

ADAPTATION OF THE MEC SPATIAL PRESENCE QUESTIONNAIRE (MEC-SPQ) INTO TURKISH WITHIN THE SCOPE OF A VR-BASED PROTOTYPE FOR EARLY BREAST CANCER DIAGNOSIS AND SCREENING: A VALIDITY AND RELIABILITY STUDY

 **Nuran Akyurt**, Marmara University, Health Services Vocational School, İstanbul, Türkiye

 **Erem Akyurt Bal**, R&D, RSG Information Technologies, Health and Innovation Services Ltd., İstanbul, Türkiye

Corresponding Author : Nuran Akyurt, nakyurt@hotmail.com, nakyurt@marmara.edu.tr

Citation: Akyurt, N. & Akyurt Bal, E. (2025). Adaptation of the Mec Spatial Presence Questionnaire (Mec-Spq) Into Turkish Within the Scope of a Vr-Based Prototype for Early Breast Cancer Diagnosis and Screening: A Validity and Reliability Study. *İnönü Üniversitesi Sağlık Hizmetleri Meslek Yüksekokulu Dergisi*, 14(1), 14–37.

 [10.33715/inonusaglik.1654435](https://doi.org/10.33715/inonusaglik.1654435)

Received: April 28, 2025 / **Accepted:** September 25, 2025

Abstract

This study was conducted as part of the ethically approved project titled “Development of a Virtual Reality (VR)-Based Prototype for Early Breast Cancer Diagnosis and Screening.” The primary aim was to adapt the MEC Spatial Presence Questionnaire (MEC-SPQ) into Turkish and evaluate its psychometric properties within a VR-based health education setting. A total of 776 participants—including university students, health sciences students, and individuals from the general public—engaged in an interactive VR breast health education module and completed the MEC-SPQ and a demographic form. Internal consistency was assessed using Cronbach’s alpha ($\alpha = 0.987$), and construct validity was examined via Confirmatory Factor Analysis (CFA). CFA results showed high construct validity, with standardized factor loadings ranging from 0.596 to 0.926. Model fit indices indicated acceptable fit (CFI = 0.909, TLI = 0.905, RMSEA = 0.0612, SRMR = 0.0328). Concurrent validity was supported through correlations with related subdimensions. The results confirmed that the Turkish version of the MEC-SPQ is a valid and reliable instrument for measuring spatial presence in VR environments. Its integration into Turkish-language research contributes significantly to VR-based health education and to user-experience evaluation.

Keywords: Virtual Reality, Questionnaires, Breast Neoplasms, Health Education, Psychometrics.

INTRODUCTION

Virtual reality (VR) has advanced rapidly due to recent technological developments and is now widely applied not only to gaming but also to education, engineering, and healthcare. VR systems provide immersive virtual environments by integrating multi-sensory inputs, allowing users to navigate simulated spaces and interact with digital objects. These systems can be experienced through head-mounted displays (HMDs), desktop interfaces, or fully interactive simulations. In healthcare, VR is used for various therapeutic and educational purposes, including improving gait, balance, and proprioception in neurological, musculoskeletal, and orthopedic conditions, and managing pain. Additionally, VR technology has become an essential tool for educating the general public, healthcare students, and medical professionals. VR applications offer innovative solutions in areas such as clinical scenario simulations and patient education, while extensive research continues on its applications. The global medical education market is projected to grow by \$143.3 billion between 2021 and 2025, with VR being a key driving force behind this growth (TechNavio, 2021). The VR healthcare market, valued at \$2.1 billion in 2019, is expected to reach \$30.4 billion by 2026 (Verified Market Research, 2021).

VR is a technology that simulates real-world objects and events through three-dimensional multisensory experiences, allowing users to explore these environments at varying levels of immersion (Pottle, 2019; Nesenbergs, Abolins, Ormanis, & Mednis, 2021). Fully immersive VR enables complete detachment from the physical world using head-mounted displays and controllers, whereas semi-immersive VR connects the user to the virtual world but offers only partial interaction (Slater & Wilbur, 1997; Kyaw et al., 2019). While VR is increasingly used in health education, understanding how users cognitively and emotionally engage with virtual environments is essential to maximizing its effectiveness. One key concept in this context is spatial presence: the subjective experience of “being there” in virtual space. Measuring spatial presence helps evaluate the impact of VR applications on learning outcomes and user engagement. The MEC Spatial Presence Questionnaire (MEC-SPQ) is a validated instrument widely used for this purpose (Vorderer et al., 2004), yet a Turkish adaptation has not previously been available. This study aims to fill that gap by adapting the MEC-SPQ to Turkish and assessing its psychometric properties in the context of a VR-based breast health education prototype.

Studies Conducted with Virtual Reality

VR is increasingly being integrated into healthcare education, offering students the opportunity to experience and master various scenarios without putting patients or themselves at risk. When effectively implemented, VR technologies provide highly engaging learning activities and interactive simulations. However, implementation challenges remain, and the key to successful adoption lies in identifying barriers and facilitating factors and in developing strategies to overcome the barriers. In a study conducted by Hood et al. (2021) in Australia, the design, pilot application, and feasibility of a VR training platform were evaluated. Pilot testing in seven hospitals included pretests ($n = 61$) and posttests ($n = 58$) conducted via user surveys and recorded user sessions. Similarly, in a study conducted by Kunnskapsdepartementet (2021) in Norway, the effectiveness of head-mounted displays (HMDs) was assessed in a VR laboratory involving 27 healthcare professionals. This study highlighted the benefits of repeated practice in procedures, anatomy, and communication skills, whereas Wi-Fi connectivity issues and EU Professional Qualification Directive regulations were identified as significant barriers. Another study by

Saab, Hegarty, Murphy, & Landers (2021) examined the experiences of undergraduate nursing students regarding VR use. This qualitative study, involving 26 participants, used semi-structured interviews and focus group discussions. Findings indicated that VR is an effective supplementary tool for traditional teaching methods but is not suitable as a standalone learning method. Challenges such as high equipment costs, time constraints due to class sizes, physical limitations (e.g., vision problems, motion sickness), and the need for human resources were noted.

The study recommended that VR be implemented in small groups, with an instructor guiding students before, during, and after VR use. For medical students, the effective design and implementation of VR applications require user engagement (Saab et al., 2021). While VR may limit real patient interactions, real-world testing is recommended to assess training effectiveness (Hood et al., 2021). However, barriers such as equipment costs, content development challenges, organizational resistance, and lack of management support hinder widespread adoption (Baniasadi, Ayyoubzadeh, & Mohammadzadeh, 2020). To overcome these challenges, user-friendly VR approaches should be developed, legal regulations updated, and appropriate instructional models adopted (Barteit, Lanfermann, Bärnighausen, Neuhann

& Beiersmann, 2021). A literature review identified studies on VR in higher education but found no comprehensive systematic review specifically focusing on VR applications in healthcare education (Bracq, Michinov, & Jannin, 2019; Woon et al., 2021; Kyaw et al., 2019). Existing reviews have examined VR simulations for disaster preparedness (Jung, 2022), VR training protocols for dementia care (Yamakawa, Sung, & Tungpunkom, 2020), and AI applications in medical education (Chan & Zary, 2019).

However, a systematic review that addresses the challenges and facilitators of VR applications in healthcare education is lacking. For VR to be successfully integrated into education, preparing end-users beforehand, providing support during use, and conducting post-use assessments are critical (Baniyadi et al., 2021; Rim & Shin, 2021). Implementing Miller's Pyramid of Professional Competence ("see one, do one, teach one, simulate one") in VR training can enhance students' experiential learning (Barteit et al., 2021). To ensure effective training processes, comprehensive guidelines should be developed and suitable application areas identified (Rim & Shin, 2021). Supporting both educators and students throughout these processes facilitates the adoption of VR technology in education (Saab et al., 2021). In light of the increasing use of VR in healthcare education, the evaluation of users' perceptual and cognitive experiences within virtual environments has become essential. One

Such an experience is the sense of spatial presence, which refers to the user's psychological state of "being there" in the virtual space. To measure this construct, validated instruments such as the MEC Spatial Presence Questionnaire (MEC-SPQ) have been utilized in various domains, including media, gaming, and simulation research. However, no validated Turkish version of this instrument was available prior to this study. Considering the critical role of user presence in VR-based health training applications, the current research aims to adapt and validate the MEC-SPQ for use in Turkish contexts. The scale's integration into this project ensures a structured and reliable assessment of spatial presence, contributing to the design, evaluation, and implementation of more effective VR-based educational interventions.

Study Purpose and Scope

This study was conducted as part of the ethics-approved project titled "Development of a Virtual Reality (VR)-Based Prototype for Early Breast Cancer Diagnosis and Screening" and supported by the Research Universities Support Program (ADEP-ADT-2023-10809). The primary objective of the study is to adapt the MEC Spatial Presence Questionnaire (MEC-SPQ) into Turkish and evaluate its psychometric properties within the context of VR-based breast health education. The MEC-SPQ, developed by Vorderer et al. (2004), is a validated instrument designed to measure individuals' sense of presence in virtual environments. It is widely used in studies involving media experiences, simulations, and immersive learning, offering valuable insights into the effectiveness of VR-based educational and healthcare applications. Despite its relevance, no Turkish version of the MEC-SPQ has been available in the literature.

In this study, the MEC-SPQ was translated into Turkish, and its validity and reliability were examined. The analyses included assessments of linguistic equivalence, construct validity through Confirmatory Factor Analysis (CFA), internal consistency using Cronbach's alpha, and criterion validity via correlation with relevant measures. These findings contribute to the literature by introducing a culturally adapted and psychometrically robust instrument for evaluating spatial presence in VR environments. This scale can facilitate the development and evaluation of VR-based health-education and public-awareness initiatives among Turkish-speaking populations.

MATERIAL AND METHOD

This study was conducted within the scope of the project titled "Development of a Virtual Reality (VR)-Based Prototype for Early Diagnosis and Screening of Breast Cancer," supported by the ADEP program (Project Code: ADT-2023-10809). Purposive sampling methods were used to evaluate participants' experiences with VR-based educational content.

Ethical Considerations

Ethical approval was obtained from the Clinical Research Ethics Committee of a state university (approval date: 08/09/2023; protocol number: 09.2023.1111). Prior to data collection, all participants were informed about the nature of the study and provided both digital and written informed consent. The study was conducted in accordance with the principles outlined in the Declaration of Helsinki.

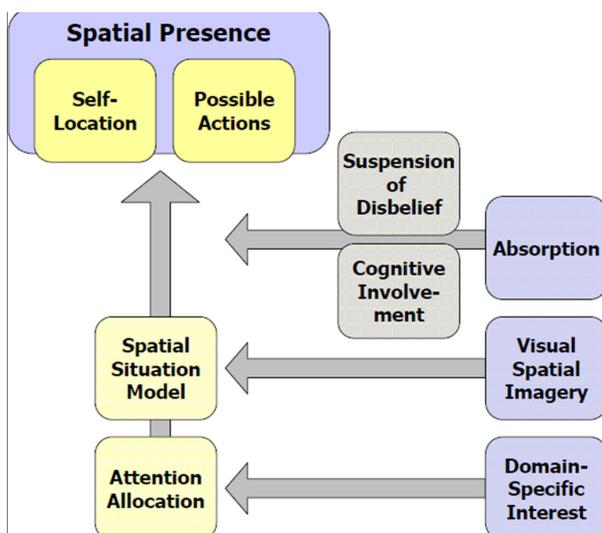
MEC Spatial Presence Questionnaire (MEC-SPQ): Theoretical Background and Structure

The Spatial Presence model, as conceptualized by Vorderer et al. (2004), defines the psychological experience in which users feel physically located within a virtual environment. This sense of presence is grounded in two core components: Self-Location, referring to the perception of being situated in the virtual space, and Possible Actions, denoting the awareness of interactive possibilities within that environment. These are supported by additional cognitive and affective processes, including attention allocation, spatial situation model, visual-spatial imagery, and domain-specific interest.

Immersive learning, a concept closely associated with spatial presence, highlights the impact of deep psychological and cognitive engagement in virtual settings on learning outcomes (Scoresby & Shelton, 2011; Dede, 2009). This immersive experience is often facilitated by head-mounted display (HMD) technologies, which track users' movements and deliver real-time interactive visual feedback (Han, 2020; Radianti, Majchrzak, Fromm, & Wohlgenannt, 2020). HMDs are widely used in virtual simulations and serious games to support knowledge acquisition, empathy development, and complex skill acquisition (Merchant, Goetz, Cifuentes, Keeney-Kennicutt, & Davis, 2014; Chittaro & Buttussi, 2015). Beyond their cognitive contributions, HMDs influence the semiotic aspects of digital communication by reshaping how users interpret and interact with virtual content (Barricelli, Gadia, Rizzi, & Marini, 2016). Despite these benefits, some research suggests that HMDs do not always lead to measurable improvements in performance and emphasizes the need for further empirical studies to identify optimal implementation conditions (Makransky, Terkildsen, & Mayer, 2019; Jensen & Konradsen, 2018). To objectively assess spatial presence, the Presence: MEC project developed the MEC Spatial Presence Questionnaire (MEC-SPQ). This instrument is based on spatial presence theory and was validated with 290 participants across Los Angeles, Helsinki, and Porto, using a dual-task paradigm (Vorderer et al., 2004; Witmer & Singer, 1998; Lessiter, Freeman, Keogh, & Davidoff, 2001). The scale evaluates both cognitive engagement and immersive experience in virtual environments.

The MEC-SPQ consists of seven subdimensions: (1) Attention Allocation (AA), which measures the focus of attention on the virtual environment; (2) Spatial Situation Model (SSM), referring to the mental representation of spatial structures; (3) Spatial Presence (SP), subdivided into Self-Location (SPSL) and Possible Actions (SPPA); (4) Suspension of Disbelief (SoD), which assesses the user's acceptance of the virtual experience despite potential inconsistencies and includes reverse-coded items; (5) Metacognitive Involvement (MI), reflecting the user's awareness and reflection during interaction; (6) Domain-Specific Interest (DSI), representing the user's interest in the content; and (7) Visual Spatial Imagery (VSI), which gauges the ability to mentally visualize virtual space. The structural relationship between these dimensions is illustrated in Figure 1.

Figure 1: Spatial Presence model and its subdimensions as structured in the MEC-SPQ framework. Source: Adapted from Vorderer, P., Wirth, W., Gouveia, F. R., et al. (2004). MEC Spatial Presence Questionnaire: Short Documentation and Instructions for Application. Project Presence: MEC (IST-2001-37661).



The questionnaire is available in 64-item, 48-item, and 32-item validated versions. Researchers can select the appropriate version based on their analytical needs and study objectives. As a validated instrument, the MEC-SPQ provides valuable insights into users' perceptions of presence and interaction quality in VR-based educational and healthcare applications. Rosenberg self-esteem scale (RSS)

Calculation of Sample Size

The minimum sample size required for the reliability and validity analyses of the MEC Spatial Presence Questionnaire (MEC-SPQ) was determined using the subject-to-item ratio method, commonly referred to as the N:p ratio. According to the criteria suggested by Bentler and Chou (1987), a minimum of 10 participants per item is recommended. Based on this guideline, the required sample size for the full version of the MEC-SPQ was calculated, and analyses were conducted on a total of 776 participants.

This sample size was deemed sufficient for conducting a two-tailed significance test for correlation coefficients with a 95% confidence level and 80% statistical power, assuming a large effect size as defined by Cohen (1988). The size and structure of the sample ensured robust statistical conditions for both the confirmatory factor analysis (CFA) and reliability testing procedures applied in this study.

Translation Process

1. Translation Process and Linguistic Adaptation

The translation and cultural adaptation of the MEC Spatial Presence Questionnaire (MEC-SPQ) into Turkish followed standard international guidelines. First, written permission was obtained from the original author of the scale. Then, the English version was independently translated into Turkish by two researchers proficient in both languages. These translations were compared in terms of semantic accuracy and conceptual consistency, and a single reconciled Turkish version was created.

To ensure linguistic accuracy, the finalized Turkish version was back-translated into English by two professional linguists who had no prior exposure to the original scale. The back-translated version was then compared with the original English form to assess conceptual and linguistic equivalence. As no major discrepancies were identified, no modifications were required at the end of the translation and back-translation process.

2. Linguistic Equivalence Studies

To assess linguistic equivalence, the English and Turkish versions of the MEC-SPQ were each administered to distinct groups of participants. In the first stage, the English version was administered to a group of undergraduate students, and test-retest reliability was assessed by re-administering the same version two weeks later. In the second stage, the Turkish version was administered to a group of 29 associate-degree students, followed by a retest with the same group after a two-week interval. Statistical analyses demonstrated a strong correlation between initial and retest scores, indicating temporal stability. Additionally, conceptual consistency between the English and Turkish versions was confirmed through comparison of item meanings and response patterns. Based on evaluations and feedback from three experts in health sciences and educational measurement ($n = 3$), no modifications were deemed necessary for the Turkish version of the scale.

3. Application of the Scale and Data Collection Process

The MEC Spatial Presence Questionnaire (MEC-SPQ) was administered to 776 participants to evaluate its construct validity and internal consistency. Participants were selected based on predefined inclusion criteria, and data were collected accordingly. All responses were recorded using a standardized data collection form and prepared for statistical analysis through appropriate software tools.

4. Validity and Reliability Analyses

To assess the construct validity of the Turkish version of the MEC-SPQ, confirmatory factor analysis (CFA) was conducted. Additionally, criterion-related validity was evaluated by calculating the correlation between MEC-SPQ

scores and those of a comparable scale designed to measure spatial presence. A moderate correlation was hypothesized and confirmed by the results. CFA was primarily conducted using AMOS (Analysis of Moment Structures), an SPSS-integrated software package that enables graphical modeling of latent constructs. Complementary statistical software packages, such as LISREL, Mplus, and R, were also utilized for structural equation modeling and model comparison. Based on the analysis results, the Turkish version of the MEC-SPQ demonstrated satisfactory levels of validity and reliability. Furthermore, the psychometric properties confirmed its cultural appropriateness for use in Turkish-speaking populations.

Prototype Design

This study employed three interactive virtual modules developed within the scope of the ADEP-supported project. The modules—“Structure of the Breast,” “Mammography Unit,” and “Breast Examination in CC Position”—were delivered via the MeduVR platform in a fully immersive virtual reality (VR) environment. The prototype design was aimed at maximizing users’ sense of spatial presence. VR goggles (head-mounted displays) provided immersive experiences via dual screens, integrated audio, and motion-tracking sensors. Users viewed 360-degree three-dimensional educational content by connecting their mobile phones or tablets to VR headsets. To ensure consistent performance, technical specifications were standardized across devices. Minimum device requirements included: a 6.3-inch screen, 64 GB of internal memory, a 3300 mAh battery, 6 GB of RAM, 12-MP camera, and a processor with a minimum configuration of 2.3 GHz and 1.7 GHz. The VR content was designed to be high-resolution, responsive to user movement, and visually aligned with the learning objectives. All components of the prototype were optimized to support effective delivery of VR-based educational material.

VR Application Process and System Design

This study was conducted using three interactive modules developed as part of the ADEP-supported project. The modules—“Structure of the Breast,” “Mammography Unit,” and “Breast Examination in CC Position”—were presented in a virtual reality (VR) environment. Participants experienced the training content using VR headsets in a quiet and distraction-free setting to support immersion and cognitive focus. Following the VR session, participants were given a short break before completing a questionnaire package administered via Google Forms. This package included a socio-demographic information form and the MEC Spatial Presence Questionnaire (MEC-SPQ), which was designed to assess participants’ perceived presence in the virtual environment. The MEC-SPQ was administered immediately after exposure to the VR content to capture real-time impressions. Participants were assured of anonymity, and items were presented in a randomized order to minimize response bias. The scale measured multiple constructs, including attention allocation, cognitive engagement, suspension of disbelief, spatial situation modeling, and perceived spatial presence. In addition, the Domain-Specific Interest (DSI) subscale was applied according to the study design and evaluated in conjunction with the other subdimensions. All responses were recorded using a 5-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree).

Inclusion and Exclusion Criteria

Participants were required to be between the ages of 18 and 69, to have the ability to read and understand Turkish, and to voluntarily agree to participate in the study. Individuals were not required to have prior VR experience. Eligible participants included university students, particularly those studying in health-related fields, as well as members of the general public. An additional inclusion criterion was the absence of sensory impairments, specifically vision or hearing loss, that could interfere with the VR experience. Participants who were unable to read or comprehend Turkish, or who had neurological or perceptual disorders (e.g., conditions affecting the vestibular system or visual processing) were excluded. Individuals with a history of severe dizziness or nausea associated with prior VR use were excluded for safety reasons. To ensure data quality and study validity, all participants provided digital informed consent. Only individuals who completed the scales in full and demonstrated understanding of the study procedures were included in the final analysis. The eligibility screening and consent processes were conducted with careful attention to ethical standards and participant safety.

Analysing the Data

To evaluate construct validity, Confirmatory Factor Analysis (CFA) was performed. CFA is used to test whether the data fit a hypothesized measurement model based on an established theoretical structure (Byrne, 2010). In this analysis, the significance of all t-values was interpreted as an indication that the individual items are meaningfully associated with the underlying latent factors and should be retained in the model. In addition to statistical significance, model fit indices were examined to assess the overall adequacy of the measurement model (Şimşek, 2007). Key fit indices (CFI, TLI, RMSEA, and SRMR) were used to assess model fit. To assess reliability, internal consistency coefficients, including Cronbach's alpha (α) and McDonald's omega (ω), were calculated. These coefficients were preferred due to the scale's multi-dimensional structure. Additionally, the item-total correlations were analyzed to assess each item's contribution to the scale's overall reliability

RESULTS

Table 1 shows the socio-demographic characteristics of the participants. Of the 776 participants, 9.4% were male, 90.6% were female, with an age range of 23.23–51.81 years ($X \pm SD = 37.52 \pm 14.29$ years). The proportion of participants with prior experience playing VR games was 25.4%, whereas 74.5% reported no prior experience. The percentage who have VR experience in their lessons is 34.1%, while 65.9% have no such experience. The percentage of those who liked the presented VR content was 86.6%, while the percentage of those who did not like it was 13.4%. During the VR experience, 23.8% of participants reported sweating, and 22.8% reported nausea. The rates of those who did not experience these symptoms were 76.2% and 77.2%, respectively. The demographic characteristics, prior VR experiences, and symptom-related responses of the participants were analyzed to evaluate the psychometric properties of the MEC Spatial Presence Questionnaire (MEC-SPQ). Analyses of internal consistency, construct validity, and concurrent validity were conducted, confirming the scale's reliability and validity. Table 1, titled "Demographic and Symptom-Related Characteristics of Participants," summarizes findings from 776 study participants. Of these participants, 9.4 percent were male and 90.6 percent were female. The participants' ages ranged from 23.23 to 51.81 years, with a mean of 37.52 years and a standard deviation of 14.29 years. Regarding prior virtual reality experience, 25.4 percent had used VR for gaming, while 74.5 percent had not used VR for gaming. Regarding educational exposure, 34.1% had experienced VR in an academic setting, whereas 65.9% had not. Additionally, 86.6 percent of participants reported that they liked the VR content presented in this study, while 13.4 percent did not. Symptom-related data collected during the VR session indicated that 23.8 percent of participants experienced sweating and 22.8 percent experienced nausea. In contrast, 76.2 percent reported no sweating and 77.2 percent reported no nausea during the experience.

Table 1. Demographic and Symptom-Related Characteristics of Participants

Statements		Frequency	Per cent
Age ($\bar{X} \pm SD$)h		37,52 \pm 14,29	
Gender	Male	73	9,4
	Woman	703	90,6
Education Level	Primary Education	254	32,7
	High School	160	20,6
	Associate Degree	190	24,5
	Bachelor's Degree	161	20,7
	Above Undergraduate	11	1,5
Profession	Housewife	320	41,2
	Pensioner	49	6,3
	Special Sek	85	11
	Public Official	97	12,5
	Student	225	29
Marital Status	Single	321	41,4
	Married	455	58,6
I've Played Virtual Reality (VR) Games Before	Yes	197	25,4
	No	579	74,6
I have experienced Virtual Reality (VR) in my lessons.	Yes	265	34,1
	No	511	65,9
Did you like the content of the virtual environment presented to you?	Yes	672	86,6
	No	104	13,4
Did You Feel Sweating During Virtual Reality Experience?	Yes	185	23,8
	No	591	76,2
	Total	776	100

Construct Validity of the MEC-SPQ Scale: Confirmatory Factor Analysis (CFA) Results for 64-, 48-, and 32-Item Forms

The construct validity of the Turkish version of the MEC Spatial Presence Questionnaire (MEC-SPQ) was assessed through Confirmatory Factor Analysis (CFA) for the 64-, 48-, and 32-item forms. For the 64-item version, standardized factor loadings ranged from 0.596 to 0.926, indicating a generally strong factor structure. Subdimensions such as Attention Allocation, Spatial Situation Model, Self-Positioning, Possible Actions, and Cognitive Involvement exhibited high loadings (0.759–0.926), supporting their contribution to the latent structure. Although the Suspension of Disbelief (SoD) subdimension showed relatively low loadings on a few items, the Absorption and Visual Spatial Imagery dimensions demonstrated robust structural validity. All *t* values were statistically significant ($p < .001$), confirming that each item contributed meaningfully to its corresponding latent factor. Therefore, no items were removed. Model fit indices further supported the adequacy of the structure: CFI = 0.909, TLI = 0.905, RMSEA = 0.0612, and SRMR = 0.0328. These results provide strong evidence for the construct validity of the Turkish adaptation of the MEC-SPQ. Detailed factor loadings and fit statistics are presented in Table 2.

Table 2. Confirmatory Factor Analysis (CFA) Results for the Construct Validity of the MEC-SPQ Scale: Standardized Factor Loadings and Model Fit Indices

Factor	Item	SE	Z	p	Stand. Estimate
Factor 1	AA1	0.0386	25.3	< .001	0.773
	AA2	0.0379	29.2	< .001	0.849
	AA3	0.0377	29.0	< .001	0.846
	AA4	0.0387	25.4	< .001	0.774
	AA5	0.0374	30.9	< .001	0.879
	AA6	0.0392	25.9	< .001	0.785
	AA7	0.0389	25.4	< .001	0.775
	AA8	0.0378	26.8	< .001	0.805
Factor 2a	SSM1	0.0388	28.5	< .001	0.833
	SSM2	0.0369	29.5	< .001	0.851
	SSM3	0.0380	31.0	< .001	0.878
	SSM4	0.0379	31.9	< .001	0.893
	SSM5	0.0363	32.3	< .001	0.900
	SSM6	0.0370	30.6	< .001	0.872
	SSM7	0.0368	29.4	< .001	0.850
	SSM8	0.0372	31.0	< .001	0.877
Factor 2b	SPSL1	0.0378	30.6	< .001	0.870
	SPSL2	0.0380	30.8	< .001	0.874
	SPSL3	0.0387	31.2	< .001	0.881
	SPSL4	0.0371	31.8	< .001	0.890
	SPSL5	0.0372	31.8	< .001	0.891
	SPSL6	0.0363	31.6	< .001	0.887
	SPSL7	0.0376	31.3	< .001	0.882

	SPSL8	0.0372	32.4	< .001	0.900
Factor 3	SPPA1	0.0370	32.8	< .001	0.906
	SPPA2	0.0372	33.4	< .001	0.916
	SPPA3	0.0370	32.8	< .001	0.906
	SPPA4	0.0374	32.6	< .001	0.903
	SPPA5	0.0358	33.7	< .001	0.921
	SPPA6	0.0365	33.3	< .001	0.914
	SPPA7	0.0380	31.7	< .001	0.888
	SPPA8	0.0384	30.4	< .001	0.865
Factor 4	HC1	0.0376	31.5	< .001	0.885
	HC2	0.0365	31.7	< .001	0.889
	HC3	0.0362	31.7	< .001	0.889
	HC4	0.0367	31.5	< .001	0.885
	HC5	0.0364	32.5	< .001	0.902
	HC6	0.0360	34.0	< .001	0.926
	HC7	0.0390	30.1	< .001	0.862
	HC8	0.0391	28.5	< .001	0.832
Factor 5	SD1	0.0396	24.4	< .001	0.759
	SD2	0.0382	17.7	< .001	0.596
	SD3	0.0380	23.3	< .001	0.735
	SD4	0.0401	20.2	< .001	0.662
	SD5	0.0375	18.6	< .001	0.621
	SD6	0.0392	26.4	< .001	0.802
	SD7	0.0397	18.9	< .001	0.630
	SD8	0.0419	23.1	< .001	0.733
Factor 6	DS1	0.0368	30.5	< .001	0.869
	DS2	0.0363	31.4	< .001	0.885
	DS3	0.0364	30.8	< .001	0.874
	DS4	0.0371	31.3	< .001	0.884
	DS5	0.0369	30.6	< .001	0.871
	DS6	0.0360	31.6	< .001	0.889
	DS7	0.0377	29.5	< .001	0.851
	DS8	0.0374	26.8	< .001	0.800
Factor 7	VSI1	0.0391	29.3	< .001	0.848
	VSI2	0.0385	30.8	< .001	0.876
	VSI3	0.0375	32.2	< .001	0.899
	VSI4	0.0381	31.2	< .001	0.883
	VSI5	0.0387	31.7	< .001	0.890
	VSI6	0.0381	31.8	< .001	0.892
	VSI7	0.0401	29.1	< .001	0.845
	VSI8	0.0390	29.4	< .001	0.852

Model Fit and Reliability Analysis

According to the results of Confirmatory Factor Analysis (CFA), all items in the model were statistically significant ($p < .001$), confirming their contribution to the corresponding latent constructs. Consequently, no items were excluded from the scale. The overall model fit was evaluated using widely accepted fit indices. The Comparative Fit Index (CFI = 0.909) and the Tucker–Lewis Index (TLI = 0.905) both exceeded the threshold of 0.90, indicating acceptable model fit. The Root Mean Square Error of Approximation (RMSEA = 0.0612; 90% CI: 0.0598–0.0627) reflected a good fit, as did the Standardized Root Mean Square Residual (SRMR).

(= 0.0328) showed a low level of residual error. These indicators collectively support the structural adequacy of the Turkish version of the MEC-SPQ. Detailed model fit indices are presented in Table 3.

Table 3. Confirmatory Factor Analysis (CFA) Fit Indices and Goodness-of-Fit Values for the MEC-SPQ

CFI	TLI	SRMR	RMSEA	RMSEA 90% CI		AIC	BIC
				Lower	Upper		
0.909	0.905	0.0328	0.0612	0.0598	0.0627	112118	113142

Following the model fit analysis, internal consistency was assessed using Cronbach's alpha (α) and McDonald's omega (ω) coefficients. As shown in Table 4, the Cronbach's α coefficient for the overall scale was 0.987, and the McDonald's ω coefficient was 0.989, both of which indicate excellent reliability. The mean item score was 2.65 (SD = 0.97), reflecting substantial variability across participants and among items. Internal consistency values above 0.97 suggest that the scale has high homogeneity and can reliably measure spatial presence in virtual reality contexts.

Table 4. Overall Reliability Coefficients of MEC-SPQ Scale (Cronbach's α and McDonald's ω)

Mean	SD	Cronbach's α	McDonald's ω
2.65	0.970	0.987	0.989

Item-Level Reliability Results

Item-level reliability analyses were conducted to assess the internal consistency of the scale. For each item, the mean score, standard deviation (SD), item-total correlation (item-rest correlation), and reliability coefficients assuming item deletion (Cronbach's α and McDonald's ω) were calculated. Item-total correlations ranged from 0.50 to 0.88, indicating moderate-to-high associations between individual items and the overall scale. Notably, items in the subdimensions of Possible Actions (SPPA), Cognitive Involvement (HC), and Domain-Specific Interest (DS) showed item-total correlations above 0.85, suggesting strong internal consistency within these subdimensions.

The overall internal consistency of the Turkish version of the MEC-SPQ was excellent. Cronbach's α (0.987) and McDonald's ω (0.989) were well above the 0.90 threshold, demonstrating high reliability. The item means were approximately 2.65, with a standard deviation of 0.97, indicating that participant responses were adequately dispersed across the Likert scale. These findings support the conclusion that the Turkish version of the MEC-SPQ is a reliable instrument for measuring spatial presence in virtual reality environments. Detailed item-level statistics are presented in Table 5.

Table 5. Reliability and Validity Analysis Results of MEC-SPQ Scale at Item Level

	Mean	SD	Item-rest correlation	If item dropped	
				Cronbach's α	McDonald's ω
AA1	2.65	1.26	0.702	0.987	0.989
AA2	2.58	1.30	0.775	0.987	0.989
AA3	2.49	1.29	0.785	0.987	0.989
AA4	2.44	1.27	0.692	0.987	0.989
AA5	2.57	1.32	0.799	0.987	0.989
AA6	2.29	1.29	0.725	0.987	0.989
AA7	2.21	1.27	0.694	0.987	0.989
AA8	2.33	1.26	0.751	0.987	0.989
SSM1	2.55	1.33	0.823	0.987	0.989
SSM2	2.45	1.28	0.811	0.987	0.989
SSM3	2.73	1.34	0.819	0.987	0.989
SSM4	2.80	1.35	0.820	0.987	0.989
SSM5	2.74	1.30	0.832	0.987	0.989
SSM6	2.67	1.30	0.814	0.987	0.989
SSM7	2.59	1.27	0.801	0.987	0.989
SSM8	2.64	1.31	0.836	0.987	0.989
SPSL1	2.64	1.33	0.848	0.987	0.989
SPSL2	2.68	1.34	0.849	0.987	0.989
SPSL3	2.67	1.37	0.839	0.987	0.989
SPSL4	2.56	1.32	0.848	0.987	0.989
SPSL5	2.54	1.33	0.839	0.987	0.989
SPSL6	2.47	1.29	0.842	0.987	0.989
SPSL7	2.55	1.34	0.837	0.987	0.989
SPSL8	2.67	1.34	0.862	0.987	0.989
SPPA1	2.62	1.34	0.870	0.987	0.989
SPPA2	2.67	1.36	0.872	0.987	0.989
SPPA3	2.66	1.34	0.867	0.987	0.989
SPPA4	2.58	1.35	0.858	0.987	0.989
SPPA5	2.58	1.31	0.880	0.987	0.989
SPPA6	2.62	1.33	0.871	0.987	0.989
SPPA7	2.66	1.36	0.862	0.987	0.989
SPPA8	2.56	1.35	0.848	0.987	0.989
HC1	2.67	1.34	0.851	0.987	0.989
HC2	2.56	1.30	0.850	0.987	0.989
HC3	2.64	1.29	0.859	0.987	0.989
HC4	2.57	1.30	0.841	0.987	0.989
HC5	2.61	1.31	0.861	0.987	0.989
HC6	2.58	1.32	0.884	0.987	0.989
HC7	2.68	1.36	0.836	0.987	0.989
HC8	2.66	1.34	0.833	0.987	0.989
SD1	3.54	1.27	0.691	0.988	0.990
SD2	2.18	1.14	0.531	0.987	0.989
SD3	2.36	1.20	0.637	0.987	0.989
SD4	2.29	1.22	0.554	0.987	0.989

SD5	2.19	1.12	0.533	0.987	0.989
SD6	3.38	1.29	0.761	0.989	0.990
SD7	2.32	1.19	0.500	0.987	0.989
SD8	2.51	1.32	0.721	0.987	0.989
DS1	2.62	1.29	0.843	0.987	0.989
DS2	2.66	1.29	0.862	0.987	0.989
DS3	2.47	1.28	0.820	0.987	0.989
DS4	2.53	1.32	0.823	0.987	0.989
DS5	2.59	1.30	0.809	0.987	0.989
DS6	2.58	1.28	0.819	0.987	0.989
DS7	2.53	1.30	0.793	0.987	0.989
DS8	2.35	1.25	0.736	0.987	0.989
VSI1	2.91	1.35	0.676	0.987	0.989
VSI2	3.04	1.36	0.663	0.987	0.989
VSI3	3.06	1.34	0.704	0.987	0.989
VSI4	3.19	1.35	0.651	0.987	0.989
VSI5	3.14	1.38	0.631	0.987	0.989
VSI6	3.15	1.36	0.651	0.987	0.989
VSI7	3.31	1.38	0.621	0.987	0.989
VSI8	3.21	1.35	0.652	0.987	0.989

Confirmatory Factor Analyses for the 48- and 32-Item Forms

Confirmatory Factor Analysis (CFA) results for the 48-item and 32-item versions of the Turkish adaptation of the MEC Spatial Presence Questionnaire (MEC-SPQ) provide strong support for the scale's construct validity. For the 48-item form, standardized factor loadings ranged from 0.750 to 0.920; for the 32-item form, they ranged from 0.736 to 0.931. These values demonstrate that items loaded strongly on their intended latent variables across both forms. Model fit indices for both versions indicated acceptable to good fit: Comparative Fit Index (CFI = 0.957), Tucker–Lewis Index (TLI = 0.951), Root Mean Square Error of Approximation (RMSEA = 0.0574), and Standardized Root Mean Square Residual (SRMR = 0.0281). Internal consistency measures were similarly high, with Cronbach's alpha ($\alpha = 0.969$) and McDonald's omega ($\omega = 0.975$) exceeding the generally accepted thresholds for reliability. Item-total correlations were mostly above 0.70, confirming the homogeneity of the items and their contribution to the overall construct

CFA Diagrams and Factor Structure Visualization

Figure 2 (Diagrams A, B, and C) presents the CFA models for the 64-, 48-, and 32-item versions of the MEC-SPQ, respectively. Each figure illustrates the latent factor structure (labeled Fc1–Fc7) and the relationships between items and their corresponding subdimensions: Attention Allocation (AA), Spatial Situation Model (SSM), Self-Location (SPSL), Possible Actions (SPPA), Cognitive Involvement (HC), Suspension of Disbelief (SoD), Domain-Specific Interest (DS), and Visual Spatial Imagery (VSI).

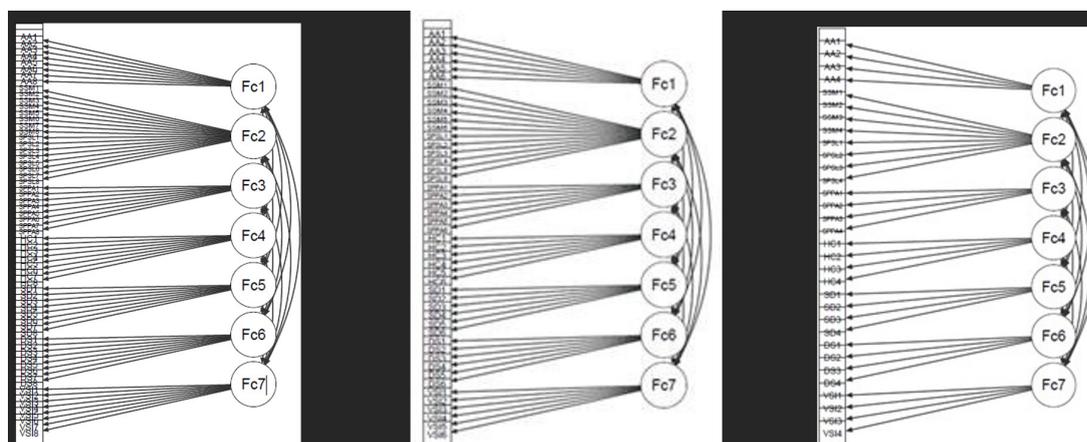


Figure 2. CFA Diagrams A: 64 items, B: 48 items, C: 32 items

Diagrams A, B, and C illustrate the confirmatory factor analysis (CFA) models for the 64-item, 48-item, and 32-item versions of the MEC-SPQ scale, respectively. These diagrams depict the relationships between observed variables and their underlying latent factors. Subdimensions such as Spatial Situation Model (SSM), Self-Location (SPSL), and Possible Actions (SPPA) consistently displayed strong factor loadings, reinforcing the theoretical framework of the scale. In addition, the observed inter-factor correlations suggest a coherent structure across subdimensions. Taken together, the visual models and statistical results demonstrate that the Turkish adaptation of the MEC-SPQ is psychometrically sound across all three forms, supporting its use in virtual reality-based educational and experiential contexts.

DISCUSSION

This study examined the Turkish adaptation of the MEC Spatial Presence Questionnaire (MEC-SPQ), focusing on its construct validity and reliability within a virtual reality (VR)-based health education context. The MEC-SPQ is widely recognized as a valid tool for measuring spatial presence in immersive media environments (Vorderer et al., 2004). Confirmatory Factor Analysis (CFA) results demonstrated that the Turkish version of the scale retained the theoretical structure of the original, with standardized factor loadings ranging from 0.596 to 0.926 across subdimensions. In particular, the subdimensions of Attention Allocation (AA), Spatial Situation Model (SSM), Self-Location (SPSL), Possible Actions (SPPA), and Cognitive Involvement (HC) showed strong factor loadings, supporting the robustness of the scale. While some items within the Suspension of Disbelief (SoD) dimension exhibited relatively lower loadings, subdimensions such as Domain-Specific Interest (DS) and Visual Spatial Imagery (VSI) maintained strong contributions to the model. Model fit indices— $\chi^2(1924) = 7527$, CFI

CFI = 0.909, TLI = 0.905, RMSEA = 0.0612, and SRMR = 0.0328 indicated an acceptable model fit according to widely accepted thresholds (Hu & Bentler, 1999). Internal consistency measures were also excellent, with Cronbach's $\alpha = 0.987$ and McDonald's $\omega = 0.989$. Item-total correlations ranging from 0.50 to 0.88 support the homogeneity of the scale, especially in the SPPA, HC, and DS dimensions, where values exceeded 0.85, and further validate the internal structure of the scale. This study also evaluated the physical effects of VR exposure. Of the participants, 23.8% reported sweating and 22.8% experienced nausea during the VR session. These results align with existing findings on cybersickness and sensory conflict in immersive environments (LaViola, 2000; Keshavarz & Hecht, 2011) and highlight the importance of monitoring physical tolerance during VR implementation in educational settings.

A major strength of this study is the large sample size ($N = 776$), which includes both VR-experienced and VR-naive individuals, thereby allowing broader generalizability across user types. However, the use of a single VR content module represents a limitation. Future studies should test the Turkish version of the MEC-SPQ across various VR applications and healthcare topics to further establish its cross-contextual validity.

Strengths and Limitations of the Turkish Validity and Reliability Study of the MEC-SPQ Scale

This study evaluated the validity and reliability of the Turkish adaptation of the MEC-SPQ scale to assess the sense of spatial presence in VR-based breast health training. With a large sample of 776 participants from different age groups, educational levels, and occupational groups, the generalizability of the findings was strengthened. The inclusion of individuals with and without prior VR experience allowed testing of the scale's applicability across a range of user profiles. The study's strengths include the use of a VR scenario specifically designed for breast health education, the evaluation of physical responses (e.g., nausea, sweating) during VR exposure, and the meticulous adherence to ethical standards throughout the consent and data collection processes.

However, some limitations should be noted. The scale was tested using only a single VR scenario, which may limit the generalizability of results to other content areas. In addition, the assessment was based on self-report measures, which may be subject to response bias. Although the sample included participants from different educational backgrounds and VR experience levels, subgroup comparisons (e.g., VR-experienced vs. VR-naive individuals or comparisons between educational groups) were not conducted, as the primary aim of the study was to evaluate the psychometric properties of the Turkish version of the scale. Future studies should address this by incorporating statistical group comparisons and expanding the scope of VR content across different healthcare domains.

RESULT

In conclusion, this study demonstrates that the Turkish version of the MEC Spatial Presence Questionnaire (MEC-SPQ) is a valid and reliable instrument for measuring spatial presence in VR-based health education contexts. The confirmatory factor loadings and model fit indices support the robustness of the scale's factorial structure. The scale was effectively applied to a diverse sample including university students, health science students, and members of the general public. While this study relied on self-report data, future research could enhance the validation process by incorporating objective physiological measures (e.g., eye tracking, heart rate) to assess spatial presence more comprehensively.

Declarations Ethics approval and consent to participate

Written informed consent was obtained, and the study adhered to the Declaration of Helsinki, with approval from the Clinical Research Ethics Committee (approval date: 08/09/2023, Protocol no: 09.2023.1111).

Competing interests

The authors declare that they have no conflict of interest.

Funding

This study was financially supported by the Council of Higher Education – University Research Universities Support Program (Project ID: 10809; Project Code: ADT-2023-10809), as was publicly announced on the official website of the Council of Higher Education. The MeduVR digital platform, which served as a core component of this project, was developed under this funding program. The preparation of digital educational content was carried out by RSG Information Technologies, Health and Innovation LLC, based in Istanbul, Turkey, and supported by the same funding source. Additionally, the study benefited from support provided by TÜBİTAK under the 1002-B Short-Term R&D Funding Program (Project No: 125S286).

REFERENCES

- Baniasadi, T., Ayyoubzadeh, S. M., & Mohammadzadeh, N. (2020). Challenges and practical considerations in applying virtual reality in medical education and treatment. *Oman Medical Journal*, 35(3), e125. <https://doi.org/10.5001/omj.2020.43>
- Barricelli, B. R., Gadia, D., Rizzi, A., & Marini, D. L. R. (2016). Semiotics of virtual reality as a communication process. *Behaviour & Information Technology*, 35(11), 879–896.
- Barteit, S., Lanfermann, L., Bärnighausen, T., Neuhann, F., & Beiersmann, C. (2021). Augmented, mixed, and virtual reality-based head-mounted devices for medical education: Systematic review. *JMIR Serious Games*, 9(3), e29080. <https://doi.org/10.2196/29080>
- Bentler, P. M., & Chou, C. P. (1987). Practical issues in structural modeling. *Sociological Methods & Research*, 16(1), 78-117. <https://doi.org/10.1177/0049124187016001004>
- Bracq, M. S., Michinov, E., & Jannin, P. (2019). Virtual reality simulation in nontechnical skills training for healthcare professionals: A systematic review. *Simulation in Healthcare*, 14(3), 188-194. <https://doi.org/10.1097/SIH.0000000000000347>
- Büyüköztürk, Ş., Kılıç-Çakmak, E., Akgün, Ö. E., Karadeniz, Ş., & Demirel, F. (2021). *Bilimsel Araştırma Yöntemleri* (29. baskı). Ankara: Pegem Akademi Yayıncılık.
- Chan, K. S., & Zary, N. (2019). Applications and challenges of implementing artificial intelligence in medical education: Integrative review. *JMIR Medical Education*, 5(1), e13930. <https://doi.org/10.2196/13930>
- Chittaro, L., & Buttussi, F. (2015). Assessing knowledge retention of an immersive serious game vs. a traditional education method in aviation safety. *IEEE Transactions on Visualization and Computer Graphics*, 21(4), 529–538. <https://doi.org/10.1109/tvcg.2015.2391853>
- Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). New York: Routledge. <https://doi.org/10.4324/9780203771587>
- Dede, C. (2009). Immersive interfaces for engagement and learning. *Science*, 323(5910), 66–69.
- DeVellis, R. F., & Thorpe, C. T. (2017). *Scale development: Theory and applications* (4th ed.). CA: Sage Publications.
- Han, I. (2020). Immersive virtual field trips in education: A mixed-methods study on elementary students' Presence and perceived learning. *British Journal of Educational Technology*, 51(2), 420–435.
- Hood, R. J., Maltby, S., Keynes, A., Kluge, M. G., Nalivaiko, E., Ryan, A., ... Walker, F. R. (2021). Development and pilot implementation of TACTICS VR: A virtual reality-based stroke management workflow training application and training framework. *Frontiers in Neurology*, 12, 665808. <https://doi.org/10.3389/fneur.2021.665808>
- Hu, L.-t., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling*, 6(1), 1–55. <https://doi.org/10.1080/10705519909540118>
- Jensen, L., & Konradsen, F. (2018). A review of the use of virtual reality head-mounted displays in education and training. *Education and Information Technologies*, 23(4), 1515–1529.
- Jung, Y. (2022). Virtual reality simulation for disaster preparedness training in hospitals: Integrated review. *Journal of Medical Internet Research*, 24(1), e30600. <https://doi.org/10.2196/30600>
- Keshavarz, B., & Hecht, H. (2011). Validating an efficient method to quantify motion sickness. *Human Factors*, 53(4), 415–426. <https://doi.org/10.1177/0018720811403736>
- Kunnskapsdepartementet. (2021). *Utdanning for omstilling — Økt arbeidslivsrelevans i høyere utdanning. Meld. St. 16 (2020–2021)*. Oslo, Norway: Kunnskapsdepartementet. Retrieved from <https://www.regjeringen.no/no/dokumenter/meld.-st.-16-20202021/id2838171/>

- Kyaw, B. M., Saxena, N., Posadzki, P., Vseteckova, J., Nikolaou, C. K., George, P. P., ... Car, L. T. (2019). Virtual reality for health professions education: Systematic review and meta-analysis by the digital health education collaboration. *Journal of Medical Internet Research*, 21(1), e12959. <https://doi.org/10.2196/12959>
- Laviola, Jr., J. J. (2000). A discussion of cybersickness in virtual environments. *ACM SIGCHI Bulletin*, Volume 32(1), Pages 47 – 56. <https://doi.org/10.1145/333329.333344>
- Lessiter, J., Freeman, J., Keogh, E., & Davidoff, J. (2001). A cross-media presence questionnaire: The ITC-Sense of Presence Inventory. *Presence: Teleoperators and Virtual Environments*, 10(3), 282–297. <https://doi.org/10.1162/105474601300343612>
- Makransky, G., Terkildsen, T. S., & Mayer, R. E. (2019). Adding immersive virtual reality to a science lab simulation causes more presence but less learning. *Learning and Instruction*, 60, 225–236. <https://doi.org/10.1016/j.learninstruc.2017.12.007>
- Merchant, Z., Goetz, E. T., Cifuentes, L., Keeney-Kennicutt, W., & Davis, T. J. (2014). Effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education: A meta-analysis. *Computers & Education*, 70, 29–40.
- Nesenbergs, K., Abolins, V., Ormanis, J., & Mednis, A. (2021). Use of augmented and virtual reality in remote higher education: A systematic umbrella review. *Education Sciences*, 11(1), 8. <https://doi.org/10.3390/educsci11010008>
- Patton, M. Q. (1987). *How to use qualitative methods in evaluation*. Sage Publications.
- Pottle, J. (2019). Virtual reality and the transformation of medical education. *Future Healthcare Journal*, 6(3), 181-185. <https://doi.org/10.7861/fhj.2019-0036>
- Radianti, J., Majchrzak, T. A., Fromm, J., & Wohlgenannt, I. (2020). A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. *Computers & Education*, 147, 103778.
- Rim, D., & Shin, H. (2021). Effective instructional design template for virtual simulations in nursing education. *Nurse Education Today*, 96, 104624. <https://doi.org/10.1016/j.nedt.2020.104624>
- Saab, M. M., Hegarty, J., Murphy, D., & Landers, M. (2021). Incorporating virtual reality in nurse education: A qualitative study of nursing students' perspectives. *Nurse Education Today*, 105, 105045. <https://doi.org/10.1016/j.nedt.2021.105045>
- Scoresby, J., & Shelton, B. E. (2011). Visual perspectives within educational computer games: Effects on presence and flow within virtual immersive learning environments. *Instructional Science*, 39(3), 227–254. <https://doi.org/10.1007/s11251-010-9126-5>
- Slater, M., & Wilbur, S. (1997). A framework for immersive virtual environments (FIVE): Speculations on the role of presence in virtual environments. *Presence: Teleoperators and Virtual Environments*, 6(6), 603-616. <https://doi.org/10.1162/pres.1997.6.6.603>
- TechNavio (2021). *Global Medical Education Market 2021-2025*. London: TechNavio.
- Verified Market Research (2021). *Global virtual reality in healthcare market size by end-use (research and diagnostics, laboratories, hospitals and clinics), by application (patient care management, education and training, fitness management), by geographic scope and forecast*. Jersey City, NJ, USA: Verified Market Research.
- Vorderer, P., Wirth, W., Gouveia, F. R., Biocca, F., Saari, T., Jäncke, F., ... Jäncke, P. (2004). MEC Spatial Presence Questionnaire (MEC-SPQ): Short Documentation and Instructions for Application. Report to the European Community, Project Presence: MEC (IST-2001-37661).
- Vorderer, P., Wirth, W., Gouveia, F. R., Biocca, F., Saari, T., Jäncke, L., & Böcking, S. (2004). Theoretical and methodological foundations of the MEC spatial presence questionnaire. *Report to the European Community, Project Presence: MEC (IST-2001-37661)*.
- Vorderer, P., Wirth, W., Saari, T., Gouveia, F. R., Biocca, F., Jäncke, F., ... Jäncke, P. (2003). *Constructing presence: Towards a two-level model of the formation of spatial presence*. Unpublished Report to the European Community, Project Presence: MEC (IST-2001-37661).

- Witmer, B. G., & Singer, M. J. (1998). Measuring presence in virtual environments: A presence questionnaire. *Presence: Teleoperators and Virtual Environments*, 7(3), 225–240. <https://doi.org/10.1162/105474698565686>
- Woon, A. P. N., Mok, W. Q., Chieng, Y. J. S., Zhang, H. M., Ramos, P., Mustadi, H. B., & Lau, Y. (2021). Effectiveness of virtual reality training in improving knowledge among nursing students: A systematic review, meta-analysis and meta-regression. *Nurse Education Today*, 98, 104655. <https://doi.org/10.1016/j.nedt.2020.104655>
- Yamakawa, M., Sung, H. C., & Tungpunkom, P. (2020). Virtual reality education for dementia care: A scoping review protocol. *JBI Evidence Synthesis*, 18(9), 2075-2081. <https://doi.org/10.11124/JBISRIR-D-19-00230>

Supplementary Material A. MEC Mekânsal Varlık Ölçeği (MEC-SPQ) – Türkçe Versiyonu (MEC Spatial Presence Questionnaire (MEC-SPQ) – Turkish Version)

Description: This scale is the Turkish adaptation of the MEC Spatial Presence Questionnaire developed by Vorderer et al. (2004). The scale was structured to assess the sense of spatial presence experienced by individuals in virtual environments. The adaptation process to Turkish was carried out by taking into account expert opinions, language equivalence analysis and content validity.

Application Note: Participants responded to each statement on a scale of 1 (Strongly Disagree) to 5 (Strongly Agree).

Dikkat Dağılımı / Dikkat Tahsisi (Attention Allocation)

	n	min	max	M	SD	Skew-ness	Kur-tosis	Cronbachs alpha
8 items	776	1	5	2,52	1,12	0,32	-0,75	0,89
6 items	776	1	5	2,41	1,14	0,35	-0,80	0,75
4 items	776	1	5	2,32	1,14	0,48	-0,70	0,76

8 items	6 items	4 items	Tanım (Explanation)	n	M	SD	P(M-1)/4	r _{it}	α	M _r
X	X	X	Tüm dikkatimi Sanal Ortam (VR)'a verdim.	776	2,65	1,264	0,413	0,735	0,935	0,669
X	X	X	Sanal Ortam (VR)'a odaklandım.	776	2,59	1,301	0,398	0,809	0,930	0,718
X	X		Dikkatim Sanal Ortam (VR) tarafından tamamen	776	2,5	1,293	0,375	0,803	0,930	0,714
X			Dikkatimi Sanal Ortam (VR)'a yönelttim.	776	2,44	1,271	0,360	0,754	0,934	0,683
X	X	X	Sanal Ortam (VR) duyularımı etkisi altına aldı.	776	2,57	1,316	0,393	0,848	0,927	0,743

X	X	X	Kendimi tamamen Sanal Ortam (VR)'a adadım.	776	2,29	1,293	0,323	0,773	0,932	0,696
X			Dikkatim Sanal Ortam (VR) tarafından	776	2,2	1,271	0,300	0,766	0,933	0,691
X	X		Algım kendiliğinden Sanal Ortam (VR)'a odaklandı.	776	2,33	1,261	0,333	0,787	0,931	0,705

Mekânsal Durum Modeli (Spatial Situation Model (SSM))

	n	min	max	M	SD	Skew-ness	Kur-tosis	Cronbachs alpha
8 items	776	1	5	2,62	1,18	0,13	-0,99	0,92
6 items	776	1	5	2,69	1,24	0,05	-1,08	0,88
4 items	776	1	5	2,66	1,21	0,09	-1,02	0,83

8 items	6 items	4 items	Tanım (Explanation)	n	M	SD	p	r _{it}	α	M _r
X	X	X	Sanal Ortam (VR)'da sunulan mekânların düzenini çok iyi hayal edebildim.	77 6	2,5 5	1,33 0	0,38 8	0,80 1	0,95 9	0,75 3
X	X	X	Sanal Ortam (VR)'da sunulan mekânsal çevre hakkında net bir fikrim vardı.	77 6	2,4 5	1,27 5	0,36 3	0,83 1	0,95 7	0,77 3
X			Sanal Ortam (VR)'da tanımlanan nesnelere düzenini zihnimde net bir şekilde canlandırabildim.	77 6	2,7 3	1,34 3	0,43 3	0,86 2	0,95 5	0,79 5
X	X	X	Sanal Ortam (VR)'da sunulan mekânın boyutlarını iyi tahmin edebildim.	77 6	2,7 9	1,35 2	0,44 8	0,88 0	0,95 4	0,80 7
X	X		Sanal Ortam (VR) deneyimimde nesnelere arasındaki mesafeyi iyi tahmin edebildim.	77 6	2,7 4	1,30 4	0,43 5	0,88 4	0,95 4	0,80 9
X	X	X	Şu anda bile mekânsal çevreye ilişkin somut bir zihinsel imgeye sahibim.	77 6	2,6 7	1,30 0	0,41 8	0,85 5	0,95 6	0,79 0
X			Şu anda bile sunulan mekânsal çevrenin bir planını çizebilirim.	77 6	2,5 9	1,27 2	0,39 8	0,83 2	0,95 7	0,77 4
X	X		Şu anda bile sunulan mekânsal çevrede yönümü bulabilirim.	77 6	2,6 4	1,31 3	0,41 0	0,85 8	0,95 6	0,79 3

Mekânda Kendini Konumlandırma Hissi (Spatial Presence: Self Location (SPSL))

	n	min	max	M	SD	Skewness	Kurtosis	Cronbachs alpha
8 items	776	1	5	2,61	1,23	0,17	-1,08	0,94
6 items	776	1	5	2,62	1,25	0,21	-1,02	0,86
4 items	776	1	5	2,56	1,22	0,24	-1,00	0,85

8 items	6 items	4 items	Tanım (Explanation)	n	M	SD	p	r _{it}	α	M _r
X			Sanal Ortam (VR) deneyimlerken yalnızca gözlemlemektense eylemin tam ortasında olduğumu	77 6	2,6 4	1,32 9	0,41 0	0,84 8	0,96 3	0,79 6
X	X		Kendimi Sanal Ortam (VR)'ın bir parçası gibi hissettim.	77 6	2,6 8	1,33 8	0,42 0	0,85 7	0,96 2	0,80 2
X	X	X	Sanal Ortam (VR) deneyimlerken gerçekten oradaymışım gibi hissettim.	77 6	2,6 7	1,37 0	0,41 8	0,86 7	0,96 2	0,81 0
X	X		Sanal Ortam (VR) deneyimlerken nesnelere beni çevrelediğini hissettim.	77 6	2,5 6	1,32 5	0,39 0	0,87 5	0,96 1	0,81 5
X	X	X	Sanki gerçek konumum Sanal Ortam (VR)'a kaymış gibiydi.	77 6	2,5 4	1,32 8	0,38 5	0,88 2	0,96 1	0,82 0
X			Sanki benliğim Sanal Ortam (VR)'da bulunuyormuş gibi görünüyordu.	77 6	2,4 7	1,29 4	0,36 8	0,87 8	0,96 1	0,81 7
X	X	X	Sanal Ortam (VR)'da fiziksel olarak varmışım gibi hissettim.	77 6	2,5 5	1,33 6	0,38 8	0,86 1	0,96 2	0,80 5
X	X	X	Sanki Sanal Ortam (VR)'daki aksiyona gerçekten katılmışım gibi hissettim.	77 6	2,6 7	1,33 9	0,41 8	0,87 4	0,96 1	0,81 4

Mekânsal Varlık: Olası Eylemler (Spatial Presence: Possible Actions (SPPA))

	n	min	max	M	SD	Skew-ness	Kur-tosis	Cronbachs alpha
8 items	776	1	5	2,59	1,23	0,15	-1,12	0,94
6 items	776	1	5	2,67	1,29	0,11	-1,19	0,90
4 items	776	1	5	2,62	1,27	0,18	-1,16	0,90

8 items	6 items	4 items	Tanım (Explanation)	n	M	SD	p	r _{it}	α	M _r
X			Sanal Ortam (VR) deneyimlerken aksiyonun içine atlayabileceğimi hissettim.	776	2,62	1,342	0,405	0,888	0,969	0,838
X	X		Sanal Ortam (VR) sunumunun içinde rol alabileceğim izlenimini edindim.	776	2,67	1,357	0,418	0,907	0,967	0,851
X	X	X	Sanal Ortam (VR) sunumunda aktif olabileceğim izlenimini edindim.	776	2,66	1,341	0,415	0,888	0,969	0,837
X	X	X	Sanal Ortam (VR) deneyimlerken nesnelere arasında dolaşabileceğimi hissettim.	776	2,58	1,348	0,395	0,892	0,968	0,840
X	X	X	Sanal Ortam (VR) deneyimlerken nesnelere bir şeyler yapabileceğim hissine kapıldım.	776	2,57	1,308	0,393	0,908	0,967	0,852
X			Sanal Ortam (VR) deneyimlerken nesnelere uzanabileceğim izlenimini edindim.	776	2,62	1,328	0,405	0,904	0,968	0,849
X	X		Sanal Ortam (VR) deneyimlerken, gerçek hayatta olduğu gibi sunumdaki şeyler üzerinde etkili	776	2,66	1,354	0,415	0,874	0,969	0,828
X	X	X	Sanal Ortam (VR) deneyimlerken ortamda istediğim her şeyi yapabilişim gibi hissettim.	776	2,57	1,350	0,393	0,847	0,971	0,809

Yüksek Bilişsel Katılım (Higher Cognitive Involvement)

	n	min	max	M	SD	Skew-ness	Kur-tosis	Cronbachs alpha
8 items	776	1	5	2,63	1,23	0,08	-1,13	0,94
6 items	776	1	5	2,61	1,22	0,13	-1,00	0,82
4 items	776	1	5	2,60	1,24	0,15	-1,10	0,90

8 items	6 items	4 items	Tanım (Explanation)	n	M	SD	p	r _{it}	α	M _r
X	X	X	Sanal Ortam (VR) ile ilgili olan şeyler üzerine en çok bunları düşündüm.	776	2,66	1,337	0,415	0,866	0,961	0,808
X			Sanal Ortam (VR)'da sunulan dünyayı daha fazla keşfetmenin nasıl bir şey olacağını tam olarak hayal ettim.	776	2,56	1,301	0,390	0,870	0,961	0,811
X			Sanal Ortam (VR) sunumu benim için kişisel bir anlam taşıyabilir mi diye merak edip durdum.	776	2,64	1,293	0,410	0,874	0,961	0,813
X	X		Sanal Ortam (VR) sunumunun anlamı üzerine yoğun biçimde düşündüm.	776	2,56	1,302	0,390	0,869	0,961	0,810
X	X	X	Sanal Ortam (VR)'da sunulan şeylerin birbiriyle nasıl ilişkili olduğunu dikkatlice düşündüm.	776	2,61	1,310	0,403	0,888	0,960	0,823
X	X	X	Sanal Ortam (VR) sunumu düşüncelerimi harekete geçirdi.	776	2,58	1,322	0,395	0,909	0,959	0,837
X	X	X	Sanal Ortam (VR) sunumunun bana faydalı olup olmayacağını düşündüm.	776	2,68	1,364	0,420	0,845	0,962	0,793
X	X		Sunumda yer alan şeyler hakkında ne kadar bilgi sahibi olduğumu düşündüm.	776	2,66	1,340	0,415	0,808	0,965	0,767

İnançsızlığın Askıya Alınması (Suspension of Disbelief (SoD))

	n	min	max	M	SD	Skewness	Kurtosis	Cronbachs alpha
8 items	776	1	5	2,44	1,00	-0,03	-0,87	0,81
6 items	776	1	5	2,34	1,04	0,25	-0,76	0,67
4 items	776	1	5	2,23	1,05	0,37	-0,85	0,75

8 items	6 items	4 items	Tanım (Explanation)	n	M	SD	p	r _{it}	α	M _r
X	X	X	(R) Sanal Ortam (VR)'da herhangi bir tutarsızlık olup olmadığına odaklandım.	776	2,46	1,271	0,365	0,692	0,866	0,575
X	X	X	Sanal Ortam (VR)'da hata ya da tutarsızlık olup olmadığına pek dikkat etmedim	776	2,17	1,136	0,293	0,563	0,878	0,497
X	X		(R) Dikkatimi Sanal Ortam (VR)'daki olası hata veya çelişiklere yönelttim.	776	2,36	1,204	0,340	0,707	0,864	0,584

X			(R) Eylemin veya Sanal Ortam (VR)'da tasvir edilenlerin makul olup olmadığını düşündüm.	776	2,28	1,219	0,320	0,656	0,869	0,556
X			(R) Sanal Ortam (VR)'da tasvir edilenlerin gerçekten böyle var olup olmayacağını merak ettim.	776	2,18	1,125	0,295	0,618	0,873	0,532
X	X	X	(R) Sanal Ortam (VR)'da tasvir edilenlere eleştirel yaklaştım.	776	2,61	1,291	0,403	0,715	0,863	0,587
X	X		(R) Sanal Ortam (VR)'da tutarsızlıkların olup olmadığını kontrol etmek benim için önemliydi.	776	2,32	1,193	0,330	0,628	0,872	0,539
X	X	X	Sanal Ortam (VR)'ın hata veya çelişkiler içerip içermediği benim için önemli değildi.	776	2,51	1,322	0,378	0,638	0,872	0,544

Alan-Specific İlgi (DSI) (Domain Specific Interest (DSI))

	n	min	max	M	SD	Skew-ness	Kurtosis	Cronbachs alpha
8 items	776	1	5	2,54	1,17	0,24	-0,93	0,92
6 items	776	1	5	2,62	1,21	0,15	-1,02	0,87
4 items	776	1	5	2,47	1,18	0,31	-0,89	0,83

8 items	6 items	4 items	Tanım (Explanation)	n	M	SD	p	r _{it}	α	M _r
X	X	X	Sanal Ortam (VR) konusu ile genel olarak ilgilenirim.	776	2,62	1,293	0,405	0,837	0,955	0,775
X	X		Sanal Ortam (VR), normalde tercih ettiklerimle çok iyi örtüştü.	776	2,66	1,288	0,415	0,852	0,954	0,785
X	X	X	Uzun zamandır Sanal Ortam (VR) konusuna karşı güçlü bir yakınlık hissediyorum.	776	2,47	1,282	0,368	0,854	0,954	0,787
X	X	X	Sanal Ortam (VR) konusuyla karşılaşmadan önce de bu konuya karşı bir ilgim vardı.	776	2,53	1,319	0,383	0,867	0,953	0,796
X			Seçme şansım olduğunda, Sanal Ortam (VR) konusunu ele almayı tercih ederdim.	776	2,59	1,299	0,398	0,854	0,954	0,787
X	X		Sanal Ortam (VR)'da yer alan benzer şeyler geçmişte de sık sık dikkatimi çekmiştir.	776	2,58	1,282	0,395	0,878	0,953	0,803
X	X	X	Sanal Ortam (VR) hakkında düşünmeyi gerçekten seviyorum.	776	2,53	1,303	0,383	0,838	0,955	0,776
X			Sanal Ortam (VR) konusu üzerine çok zaman harcadım.	776	2,35	1,252	0,338	0,790	0,958	0,742

Görsel-Mekânsal İmgeleme (VSI) (Visual Spatial Imagery (VSI))

	n	min	max	M	SD	Skewness	Kurtosis	Cronbachs alpha
8 items	776	1	5	3,07	1,23	-0,28	-0,91	0,93
6 items	776	1	5	3,17	1,28	-0,36	-0,92	0,87
4 items	776	1	5	3,18	1,26	-0,37	-0,91	0,84

8 items	6 items	4 items	Tanım (Explanation)	n	M	SD	p	r _{it}	α	M _r
X	X	X	Biri bana bir kroki gösterdiğinde, ona ait mekânı kolayca gözümde canlandırabilirim.	776	2,91	1,352	0,478	0,828	0,959	0,775
X	X	X	Bir mekânı, gerçekte orada olmadan, gözümde canlandırmak bana kolay gelir.	776	3,04	1,356	0,510	0,854	0,958	0,793
X			Bir metni okuduğumda, genellikle tarif edilen çevrenin ayrıntılı bir görüntüsü zihnimde canlanır.	776	3,06	1,346	0,515	0,875	0,956	0,807
X	X	X	Bir metni okurken, tarif edilen nesnelere dizilişini genellikle kolayca hayal edebilirim.	776	3,19	1,349	0,548	0,860	0,957	0,796
X	X		Birisi bana bir yerin tarifini verdiğinde, rotayı sanki bir film izliyormuşum gibi gözümde canlandırabilirim.	776	3,14	1,376	0,535	0,873	0,956	0,805
X	X	X	Birisi bana bir mekânı tarif ettiğinde, onu açıkça hayal etmem benim için genellikle çok kolaydır.	776	3,15	1,359	0,538	0,873	0,956	0,805
X			Yüksek bir dağın eteğinde ne kadar küçük göründüğümü canlı bir şekilde hayal edebiliyorum.	776	3,31	1,382	0,578	0,835	0,959	0,779
X	X		Bir resim mekânın sadece bir kısmını gösterdiğinde, geri kalanını da net bir şekilde hayal edebiliyorum.	776	3,21	1,348	0,553	0,840	0,958	0,782