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ORIGINAL ARTICLE

Development of educational virtual reality attitude scale: A validity and reliability study

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Abstract

The aim of the study is to address a gap in the literature by developing an educational virtual reality (edVR) attitude measurement instrument, which determines college students' attitudes towards using VR technology for educational purposes. A sequential exploratory mixed method was employed to develop the measurement instrument. Initially, a qualitative approach was used to establish the face and content validity of the instrument and subsequently a quantitative approach was used to test the construct validity and reliability of attitude statement items. Critical reviews and constructive feedback were gathered from a range of parties, including target users (i.e., college students), learning technology experts, assessment and evaluation authority, and linguists of English and Turkish. The psychometric properties of edVR attitude measurement instrument were tested with a total sample of 305 sophomore, junior and senior students studying at different faculties. The exploratory factor analysis (EFA) results confirmed the single-factor structure with nine items, explaining 63.46% of the total variance and the confirmatory factor analysis (CFA) results indicated a sufficient fit of this single-factor model. The Cronbach's alpha coefficient for the edVR attitude measurement instrument was 0.92 and the test–retest reliability of the instrument was 0.94. The t-values were significant for all items for 27% of the participants to compare the top and bottom. As a result, the edVR attitude measurement instrument was valid and reliable in measuring students' attitudes towards educational VR.

Keywords Virtual reality · Attitude · Virtual reality attitude instrument · Attitude towards virtual reality

1 Introduction

Information and communication technology (ICT) supports and facilitates learning. ICT has become a key part of learning environments, offering new learning opportunities to make learning tasks easier. The integration of emerging technologies in the classroom plays a key role in teaching and learning processes. Specifically, technology has the power to create an authentic learning environment that resembles a real-life situation in many aspects. In recent years, technological advances have contributed to the significant improvement of virtual reality (VR) technology that offers immersive simulated learning experiences. Even though VR has been utilized in many fields like the military, the advancement of VR technology and the dramatic drop in its price have led to attract educators' attention and become an educational tool (Bower et al. 2020; Huang et al. 2019).

VR provides real-time simulations that can be produced by three-dimensional computerized graphics to mimic real-world situations or to create fictional situations. Students are allowed to explore and interact with both simulated situations in which they perceive their bodies are present due to the advanced VR features (Radianti et al. 2020). Therefore, learning experiences become valued and high quality in terms of being authentic and interactive (Shu et al. 2019). VR creates interactive and engaging learning scenarios that are appropriate to students' needs to help them acquire new skills (Jensen and Konradsen 2018).

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VR is a powerful and motivative educational tool to deliver quality learning content for students to enable them to interact with virtual objects in the simulated world (Huang and Liaw 2018). The attractive atmosphere of virtual environments motivates students to be active learners to spend their time accomplishing learning tasks (Norris et al. 2019). Students also have the opportunity to gain hands-on learning experiences that allow the construction of their knowledge and skills in computer-generated authentic environments (Ustun et al. 2020). Although VR offers practical experiences within authentic contexts, the learning environment is risk-free and low cost for them to build and practice knowledge and skills (Norris et al. 2019). Retaining information and acquiring new skills are easier for students after they put what they have learned into practice in virtual environments (Krokos et al. 2019).

It is not guaranteed that the use of VR attracts students' attention to learning, engages them in the learning process and enhances their learning although VR technology has a great potential to facilitate learning in education. Many researchers have asserted that taking advantage of technologies relies on students' positive attitudes (Horzum and Gungoren 2012; Sezer and Yilmaz 2019; Yilmaz et al. 2021). While it is a crucial factor to determine students' attitudes toward the use of VR in education and training, there is a lack of a valid and reliable measurement tool to measure their attitude in the literature. Therefore, the aim of this study is to develop a VR attitude scale for the determination of students' attitudes toward the use of VR in education.

2 Related literature

2.1 Virtual reality

The roots of VR trace back to the early 1920s, although the recent advances in technology make VR an emerging trend. The adventure of VR begins with a primitive flight simulator and becomes a sophisticated worldwide product considered a technological revolution (Ustun et al. 2020). It is predicted that the market price of VR will be over 292 billion dollars and there will be over 337 million users in 2025, according to Huawei's global industry vision report (2019). Also, it is estimated that the VR market will go up to 1.3 trillion dollars in revenue by 2028 as indicated in the same report.

Pan et al. (2006) define VR as "the use of computer graphics systems in combination with various display and interface devices to provide the effect of immersion in the interactive 3D computer-generated environment" (p. 20). VR can also be defined as "a computer-generated simulation of a 3-D environment that users can interact with in a seemingly real or physical way using special electronic equipment, such as a helmet with a screen inside or gloves fitted with sensors" (Zhang et al. 2018, p. 138). These definitions emphasize a particular technological system that is capable of creating an interactive and immersive 3D virtual environment with computer-generated simulations. Users feel that they interact with simulated objects in this artificial virtual world like interacting in the real world. Because of this reason, experiencing this virtual environment is depicted by first-time users as an incredible experience (El Beheiry et al. 2019).

2.2 Educational use of virtual reality

After recent developments, VR systems' immersive and interactive features have made VR very attractive for educational purposes (Radianti et al. 2020; Zhang and Aslan 2020). Students are immersed in a simulated learning environment in which their feeling of being in the real world is disconnected and instead, they feel like being physically in a virtual world (Freina and Ott 2015). Teachers are willing to take advantage of the immersive feature of VR (Hanson and Shelton 2008) because this captivating virtual world engages them in learning activities by attracting students' attention (Norris et al. 2019). Jensen and Konradsen (2018) indicate that the immersive power of VR engages students in the learning tasks more and helps them acquire cognitive, emotional and physical skills better.

VR devices have unique interfaces that are designed to detect students' input and provide feedback on their commands instantaneously. This feature allows them to interact with virtual objects in the simulated world. Interaction enables them to use their multiple senses such as seeing, touching, and manipulating virtual objects (Huang et al. 2010). Engaging their sensorial channels that grabs their attention and promotes effective learning experiences enables them to easily and permanently build knowledge and skills (Ustun et al. 2020). They also interact with the teacher who acts as each student's tutor and they perceive that the whole class is designed according to their needs and expectations to facilitate their learning in an interactive learning environment (Alfadil 2020). As a result, interacting with each other, teacher and virtual objects allows them to explore, share, and build their own knowledge in the simulated environment.

VR can be used as a beneficial educational tool to allow students to find effective learning resources (Guttentag 2010) and enable them to draw on these resources without classroom distractions (Gadelha 2018). VR basically offers a positive learning atmosphere in which students are satisfied with the teaching and learning process. Gadelha (2018) states that VR has changed the way of learning by centering students in the teaching process. According to Huang and Liaw (2018), VR creates situated learning environments to improve students' critical thinking skills. They become active knowledge seekers in a user-friendly, realistic and immersive learning environment.

VR creates a safe learning environment for students to carry out specific tasks. Dangerous or risky situations can be simulated to provide opportunities for them to have practical experiences that are impossible or perilous to gain in real life. For instance, Çakiroğlu and Gökoğlu (2019) create a virtual environment to provide fire safety training for young students. Students acquire and improve behavioral skills to ensure fire safety without putting themselves at risk in their study. Similarly, although surgery training or combat training is potentially arduous and hazardous training in real life, VR generates realistic and safe virtual training scenarios in which students have enough opportunities to gain knowledge and skills while they complete dangerous tasks. Producing these scenarios is limitless except for VR designers' competence and imagination. Also, social and natural resources are almost not consumed to create these scenarios compared with real-life scenarios (Zhang et al. 2018).

2.3 Benefits and drawbacks of virtual reality

The use of VR has several advantages in the teaching and learning process (Ustun et al. 2022). First, VR provides an adaptable and flexible learning environment where students have learning opportunities according to unique needs and expectations. Norris et al. (2019) indicate that a virtual learning environment can be personalized to allow students to achieve tasks and skills better. Second, VR enables students to be repeatedly trained and practice until comprehending complicated tasks (Zhang and Aslan 2020). Medical students can practice clinical scenarios over and over again until developing confidence and acquiring skills for real-life operations (King et al. 2018). Aim et al. (2016) find that VR is an effective tool to improve technical skills in orthopedic surgery according to their comprehensive systematic review. Another benefit is that VR motivates students to focus on learning tasks. Students are motivated to learn because VR makes teaching and learning more interesting and fun (Chavez and Bayona 2018). The fourth benefit is the cost and time effectiveness of VR. VR provides cost-effective teaching approaches that improve learning outcomes (Makransky et al. 2016). Virtual scenarios can also be generated for students to practice unlimited times and these scenarios are not only generally time-consuming and costly to be constructed in real-life but also used generally only one time for practice in reality (Makransky and Lilleholt 2018; Zhang and Aslan 2020). Fifth, VR enhances communication. Uppot et al. (2019) have seen VR as an innovative means to communicate. For instance, journalists can benefit from VR to put their readers into stories (Markowitz and Bailenson 2019). The sixth benefit is that VR offers a safe learning environment where students can learn and rehearse dangerous tasks and improve their abilities for risky learning objectives. Although injuries and fatalities are possible in the real world to learn hazardous tasks when students fail to comply with instructions, they don't risk their health to learn hazardous tasks in VR learning environment that might not be replicated in an actual educational setting (Norris et al. 2019; Zhang and Aslan 2020). Lastly, VR is eco-friendly because it reduces material consumption. The use of VR is barely or no harm to the environment and consumes minimal social and natural resources (Zhang et al. 2018).

Although there are several benefits of utilizing VR in educational settings, teachers should realize the challenges of employing VR for learning instead of being enticed by dazzling VR environments because scholars are concerned about the challenges of using VR for educational purposes. The first disadvantage of VR is a lack of educational content although teachers commonly utilize VR content provided by the VR application market (Jensen and Konradsen 2018). Designing VR simulation is highly challenging because it requires highly professional programming skills (Huang et al. 2010). It is difficult to create a realistic or fictional model of a virtual environment and objects, program a virtual world to seamlessly work in different systems and create smooth interaction between a user and objects in a virtual environment (Zhang et al. 2018). Moreover, teachers might lack experience in utilizing VR in classroom settings. Using VR software might be difficult for them because using the software requires creating a profile, profile logins, updates, and purchasing apps and it could be challenging to incorporate VR apps in their pedagogical planning (Fransson et al. 2020). Teachers also lack time to plan how to adapt VR technology to teaching and learning processes (Alfalah 2018). Incorporating VR into educational settings can be time-consuming because it requires preparation for hardware and software systems. In addition to these challenges, VR might provide too much information at the same time so students might not be able to process the information. Makransky et al. (2019) reveal that VR apps exploit a high amount of working memory resources and effective learning can be obstructed because of cognitive overload. Another challenge is that using VR might cause dizziness, headaches and nausea. A feeling of motion sickness known as cybersickness is a common problem influencing a noteworthy percentage of VR users (Rebenitsch and Owen 2021). Lastly, in spite of the fact that today's VR technology is much more affordable than previous versions, it could still be costly for schools to afford. Fransson et al. (2020) state that the cost of VR is one of the challenges in using it for educational purposes.

2.4 Attitude toward virtual reality

One of the determinants of system acceptance is an individual's attitude toward the usage of the system (Huang and

Liaw 2018). In this sense, assessing student attitude toward VR as a learning tool is crucial because the attitude is a critical determinant of behavioral intentions (Fishbein and Ajzen 1975) and plays a significant role in increasing learning motivation (Huang and Liaw 2018). Similarly, student motivation to be involved in a learning experience affects her/his eagerness to accept and use VR as a learning tool (Guttentag 2010). The novelty of VR positively influences students' enthusiasm for utilizing state-of-the-art technology for learning (Makransky and Lilleholt 2018; Zhang and Aslan 2020), as their need for pleasure and entertainment is satisfied in the exciting simulated virtual environment (Verhagen et al. 2012). Thus, learners are likely to develop a positive attitude toward VR because the VR environment can be inherently intuitive and interesting (Shim et al. 2003). However, unfamiliarity with VR (Bower et al. 2020) might cause negative attitudes toward VR.

2.5 Purpose of the study

Extensive research has investigated technology acceptance in educational contexts. For example, applying the Unified Theory of Acceptance and Use of Technology (UTAUT) framework, Students' attitudes towards learning technologies affect their technology use behaviors and ultimately influence the learning outcomes (e.g., Alasmari and Zhang 2019; Huang and Liaw 2018). In this sense, benefitting from the advantage of VR for educational purposes ties into students' positive attitudes but their negative attitudes toward educational VR usage might result in underperforming. Therefore, it is critical to assess students' attitudes towards using VR for educational purposes or educational VR (edVR). But there is not a widely accepted measurement instrument that is valid and reliable to assess students' attitudes toward educational VR usage in educational research literature. The study aims to address this need by developing a measurement instrument to determine their attitude towards the use of VR in education.

3 Method

This study was conducted to develop an educational VR (edVR) attitude measurement instrument to determine the university students' attitudes towards the use of VR technology for educational purposes. Likert-type scales are based on self-report (Tezbaşaran 1997). The study followed standard steps to develop a Likert-type survey to measure students' attitudes towards educational virtual reality applications that they have use for various tasks. A sequential exploratory mixed method was employed to develop the instrument. Initially, a qualitative approach was used to establish the face and content validity of the instrument and subsequently a quantitative approach was used to test the construct validity and reliability of attitude statement items.

3.1 The edVR Attitude Instrument

The edVR attitude survey was created and developed through multiple phases with rigorous rounds of review and revisions, before it was implemented with the three groups of participants.

3.1.1 Phase 1

It started with a critical review of empirical studies on the use of VR for educational purposes. After multiple rounds of search and review of related literature; however, no edVR attitude or similar surveys were found. Then, extended searches and reviews were carried out to identify attitude surveys concerning digital technologies in educational research literature. A pool of scales was selected for review during this phase (e.g., Hernández-Ramos et al. 2014; Küçük et al. 2014; Yavuz 2005). Items in these surveys were carefully selected to formulate the edVR attitude scale. Studies investigating the general characteristics of attitude were examined (e.g., Edwards 1957; Korkmaz 2012; Taherdoost 2019) and selected items were added to the item pool. As a result of the extended literature review, an initial pool of 17 attitude statement items was created.

3.1.2 Phase 2

To ensure that the items would be clearly understood by participants, 11 college students with educational VR experience were invited to review the initial pool of items. They read each item carefully and articulated on what they thought each statement meant, and then discussed their thoughts, questions, and suggestions about each item. Then the items were revised for clarity, length, and language (e.g. reading level, appropriateness, etc.), according to their feedback. Items that were identified as too complicated, unclear, or identical were then removed from the initial pool. At the end of this phase, 15 items were retained after modifications, using a 5-point Likert scale with 1 being strongly disagree and 5 being strongly agree.

3.1.3 Phase 3

During this phase, construct validity, face validity and content validity were checked through expert reviews. Three experts of assessment and evaluation and three educational technology experts provided critical feedback on the 15 items. Based on the expert opinions, six items were removed and three items were modified. Thus, the edVR attitude survey was revised to include only nine items as a result of expert reviews.

3.1.4 Phase 4

Further, two linguists, one of English and one of Turkish reviewed the scale for linguistic assessment and revisions were made to refine the nine-item survey. After the revisions, a pilot study was conducted with 15 students (9 female and 6 male) to gather individual feedback and to test the time duration for completing the survey. A focused group interview followed afterwards for rich discussions on the clarity of the instructions and items. According to the feedback, unclear and vague texts were revised in the directions about the scale items and the instructions during the administration of the scale. The survey length was calculated by taking the average of the students' time to finish the questionnaire. The data obtained from this student group were not included in the main data set.

3.1.5 Phase 5

Lastly, the 9-item scale was shaped to its final form to be implemented in this study. The bilingual version of the instrument, in both Turkish and English is available in Appendix 1. Exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were performed with different groups of participants (see Table 1); and data analysis and results are reported in later sections.

3.2 Participants

This study aimed to develop a tool to determine users' attitudes towards educational VR. Thus, participants were purposefully recruited to include only students who had experienced VR for educational purposes. In 2021 fall semester, sophomore, junior and senior students at a public university in Turkey were recruited from the Faculty of Science, Faculty of Education, Faculty of Engineering and Faculty of Health Science. All participants had previous educational VR experiences. All data collection procedures were carried out in accordance with the ethical and professional standards of the university. Informed consent was obtained from all participants.

Table 1 Groups of participants in the study

Participant group	Statistical analyses conducted
First group (n = 171)	Exploratory Factor Analysis was performed
Second group (n = 103)	Confirmatory factor analysis was performed
Third group (n = 31)	Test–retest reliability of the scale was made

Participants were carefully selected to represent the diverse body of college students, reflecting the different levels of experience in educational VR, various academic backgrounds, and grade levels in college. The diversity of participants contributed to a better determination of the students' attitude towards VR for educational purposes. In addition, it strengthened the reliability of the study.

The research was carried out with three different participant groups. The first group had 171 undergraduate students, including 78 female and 93 male. Exploratory factor analysis (EFA) was performed on the data obtained from this group. The second participant group had 198 undergraduate students, including 103 female and 95 male. Confirmatory factor analysis (CFA) was performed on the data obtained from this group. In addition, Cronbach's alpha reliability coefficients were calculated and item analyzes were performed using all of the data obtained from the first and second groups (n = 369). The literature suggests that EFA and CFA should be performed using different samples (İlhan and Çetin, 2014). Therefore, EFA and CFA were performed on the data obtained from different participant groups.

The test–retest reliability was examined using the data of the third group. Test–retest reliability is a statistical method used to evaluate the stability and consistency of a test or measurement instrument over time. The test–retest reliability method involves applying the same test to the same group of individuals in two different situations and calculating the correlation between the scores from both tests. The aim of this procedure is to determine to what extent scores on a test are repeatable and consistent over time. A high coefficient of test–retest reliability indicates that the test is consistent and stable, while a low coefficient indicates that test scores may not be reliable and can vary greatly from one application to another. This method is often used in psychology and other social sciences to evaluate the reliability of measures such as surveys and other self-report tools. The sample size for test–retest reliability depends on several factors, such as the nature of the test or measurement instrument, the type of population and the level of precision desired for the reliability estimate. In general, a larger sample size is more likely to provide a more accurate and stable estimate of test–retest reliability, although in some cases a smaller sample size may still be sufficient. A sample size of at least 20 is acceptable for the Pearson correlation coefficient correlation analyses. However, this number may vary depending on the variability of scores and the expected level of correlation between the two test administrations. It is also important to note that a larger sample size is not always necessary to assess test–retest reliability. In some cases, a smaller sample size may be sufficient if test scores are fairly consistent and reliable or if the sample represents the studied population. In the research, the test scores were consistent and reliable so testing-retest reliability on 31 students would be sufficient.

Findings on test–retest reliability were given in the "Results" section. However, similar studies can be conducted on a larger sample group to examine the reproducibility of the results in future studies. As a result, originally there were 34 undergraduate students, but three students did not attend both sessions, so their data were excluded from the data set. Therefore, the third group had 31 undergraduate students, including 13 female and 18 male. The scale was applied to the third group for the first time and was administered twice at an interval of 3 weeks. Table 1 summarizes the information about the scale applied to the participant groups and the statistical analyses of the data obtained from these groups.

3.3 Data analysis

The psychometric properties of the scale were examined by various statistical analyses. First, EFA was performed on the data from the first group of participants. For EFA, the sample size requirement was met by the first group of 171 participants (Cattell 1978; Comrey & Lee 1992; Çokluk et al. 2012; Hair et al. 1979; Kline 1994). Also, the Kaiser-Mayer-Olkin (KMO) and the Bartlett tests were performed to check if the data set was suitable for factor analysis. The data set was suitable for factor analysis after having over 0.60 KMO values and the statistical significance of Bartlett's test (Büyüköztürk 2010).

EFA can be performed using multiple factorization techniques (Tabachnick and Fidell 2007); while principal component analysis is stronger than other analyses psychometrically (Stevens 1996). According to Akbulat (2010), principal component analysis should be the initial preference when deciding which factorization technique to use. Therefore, principal component analysis was used for factorization in this study.

A factor loading should be at least 0.30 in the relevant factor, in order to retain each item in the scale (Pallant 2005). In addition to the factor loading of each item, communality values (h2) of the measured variable were considered. Low communality values point out that the item needs to be ejected from the measurement tool. Using a cut-off value of 0.20 for communality is appropriate according to Tabachnick and Fidell (2007). For this reason, a cut-off value of 0.20 was used in this study.

CFA was performed to verify the results of EFA and to test the measurement model that was theoretically constructed. Significant $\chi 2$ values obtained from CFA showed that data did not confirm the theoretically constructed model. Moreover, standardized values and other fit indices were investigated as suggested by researchers (Byrne 2010; Hu and Bentler 1999; Kline 2011). Chi-square goodness of fit test, goodness of fit index (GFI), standardized root mean square (SRMR), Tucker–Lewis index (TLI), incremental fit index (IFI), normed fit index (NFI), comparative fit index (CFI) and root mean square error of approximation (RMSEA) were investigated for CFA in this study.

The reliability of the measurements using the edVR attitude instrument was tested by Cronbach's alpha and test–retest methods. Adjusted item-total correlations were computed to scrutinize the discriminative power of each item, and the bottom 27% and the top 27% of the participants were compared. EFA, test–retest reliability, Cronbach's alpha, fit validity and item analysis were made using SPSS 24.0 software package; and the AMOS 22.0 software package was used for CFA-related calculations.

4 Results

4.1 Construct validity

4.1.1 EFA

EFA was performed with the data obtained from the first group of participants. The KMO test was first conducted to determine if the requirement for sample size was met and Bartlett's test of sphericity was conducted to determine if the data set was suitable for factor analysis. The KMO value was found as 0.909, and Bartlett's test of sphericity was found as significant ($\chi 2(36)=1039.121$, $p=0.000$). The data set was suitable for EFA according to these results. Principal component analysis was performed with varimax rotation in order to reveal the factor pattern of the survey. The results of EFA is summarized in Table 2.

As shown in Table 2, a factor loading was over 0.30 in each of the 9 items. The common factor variance met the criterion of 0.20 in all items. The scale had one dimension, explained 63.466% of its variance, and consisted of 9 items with factor loadings varying between 0.69 and 0.88. The total variance of the survey instrument was 63.466%, which indicated that the survey was successful in explaining the

Table 2 EFA results of the edVR attitude instrument by item

Item	Factor	h^2
Item1	0.88	0.77
Item2	0.86	0.73
Item3	0.85	0.73
Item4	0.82	0.67
Item5	0.8	0.64
Item6	0.76	0.58
Item7	0.76	0.58
Item8	0.73	0.54
Item9	0.69	0.47
% eigenvalue (total = 5.712)		
% variance explained (total = 63.466)		

measured feature. Therefore, the EFA resulted in a single-factor structure with nine items.

4.1.2 CFA

Data from the second group were used to validate the single-factor, 9-item structure that emerged from EFA. The fit indexes of CFA for the survey instrument resulted in the following values: $\chi^2/df = 1.945$, CFI = 0.98, GFI = 0.95, AGFI = 0.91, IFI = 0.98, TLI = 0.97, RMSEA = 0.069 ve SRMR = 0.04. As shown in Table 3, fit indexes that were used to determine if the model is sufficiently fit with the data (Hooper et al. 2008; Hu and Bentler 1999; Kline 2005; Tabachnick and Fidell 2001) indicated values of an acceptable fit value and a perfect fit. As a result, the single factor model from CFA had sufficient fit.

The factor loadings for the single factor model derived from CFA are demonstrated in Fig. 1. As seen in Fig. 1, factor loadings varied between 0.54 and 0.83.

4.2 Item analysis

Adjusted item-total correlations were calculated to examine the discriminatory power of the items in the survey and their predictive power of the total score, and the bottom 27% and the top 27% of the participants were compared. The item analysis results are summarized in Table 4.

Table 4 shows that the t values of the difference between the upper 27% and the lower 27% of the participants varied between 15.75 and 25.68. The t-values were significant for all items for 27% of the participants to compare the top and bottom. Significant t values in comparisons between the lower and upper groups were accepted as evidence for the discriminatory power of the items (Erkuş, 2012). Item-total correlations varied between 0.60 and 0.80 as in the Table 4. Item-total correlations can be interpreted as having sufficient discriminatory power, if items are 0.30 and above 0.30 (Büyüköztürk 2010; Erkuş 2012). This requirement was met by all items. These results show that all items in the instrument had discriminatory power.

4.3 Interpretation of reliability and edVR attitude scores

Cronbach's alpha and test–retest methods were used to determine the reliability of the instrument. The Cronbach's alpha reliability coefficient of the one-dimensional scale was determined as 0.92. Considering that the reliability coefficients of 0.70 and above indicate reliable measurements (Fraenkel et al. 2012), the reliability coefficients were high in this study. The test–retest reliability of the survey instrument was 0.94. The edVR attitude measurement instrument consisted of 9 items gathered in a single dimension. A five-point Likert scale was used, ranging from 1 being strongly disagree to 5 being strongly agree. There was no item in the instrument that required the scores to be reversed. The total scores varied between 9 and 45, and the higher the total scores indicated more positive attitudes toward educational VR.

5 Discussion and conclusion

In this study, a simple to implement instrument was created and tested to measure college students' attitude towards the use of VR in education, using nine attitude statement items and a Likert scale of five. The initial items were drafted based on an extended review of research on educational technology attitudes. Multiple rounds of rigorous reviews and revisions were conducted to ensure the validity and reliability of the instrument. Critical reviews and constructive feedback were gathered from a range of parties, including target users (i.e., college students), learning technology experts, assessment and evaluation authority, and linguists of English and Turkish. Diverse methods were utilized in the multi-phase review and revision process, including individual reviews, focus group interviews, discussions, and one on one consultations.

The finalized nine-item instrument was then implemented with three different groups of participants and tested in varied analyses, such as EFA, CFA, and item analysis (see Table 1). The psychometric properties of edVR attitude

Table 3 Values of the goodness of fit index

	Fit indexes obtained	Perfect fit	Acceptable fit	Result
X^2/df	1.945	$0 \le \chi^2/df \le 3$	$3 < \chi^2/df \le 5$	Perfect
CFI	0.98	$0.95 \le CFI \le 1$	$0.90 \le CFI < .95$	Perfect
GFI	0.95	$0.95 \le GFI \le 1$	$0.90 \le GFI < .95$	Perfect
AGFI	0.91	$0.95 \le AGFI \le 1$	$0.90 \le AGFI < .95$	Acceptable
IFI	0.98	$0.95 \le IFI \le 1$	$0.90 \le IFI < .95$	Perfect
TLI	0.97	$0.95 \le TLI \le 1$	$0.90 \le TLI < .95$	Perfect
RMSEA	0.069	$0.00 \le RMSEA \le .05$	$0.05 < RMSEA \le .08$	Acceptable
SRMR	0.04	$0.00 \le SRMR \le .05$	$0.05 < SRMR \le .10$	Perfect

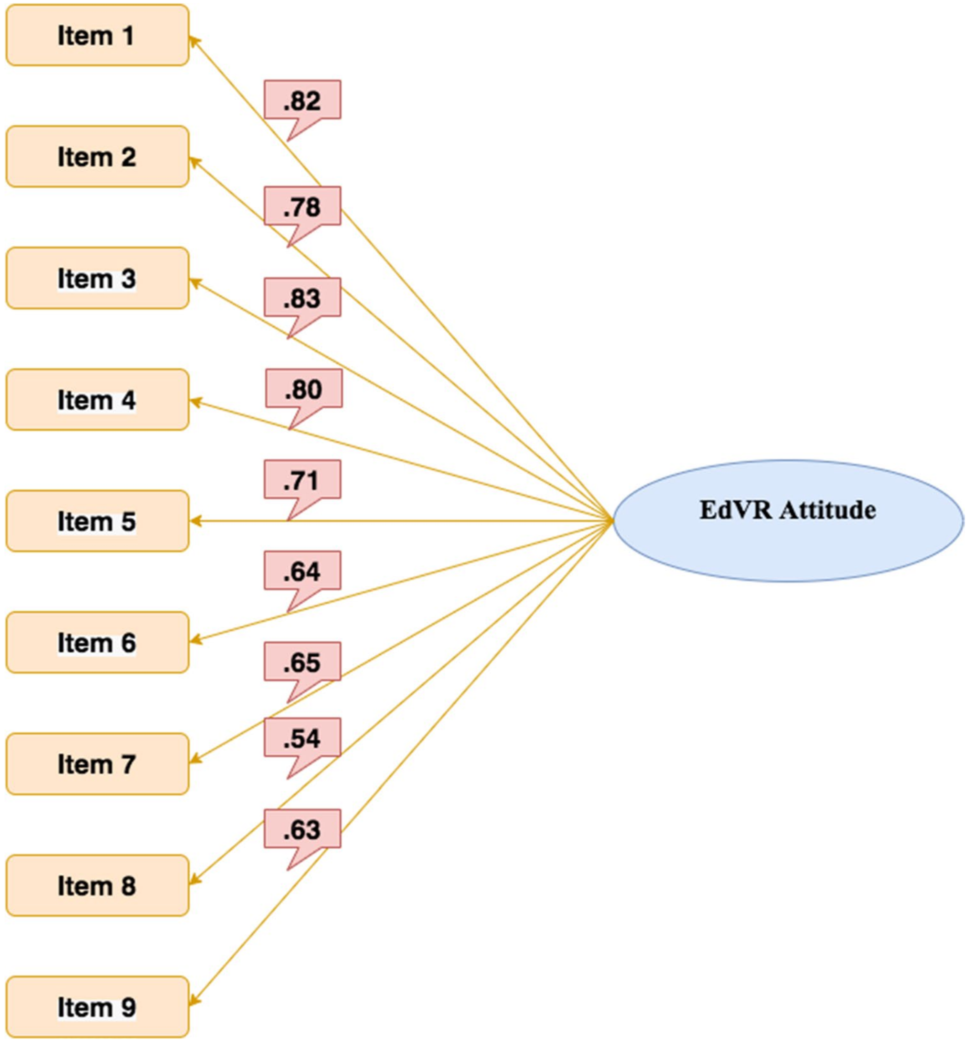

Fig. 1 Standardized solutions for the one-factor model of the edVR attitude instrument

Table 4 Item analysis results

Item	Cronbach's alpha if item deleted	Corrected item – total correlation	Mean	sd	t
1:Virtual reality increases my study efficiency	0.9	0.8	4.27	0.68	21.74*
2: Using virtual reality for learning boosts my productivity	0.9	0.78	4.32	0.64	22.84*
3: Using virtual reality increases my learning efficiency	0.9	0.78	4.34	0.61	25.68*
4: Using virtual reality for learning purposes helps my professional development	0.9	0.74	4.32	0.64	22.29*
5: I find using virtual reality beneficial for learning purposes	0.9	0.73	4.41	0.58	21.51*
6: I think it's a good idea to use virtual reality for learning purposes	0.91	0.67	4.41	0.56	20.45*
7: I will encourage people around me to use virtual reality for learning purposes	0.91	0.67	4.17	0.75	16.29*
8: Using virtual reality for learning is compatible with my professional perspective	0.91	0.6	4.25	0.74	15.75*
9: Using virtual reality for learning helps solve problems I encounter in learning	0.91	0.62	4.18	0.7	17.94*

*$p < .01$

measurement instrument were tested with a total sample of 305 college students. The EFA results confirmed the single-factor structure with nine items, explaining 63.46% of the total variance; and the CFA results indicated a sufficient fit of this single-factor model. The Cronbach's alpha coefficient for the edVR attitude measurement instrument was 0.92, and the test–retest reliability of the instrument was 0.94. The t-values were significant for all items for 27% of the participants to compare the top and bottom. The item analysis further affirmed that the instrument was successful in explaining the measured features with a high total variance, and each of the nine items had sufficient discriminatory power. All analyses confirmed the instrument was valid and reliable in measuring students' attitudes towards educational VR.

Students' positive attitudes are critical for the successful applications of learning technologies (Horzum and Gungoren 2012; Ustun and Tracey 2020; Sezer and Yilmaz 2019). With the emergence of VR in education, a valid and reliable instrument to measure students' attitudes is essential. The new edVR attitude instrument addresses this critical need. This new instrument is significant and promising with great potential in advancing the research and practice of VR in education. On the theoretical level, the edVR attitude instrument provides a lens to explore the key positive aspects of college students' attitudes towards VR in education, with a strong literature support (e.g., Alfadil 2020; Shim et al. 2003; Jensen and Konradsen 2018; Radianti et al. 2020; Zhang and Aslan 2020). Practically, this nine-item instrument is simple to administer, and the results are also easy to interpret. Thus, educators, administrators, and instructional designers could use this instrument to gather data at a scale, either before a VR initiative for baseline data or afterwards for evaluation purposes. Data gathered using this instrument will help build a good understanding of students' attitudes towards educational VR, which may inspire more creative thoughts on how to integrate VR for varied educational benefits. It could also be employed in pre- and post-test research design to measure attitude changes in educational VR studies. For students completing the instrument, the statements may stimulate critical reflections upon the educational applications of VR as well.

The edVR attitude instrument only focuses on the positive aspects, and it does not include any items concerning negative perceptions or attitudes. Thus, it is limited in its scope and purpose of use. In future research, it will be beneficial to extend the instrument with additional items regarding concerns, problems, and other negative attitudes towards educational VR. Implementing it with more participants, in other languages, or in other cultures will also help to further test the validity and reliability of this instrument.

Appendix 1 The EdVR Attitude Measurement Instrument in Turkish and English

Item No	Turkish version of the edVR attitude measurement instrument	English version of the edVR attitude measurement instrument
1	Sanal gerçekliği kullanmak çalışma verimliliğimi artırır	Virtual reality increases my study efficiency
2	Sanal gerçekliği öğrenme amaçlı kullanmak üretkenliğimi artırır	Using virtual reality for learning boosts my productivity
3	Sanal gerçekliği kullanmak öğrenme verimliliğimi artırır	Using virtual reality increases my learning efficiency
4	Sanal gerçekliği öğrenme amaçlı kullanmak mesleki performansımı geliştirir	Using virtual reality for learning purposes helps my professional development
5	Sanal gerçekliği öğrenme amaçlı kullanmayı faydalı görüyorum	I find using virtual reality beneficial for learning purposes
6	Sanal gerçekliği öğrenme amaçlı kullanmanın iyi bir fikir olduğunu düşünüyorum	I think it's a good idea to use virtual reality for learning purposes
7	Sanal gerçekliği öğrenme amaçlı kullanmaları için çevremdeki kişileri teşvik edeceğim	I will encourage people around me to use virtual reality for learning purposes
8	Sanal gerçeklik öğrenme amaçlı kullanımı benim mesleki anlayışıma uyuyor	Using virtual reality for learning is compatible with my professional perspective
9	Sanal gerçekliği öğrenme amaçlı kullanmak karşılaştığım problemleri çözmem konusunda kullanışlıdır	Using virtual reality for learning helps solve problems I encounter in learning

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Declarations

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