telepresence and technostress) to the context of the current study (AR.LRP). Further, the proposed model was able to adequately fit the observed data as well as capture a good predictive validity level due to the large portion of variance accounted in students learning experience with AR.LRP (0.59) and e-learning performance (0.43). This, in turn, supports the current study's proposed model and provided further evidence for the suitability of UGT to the context of AR.LRP.

In terms of path coefficient analyses, except the path between SIB and EXP, all other paths were supported to be significance. For example, students learning experience with AR.LRP was found to be largely contributed to by the role of AB. This means that students would have a more positive interaction and experience with AR.LRP if they perceive that such learning applications could give them feelings of pleasure, joy, and entertainment. Such results could be returned to the fact that AR.LRP has a high level of novelty and uniqueness, and accordingly, students are more able to feel innovative and creative by using such learning applications in comparison with traditional ones (Chitturi et al., 2008; Gallego et al., 2016; Kim et al., 2020; Nambisan and Baron, 2009). Further, students who actively use AR.LRP are more able to have self-esteem and status as they can easily share their knowledge, skills, and success with their peers, which in turn, satisfies their affective needs (Kim, 2020). Such results are in the line with other studies that have supported the role of AB (i.e. Gallego et al., 2016; Kim et al., 20120; Merhi, 2016; Rauschnabel et al. 2017).

Empirical results also supported the significant impact of CGB on The EXP. Such results mean that as long as AR.LRP is able to match the students learning needs and expectations, a more positive learning experience for students is offered with AR.LRP. As argued in the conceptual model, due to the high level of interactivity in AR.LRP, students are more able to control and retain what they learn and study, and accordingly, sustain the efficiency and effectiveness of the learning process (see Hsiao et al., 2016; Hwang et al., 2016; Liou et al., 2017; Squire et al., 2007). AR.LRP also helps students to have consistent valuable feedback which improves the learning process in general and the learning outcomes (i.e. Ha et al., 2015; Martin-Gutierrez et al., 2017; Verhagen et al., 2015). Such results are not far from other studies that have supported the role of CGB (Dunleavy et al., 2009; Kim et al., 2020; Verhagen et al., 2015).

Path coefficient analyses also supported the causal path between PIB and EXP which explains how students are more likely to have a positive learning experience as long as using AR.LRP helps them to gratify their personal needs such as confidence, self-efficacy, and self-esteem (Godey et al., 2016; Nambisan et al., 2016; Verhagen et al., 2015). AR.LRP represents a new way of learning that enhances the concept of self-learning and student personality development. This is along with providing students with more opportunities to share their knowledge with colleagues, and this will enhance student self-confidence as well as their self-efficacy (Chang & Chuang, 2011; Verhagen et al., 2015; Wang et al., 2013). There are several studies that have approved the role of PIB in shaping technology users' perceptions and experience such as Chang et al. (2021); Gu and Kim (2019); Nambisan and Baron (2009); Verhagen et al. (2015).

Telepresence was proposed as an external factor in the current study model alongside UGT factors. The empirical findings largely supported the current study proposition regarding the impacting role of telepresence in shaping students' experience with AR.LRP. In other words, students, who have such cognitive and emotional immersion in the virtual world empowered by AR.LRP (i.e. Hyun and O'Keefe, 2012), are more likely to have positive e-learning experience. This could be related to the ability of AR.LRP in simulating the real environment of education due to the high level of interactivity and vividness that characterise such learning applications as reported by Algharabat et al. (2018); Azuma et al. (2001); Faiola et al. (2013); Hyun and O'Keefe (2012); Klopfer and Squire (2008). There are several examples in the prior literature that have supported the role of telepresence in shaping technology users experience especially those related to augmented reality and virtual reality (Algharabat et al., 2018; Hollebeek, 2011; Mollen and Wilson, 2010; Pelet et al., 2017; Song et al., 2007; Wang et al., 2014).

As expected, the moderation role of technostress on the relationships between UGT factors (CGB; SIB; PIB; and AB) was supported as seen in Table 8. In detail, technostress caused by using AR.LRP mitigates the strength and momentum of the relationships between CGB; SIB; PIB; and AB and EXP as these relationships reached their lowest level within the group of students who had a high level of technostress. Regardless of the cognitive, social, personal and affective values which could be captured by using AR.LRP, the existence of technostress hinders the ability of students to fully have a unique and positive learning experience with AR.LRP. The associated technostress with using AR.LRP could be attributed to the extent of complexity perceived in using such learning applications (Chiang et al., 2014; Lin et al., 2011). Furthermore, in comparison with common e-learning applications that students become familiar with, AR.LRP presents new learning methods requiring greater independence from students. Therefore, students are required to spend more effort and time to develop the new skills and competences to effectively interact with AR.LRP. This, in turn, would present another source of stress, hindering the benefits yielded from using AR.LRP, and accordingly, students would less likely to have positive learning experience from using such applications. Over the prior literature, there are several examples of studies that have confirmed the role of technostress in the users' evaluation and experience with new systems such as Hung et al. (2015); Nisafani et al. (2020); Wang et al. (2020a); Ragu-Nathan et al. (2008); Tarafdar et al. (2015); Tarafdar et al. (2010); Tarafdar et al. (2007; Wang et al. (2020b).

Finally, students' e-learning performance has been noticed in the current study to reach the highest level among those students who were able to have a positive experience with

AR.LRP. As discussed above, AR.LRP empowers students to have a more interactive, vivid, and personalised learning experience. This, in turn, makes the learning process more productive and attractive from the students’ perspective (Beck and Cri´e, 2016; Chiang et al., 2014; Hilken et al., 2018; Rosenbaum et al., 2007). Further, as approved regarding the main predictors of EXP, AR.LRP has the ability to sustain and maintain students’ motivation and immersion in the learning process, and accordingly, enhances student understanding and awareness of the subjects they are studying (Chiang et al., 2014; O'Shea et al., 2011; Rosenbaum et al., 2007). These results are in the line with other studies that have approved the role of EXP in learning (see Chang et al., 2018; Chen and Wang, 2017; Klopfer & Squire, 2008; Kudryavtsev et al., 2012; Wojciechowski & Cellary, 2013).

6.1 Theoretical Implications

This study has been conducted in the light of a limited number of studies that have tested the related issues of students experience with AR.LRP. Therefore, the theoretical contribution of the current study has several aspects. For example, this study was able to provide an accurate and comprehensive understanding of the main predictors of students’ experience with AR.LRP by proposing UGT as the theoretical base of the current study. In this respect, it is worth mentioning that even though UGT factors have been widely tested over the related area of e-learning (i.e. Gallego et al., 2016; Han et al., 2015; Mondi et al., 2008; Shin, 2009), there are very few attempts that have adopted this theory to test AR.LRP. Also, prior studies have commonly test the impact of UGT on the users’ intention, adoption, and satisfaction (Kim et al., 2020), yet, little is known about the impact of UGT factors on the students’ experience with AR.LRP. Therefore, this study captures a considerable contribution by expanding the applicability of UGT to a new context (i.e. AR.LRP) and considers new kinds of consequences (student learning experiences). This study also proposes the role of telepresence alongside UGT factors, which in turn, enables the current study’s model to provide a comprehensive picture regarding the main predictors of students’ experience with AR.LRP.

As this is new technology, students could experience a certain level of technostress. However, technostress has received little attention in the AR body of literature despite the importance of the negative role it can play in shaping student perception and experience with AR.LRP (Nisafani et al., 2020). In this respect, Salo et al. (2018) argued that technostress is among the most critical aspects presenting the dark side of using new media technologies like social networking platforms. Therefore, this study attempts to address how such a construct (technostress) could negatively moderate the relationships between the main dimensions of UGT and the students' learning experience with AR.LRP. This is a main contribution of the current study, as technostress has not been well covered over the related area of AR applications in general and especially these applications used within the e-learning context. Furthermore, the vast majority of prior studies have addressed technostress either as consequence of other factors (i.e. Hung et al., 2015) or as inhibitor of the user's perception and behaviour toward new technology (i.e. Fuglseth and Sørebø, 2014). However, no study has tested technostress as a moderator between the key antecedences (i.e. UGT dimensions) and user's behaviour, perception, and experience. Thus, this study comprises a considerable contribution by arguing how technostress could moderate the relationship between UGT dimensions and students' experience with AR.LRP.

6.2 Practical implications

The current study results have enriched the current understanding regarding the main features that should be the focus of attention of practitioners to effectively design and implement AR.LRP applications. Further, this study has provided further clues about the main aspects from student's perspective which could help to assure a unique and positive learning experience. For example, the significant results pertaining to UGT dimensions clearly demonstrate which kinds of benefits and expectations students are hoping to gain from using AR.LRP. This, in turn, helps to clearly identify the size and nature of the efforts required to gratify student's expectations from using AR.LRP. For example, the significant results of CGB give clues for practitioners and designers suggesting they pay more attention to aspects related to the cognitive and informational dimension. In this respect, emphasis should be placed on the amount and variety of knowledge and information obtained by students from engaging in the AR.LRP activities. Such knowledge and information delivered via AR.LRP should also be customised in a way that considers the needs of students and their intellectual and scientific capabilities.

The significant role of PIB should also encourage more efforts in enhancing the ability of AR.LRP to improve the student's sense of his/her presence, status, and reputation among his/her colleagues. This would be attained by improving the interactive and communicative features of AR.LRP which allow students to have a better opportunity to interact and exposure. Enhancing and developing the features which relate to sharing knowledge and skills among students may also help students to sustain credibility within the student community. This, in turn, will enrich the students' positive view of themselves and, accordingly be reflected on their experience with AR.LRP and their academic performance.

Affective benefits have been the most important factors contributing to the students learning experience with AR.LRP, and therefore more attention should be paid to the entertaining and enjoyable elements of AR.LRP by practitioners and marketers. In this respect, and according to Kim et al. (2020), practitioners should make learning programs delivered by AR.LRP more authentic, novel, and unique in comparison with traditional kinds of e-learning platforms. It is also important to embrace unique features of the learning content delivered by AR.LRP. This would be attained by using multimedia content (i.e. audio with vivid sound, tactile experiences and 3D video,). Furthermore, affective benefits would be accelerated by enriching the ability of AR.LRP to stimulate student's creativity and critical thinking skills as reported by Nambisan & Baron (2009).

The results of the current study assures the crucial role of telepresence, and accordingly, more attention should be paid to accelerate the unique features of AR.LRP in emulating the real learning environment, and accordingly, enhance student psychological immersion in the virtual environment. According to Algharabat et al. (2018); Faiola et al. (2013), Hyun and O'Keefe (2012), more efforts should be made to sustain AR.LRP's interactivity and vividness which would considerably enrich the students' sense of telepresence. In this regard, Algharabat et al. (2018) provide a number of guidelines that would enhance technology users' telepresence. Designers should concentrate on developing and designing the AR.LRP interface to reflect; (1) a real authentic imitation of the offline learning programs, (2) a system quality in which AR.LRP interface is uncomplicated, useful, and attractive; (3) a high level of playfulness and vividness; (4)

So as to fully guarantee a positive student experience with AR.LRP, technostress causes should be carefully addressed. Initially, educational institutions are recommended to survey the current level of technostress that students feel toward AR.LRP, and then clearly define and identify the main causes of technostress from a student perspective. This would facilitate designing and developing effective strategies to cope with such challenges (Verkijika, 2019). Educational institutions should be keen on the size and nature of the scientific content and material delivered by AR.LRP so that they should consider the student's competencies and skills as well as do not represent additional burdens compared to traditional offline learning programs. In other words, educational institutions should make the digital transformation process run smoothly and without any tensions and stress for students. This could require educational institutions to spend more time and effort in training and empowering students to successfully use AR.LRP. Students who suffer from high levels of technostress should be given more time to get used to AR.LRP without any pressure to learn quickly or in a hurry. Further, technical support must be available to students on a permanent basis so as to handle any problem that could emerge in using AR.LRP. This, in turn, would help decrease the level of stress that students could perceive in using AR.LRP.

6.3 Limitations and Future Research Direction

Even though this study comprises a number of theoretical and practical contributions as described in the prior sections, there are several limitations which need to be reported and discussed as directions to be considered for future study. Firstly, this study has exclusively proposed UGT dimensions as key antecedences of the students' experience with AR.LRP: it has not covered other important factors (i.e. self-efficacy, innovativeness, compatibility, technology readiness, interactivity, and vividness). Therefore, future studies could give further attention to these factors to provide a comprehensive picture regarding the main predictors of students experience with AR.LRP. Further, this study has not addressed the key antecedences that could contribute to UGT dimensions, which in turn, present an important direction to be considered by future studies: examining these antecedences as levers of UGT dimensions (CGB; SIB; PIB; and AB). In spite of the fact that including telepresence adds a contribution to the theoretical horizon, there is still a room to look at other related factors (i.e. social presence) and to see how these factors could shape the students experience with AR.LRP. This study only considers student experience; yet, other aspects of students' interaction with AR.LPR (i.e. engagement; satisfaction; loyalty) would be worth further study. Finally, the empirical part of the current study has been conducted over the higher educational sector in the Saudi Arabia. This in turn, would hinder the generalisability of the current study' results to other educational sectors (school and technical education) and other countries as well.

7. Conclusion

Based on critical reviewing the main body of e-learning literature, the current study recognises the dearth of studies that have tested the main factors and antecedences of the student's experience with AR.LRP learning applications (i.e. Olsson et al., 2013).

Accordingly, this study attempts to fill this gap by proposing and empirically validating the main factors that could either positively or negatively shape the student learning experience with AR.LRP. Uses and Gratifications Theory (UGT) was selected as a theoretical foundation of the current study's conceptual model. In detail, four dimensions of UGT: CGB; SIB; PIB; and AB were proposed as key predictors of AR.LRP. Telepresence was included alongside UGT dimensions as key predictors of students' experience with AR.LRP. Technostress was also proposed as a factor moderating the relationship between the dimensions of UGT and student's learning experience with AR.LRP. The empirical data of the current study was collected using an online questionnaire allocated to a sample size of 500 undergraduate students from the four largest Universities in Saudi Arabia. The empirical results largely supported the impact of UGT dimensions (CGB; PIB; and AB) and telepresence in predicting EXP. The moderation impact of technostress was also approved in the current study. This study was also able to capture a contribution to both researchers and practitioners by providing an accurate understanding of the features and aspects that should be considered in designing and implementing AR.LRP.

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Appendix: Scale Items

Construct	Items	Citations
Cognitive benefits	1. I get varied knowledge from using the AR.LRP activities. 2. I collect diverse information from using the AR.LRP activities. 3. Using AR.LRP helps me to enhance my knowledge. 4. Using AR.LRP helps to obtain solutions related to my problems.	Nambisan & Baron (2009) Kim et al. (2020)
Social integrative benefits	1. Using AR.LRP helps me to expand my personal/social network. 2. Using AR.LRP helps me to enhance the strength of my affiliation with the student community. 3. Using AR.LRP helps me to enhance my sense of belongingness with the student community.	Nambisan & Baron (2009)
Personal integrative benefits	1. Using AR.LRP enhances my status/reputation as an expert in the student community. 2. Using AR.LRP reinforces my credibility/authority in the student community. 3. Using AR.LRP helps me derive satisfaction from increasing other participants' knowledge. 4. Using AR.LRP makes me feel like a better student.	Nambisan & Baron (2009) Alnawas and Aburub (2016)
Affective benefits	1. Using AR.LRP helps me to spend some enjoyable and relaxing time. 2. Using AR.LRP derives fun and pleasure. 3. Using AR.LRP entertains and stimulates my mind. 4. Using AR.LRP derives enjoyment from problem solving and idea generation.	Nambisan & Baron (2009)
Telepresence	1. While I used the AR.LRP, I felt that I was in the world AR created. 2. While I used the AR.LRP, I forgot that I was in the middle of an experiment. 3. While I used the AR.LRP, my body was in my real life, but my mind was inside the world created by AR. 4. When I was navigating through the AR.LRP, I forgot about my immediate surroundings.	Kim and Hyun (2016)
Technostress	1. I feel stressed to adapt to AR.LRP. 2. I find it difficult to effectively use AR.LRP due to my limited investment of time and effort. 3. I feel stressed to cope with the high demands of AR.LRP with my current capability. 4. I find it hard to catch up with the constant updates of AR.LRP with my current skillset. 5. I feel drained from tasks that require me to read or study using AR.LRP.	Wang and Tan (2020) Verkijika (2019)
e-learning experience	1. Using AR.LRP activity provided me with authentic learning experiences. 2. Using AR.LRP activity provided me with genuine learning experiences. 3. Using AR.LRP activity provided me with exceptional learning experiences. 4. Using AR.LRP activity provided me with unique learning experiences.	Kim, Lee, and Preis (2020)
e-learning performance	1. Using AR.LRP helps improving my academic performance. 2. AR.LRP helps me think through problems. 3. Most of the students bring a positive attitude or evaluation towards AR.LRP function. 4. AR.LRP helps students to get better e-learning services. 5. AR.LRP helps students to speed up their e-learning performance. 6. AR.LRP helps student to achieve their educational goal.	Wang et al. (2007)