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CYBERSICKNESS SYMPTOMS OF USING VIRTUAL REALITY AMONG PRIMARY SCHOOL STUDENTS

Abstract: Virtual reality is a cutting-edge educational technology with the capacity to enhance learning processes significantly, but may also provoke various cybersickness symptoms. The aim of this study is to analyse the frequency and interrelationships of 19 cybersickness symptoms during virtual reality use, and to determine whether the presence of these side effects influences students' intention to continue using this technology in the future. Seventy third-grade primary school students participated in a fully immersive VR environment over an eight-week period to investigate abstract natural phenomena using the Meta Quest 3 device. The Mann–Whitney test was used to examine gender differences in cybersickness symptoms; factor analysis to identify latent symptom factors; descriptive statistics to determine symptom frequencies; and the chi-square test of independence to explore the relationship between behavioural intention to use and cybersickness symptoms.

The results indicate that males and females differ only in sweating, while more than half of the students reported experiencing blurred vision and disorientation. This suggests that particular attention should be paid to preventing these symptoms. Symptoms typically occur in groups, appearing alongside other adverse reactions. Three symptom groups were identified with low, medium, and high frequency. Significant correlations indicate that, although participants reported eyestrain, nausea, and fear, they still consider virtual reality a good idea, find it engaging for learning, and intend to continue using it in various school subjects in the future. To minimise the side effects of virtual reality, pedagogical recommendations for prevention are proposed, along with scientific implications for its further educational application.

Keywords: behavioural intention, cybersickness, education, symptoms, virtual reality.

Introduction

By integrating cutting-edge technologies into the teaching process, innovative methodological approaches can create stimulating learning environments and develop competencies, relying on more dynamic instructional processes and diversified learning and teaching experiences. Grounded in key constructivist principles that emphasise the learner's active participation in learning situations, the question arises which forms of modern technology can effectively support such engagement and reduce the gap between the learner's knowledge and real-life experience (Huang & Liaw, 2018: 91).

In today's educational systems with supportive artificial intelligence (Mandic, 2023), activities aimed at integrating digital technologies and developing effective implementation models pose a significant challenge (Ristic, 2017). To successfully assimilate any technology into the teaching environment, from K–12 to the university level, it must be purposeful, user-friendly, and supportive of various methodological strategies for fostering students' potential. This includes developing creativity (Stojanovic & Bogavac, 2016), creative habits (Markovic, 2025), and instructional models

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such as information-developmental teaching to explore natural and social phenomena (Bujisic, 2025) or to promote algorithmic thinking (Matovic & Ristic, 2024).

One potential answer may be found precisely in virtual environments. The meaning of virtual has evolved alongside technological advancements. It has transitioned from desktop-based virtual content consumed on computer screens, through semi-immersive virtual environments enabled by specialised simulators, to fully immersive experiences perceived through the hardware and software components of virtual reality (VR) technology.

According to Villena-Taranilla et al. (Villena-Taranilla et al., 2022: 2) and Al-kfairy et al. (Al-kfairy et al., 2024: 15), virtual reality is generally conceptualised as a technological system that enables and increases immersive engagement in computer-generated three-dimensional environments. In this setting, users' virtual presence can substantially transform conventional behavioural patterns of user interaction within digital learning environments and encounter a range of sensory and emotional experiences. The capacity of VR to simulate real-life situations in 3D graphics environments is profoundly enriching for learners (Shen et al., 2017: 130) because it incorporates multisensory interfaces that enable them as engaged participants to actively explore and engage with immersive virtual environments through the interactive learning process. VR can be helpful to understand abstract concepts (Puiu & Udristioiu, 2024: 9), the study of the solar system, anatomy, navigating dangerous situations, conducting experiments, or, in the case of certain assistive technologies, for language learning, the development of empathy, or therapeutic purposes for different forms of autism (Ristic et al., 2023: 275).

Virtual reality is rapidly advancing and offers educational and therapeutic benefits, but its use may be limited by negative symptoms experienced by users, making it essential to assess VR's effectiveness and safety before implementation (Simón-Vicente et al., 2024: 708; Velickovic et al., 2020: 26). Using specialised hardware that includes a VR headset and controllers provides an immersive experience, and different senses are activated, such as vision, hearing, and touch (Ristic, 2022: 282), actually by a combination mostly of vestibular, visual, and proprioceptive input (Benelli et al., 2023: 1796–1797). Through the synergy of various senses, the VR user is, to some extent, deceived into believing they are in another virtual world, in which they can experience various types of self-motion (vection) and kinaesthetic sensations.

This immersive simulation of movement means users may perceive motion while physically stationary. This increases the experience's complexity and may elicit a range of adverse symptoms, commonly referred to in the literature as motion sickness, simulation sickness, or cybersickness. Although these terms are commonly used interchangeably to describe the unpleasant symptoms associated with virtual reality technology (Duzmanska et al., 2018: 2), it is important to establish a clear distinction among them.

Motion sickness represents a collection of adverse symptoms triggered by exposure to abrupt, repetitive, or unnatural motion stimuli (McCauley, 1984: 1). It occurs when sensory inputs associated with bodily movement primarily visual and vestibular signals, together with feedback from other motion-sensitive receptors—deviate from the sensory patterns anticipated by the central nervous system, resulting in a perceived mismatch within the brain's internal model of motion (Benson, 1988: 3; Nürnberger et al., 2021: 2).

Simulator sickness is a type of motion sickness that may occur due to acceleration or from visual motion cues without actual movement (Johnson, 2005: 2, 22; McCauley, 1984: 1). Many authors (Duzmanska et al., 2018:2; Mittelstaedt et al., 2019: 1) note that Simulator sickness first described effects from simulators with platforms and computer-generated visuals, without head-tracking. Cybersickness is linked to head-mounted displays and screens, introducing other issues, such as the delay between head movements and the displayed image, that can cause unpleasant symptoms.

Cybersickness does not constitute a disease. Instead, it is a psychophysiological response to unusual stimuli in artificially created environments—perceptual illusions within a virtual environment (Bos et al., 2022: 757; Josupeit, 2023: 2; Velickovic et al., 2020: 26, 29). Cybersickness is often seen as a subtype of motion sickness (Long et al., 2025: 2) and simulator sickness. It should not, however, be considered identical, as its adverse symptoms are visually induced (Rebenitsch & Owen, 2016: 103). Cybersickness is closely linked with VR technology and is a major limitation to its effective use (Maneuvrier et al., 2023: 2). It is characterised by discomfort, apathy, and sensory disturbances (Pawełczyk et al., 2025: 3).

Moreover, numerous literature reviews (Biswas et al., 2024: 284: 2; Caserman et al., 2021: 1153; Nürnberger et al., 2021: 9; Park et al., 2022: 980; Rebenitsch & Owen, 2016: 101) report various terms used synonymously with cybersickness, such as virtual simulator sickness or VR-induced motion sickness. The main causes are the absence of actual physical motion and a mismatch between visual information and insufficient vestibular input, further influenced by device latency and the design of the VR experience. More precisely, visual-vestibular conflict in virtual reality occurs when the brain receives visual information about movement that is not aligned with the actual bodily sensations, resulting from a mismatch of sensory signals from the visual, vestibular, and somatosensory systems (Long et al., 2025:2). In other words, vection is the illusion of self-motion in the absence of real physical movement" (Keshavarz et al., 2014: 827) this happens when the perception of self-motion (vection) is uncontrollable, that is, when vestibular and body position signals are absent, meaning that the body is not actually undergoing real movement (Benelli et al., 2023: 1796–1797; Riecke & Keshavarz, 2025:10).

Cybersickness within the framework of explanatory theories and determining factors

Theories that were used before the 1970s to explain motion and simulator sickness can also be found in more recent literature as frameworks for understanding the emergence of cybersickness. One of the most widely represented theories in the majority of studies (Palmisano & Constable, 2022; Teixeira et al., 2022) is the Sensory Conflict Theory. Since Reason and Brand (1975), this theory has explained that the feeling of discomfort and the symptoms of motion sickness occur when different sensory systems such as the visual, vestibular, proprioceptive, or other systems receive conflicting signals that do not correspond with one another and do not match the movement expected by the brain (Velickovic et al., 2020: 27). As Johnson emphasises 'there was a large conflict between current and expected patterns' (Johnson, 2005: 18). This mismatch arises not only between what we currently perceive but also between incoming sensory information and previously formed mental models and expectations based on one's past movement experiences, developed over a lifetime (Palmisano & Constable, 2022: 1374; Riecke & Keshavarz, 2025: 12).

Another widely represented theory is the Postural Instability Theory. Many studies (Caserman et al., 2021; Duzmańska et al., 2018; Johnson, 2005; Maneuvrier et al., 2023; Pawełczyk et al., 2025) explain that postural instability leads to cybersickness, which occurs when a person adapts to an unfamiliar virtual or simulated environment. Under the influence of a simulator that imposes specific movements, the individual is unable to maintain a stable body posture because the vestibular system cannot adequately process and reconcile the received sensory inputs with motor responses.

Rest Frame Theory, Poison Theory, Flow Theory, and Adaptation Theory offer additional perspectives on the causes and dynamics of cybersickness. According to the Rest Frame Theory, symptoms of cybersickness occur when the body is unable to maintain an internal sense of rest (even while sitting) while simultaneously being exposed to virtual movements, leading to disturbances in balance and orientation (Rebenitsch & Owen, 2016: 105; Velickovic et al., 2020: 28). According to Treisman's Poison Theory (1977), the body interprets sensory conflicts as signs of toxin ingestion and responds by triggering nausea and vomiting to eliminate the perceived harmful substances (Caserman et al., 2021: 2; Maneuvrier et al., 2023: 2). Flow Theory describes a mental state in which a person is highly motivated and fully immersed in an activity (Pawełczyk et al., 2025: 2). However, achieving this state is not always simple, as it requires maintaining a balance between the complexity of the task and the individual's skill level (Lu, 2016: 18). According to the Adaptation Theory, the intensity of cybersickness gradually decreases as users repeatedly engage with virtual reality technology and their sensory systems adapt over time (Wang & Suh, 2019: 4).

Additionally, other, less frequently mentioned theories in the literature also address cybersickness, such as the Theory of the Subjective Vertical Conflict, Sensory Rearrangement theory, and Vection Conflict theory. Theory of the Subjective Vertical Conflict the holds that negative reactions occur only when there is a mismatch in sensory information related to the perception of the body's upright orientation in relation to gravity (Caserman et al., 2021: 02; Maneuvrier et al., 2023: 2). Sensory rearrangement theory, which is a slightly more complex theory than the Sensory Conflict Theory, encompasses the concept of adaptation with a focus on the phenomenon known as neural mismatch (Teixeira et al., 2022: 2) as well as Vection Conflict Theory which advocates statement that unexpected vection appears to be particularly provocative for cybersickness. According to same authors a specific threshold of unexpected vection may be necessary to provoke a level of sickness severe enough for users to discontinue or exit HMD VR (Teixeira et al., 2022: 10).

All of the aforementioned theories are important for descriptively explaining and understanding how a specific sensory conflict arises. In this context, it is also crucial to analyse the possible factors that influence the onset of cybersickness symptoms. Only by understanding the homogeneous nature of the factors can appropriate preventive strategies be developed for implementing VR in a way that makes the transition from the real to the virtual world as comfortable as possible, without long-term health consequences or potential dropouts (Pot-Kolder et al., 2018; Veling et al., 2021; Setu et al., 2024).

Biswas et al. (2024: 284–6) explain that the Taxonomy of causes of cybersickness is divided into two main categories. Internal factors include elements such as age, gender, susceptibility to motion sickness, physical condition, and emotional state, with Riecke & Keshavarz (2025: 16) additionally noting ethnicity. External factors are further divided into hardware and VR content. In hardware, factors such as display resolution, latency, latency jitter, display type, and input method play a role. Factors related to VR content that contribute to cybersickness include visual motion, means of locomotion, field of view, type of content, duration, visual complexity, navigation, display type, rendering modes (Rebenitsch & Owen, 2016: 120), and overall setup (Riecke & Keshavarz, 2025: 17). These categories collectively highlight the diverse influences that can cause discomfort or sickness when using virtual reality systems.

In current literature, technological, task, and individual factors are also highlighted (Wang & Suh, 2019: 2), along with previous experience and balance disorders (Josupeit, 2023: 2). In the context of VR, even Cobb et al. (Cobb et al., 1999: 184–185), more than two decades ago, emphasised the importance of assessing symptoms at an individual level, noting that in some cases, after using VR, individuals exhibited significant post-experience changes in postural stability, heart rate, and cortisol levels in urine and saliva. Consequently, symptoms are often described collectively as VR-induced symptoms and effects (VRISE). The symptoms of cybersickness are polysymptomatic (many symptoms) and polygenic (symptoms manifested differ from individual to individual)" (Rebenitsch & Owen, 2016: 103).

Older studies (Cobb et al., 1999; Johnson, 2005; Kennedy et al., 1993), as well as more recent research (Kourtesis et al., 2019; Mittelstaedt et al., 2019; Nürnberger et al., 2021; Punako, 2018) identify three main symptom categories. The SSQ scale has been used to classify individual symptoms into specific categories named Nausea, Vestibular, and Oculomotor by calculating symptom intensity and applying weighting procedures to the subscales and the total score (Hasan et al., 2024: 193; Josupeit, 2023: 3; Punako, 2018: 243;). These three distinctions provide diagnostic information about specific categories of symptoms (Hasan et al., 2024: 193; Johnson, 2005: 29–30), emphasising that they are not independent of each other, but they mostly share a common general factor:
1) Nausea mostly includes symptoms such as nausea, vomiting, stomach awareness, increased salivation, sweating, and burping. 2) Vestibular common encompasses disorientation, dizziness (with eyes open and closed), vertigo, and blurred vision. 3) Oculomotor comprises symptoms related to visual strain, such as eyestrain, difficulty focusing, hazy vision, fatigue, and headaches.

These categories of cybersickness symptoms have been investigated using various devices, ranging from VR headsets such as HTC Vive, Oculus Rift (Caserman et al., 2021: 1170), and Meta Quest, which enable immersion in the virtual environment, to tools such as electroencephalography (EEG) (Benelli et al., 2023; Kim et al., 2005; Nürnberger et al., 2021; Park et al., 2022) used to measure physical parameters and physiological mechanisms associated with cybersickness (Long et al., 2025: 15).

Behavioral intention to use virtual reality as educational technology

VR has shown a significant impact on students' attitudes, acceptance, and intention to use (Fussell & Truong, 2022: 260) as well as a positive effect on long-term learning outcomes (Lin et al., 2023: 2). The role of the student is completely transformed, as opportunities emerge for fully immersive environments to be enriched with various types of avatars (Mandic et al., 2025a; Mandic et al., 2025b) or chatbots (Mandic et al., 2024) enabling active collaboration and communication that can even extend into metaverse environments (Babic et al., 2025; Matovic et al., 2025).

There are studies that examine in more detail the various factors affecting students' behavioural intention to use virtual reality in learning (Huang & Liaw, 2018; Manis & Choi, 2019; Puiu & Udriștioiu, 2024; Shen et al., 2017) and emphasise the importance of understanding all circumstances that influence the potential acceptance of a particular technology.

The relationship between cybersickness and behavioural intention to use can be further explained through Xie et al. (Xie et al., 2024: 5), who state that 'behavioural intention is a predictor that influences whether an individual will perform a specific action in a given situation' that is, whether a user is willing to accept a new technology to a certain extent (Xie et al., 2024: 5). Considering that VR is a technology users need to adopt for teaching or developing specific educational competencies, the given situation would represent moments when the user experiences one or more of the mentioned side effects or symptom groups within a particular immersive environment.

The investigation of the impact of cybersickness is important because it also affects the perceived enjoyment of using VR, as side effects or various combinations of associated symptoms can diminish the sense of enjoyment. It is worth emphasising that previous studies have demonstrated a positive relationship between perceived enjoyment (PEU) and learners' behavioural intention to use VR in education (Huang et al., 2013: 13; Fussell & Truong, 2022: 254), indicating that a higher level of enjoyment directly encourages greater intention to adopt and use VR technology. All of these points highlight the complexity of using VR for teaching and learning and raise numerous research questions.

Method

This research examines individual cybersickness symptoms and their interrelationships, with particular emphasis on shaping users' future intentions to use VR for educational purposes. The aim of this study is to analyse the frequency and interrelationships of cybersickness symptoms during VR use among primary school students, and to determine whether the presence of cybersickness influences students' intentions to continue using VR technology for learning.

The study involved 70 third-grade primary school students (33 male and 37 female). They used a fully immersive form of virtual reality 2–3 times per week for 8 weeks under controlled conditions, using the Meta Quest 3 device, accompanied by didactic-methodological guidance for the exploration of abstract natural phenomena within the subject Nature and Society.

Guided by the premise that 'cybersickness is mostly measured using subjective methods' (Maneuvrier et al., 2023: 02), the chosen instrument was a test employing self-report scales, which belongs to the category of questionnaires used to record users' subjective experiences of discomfort following exposure to immersive VR environments (Long et al., 2025: 2).

The final instrument (Table 1) was developed based on several existing validated instruments, namely the Virtual Reality Sickness Questionnaire (derived from the Simulator Sickness Questionnaire (SSQ) by Kennedy et al., 1993). It was expanded with additional items to enable a more comprehensive analysis of the most frequently reported health-related symptoms associated with VR use (Meyer et al., 2019; Pawełczyk et al., 2025; according to Punako, 2018; Simón-Vicente et al., 2024).

The standard measurement instrument, the Simulator Sickness Questionnaire (SSQ) (Kennedy et al., 1993) lists 16 symptoms: general discomfort, fatigue, headache, eyestrain, difficulty focusing, increased salivation, sweating, nausea, difficulty concentrating, fullness of head, blurred vision, dizziness (eyes open), dizziness (eyes closed), vertigo, stomach awareness, and burping. For the purposes of this research, the SSQ model was modified by excluding vertigo, stomach awareness, and burping, and by adding the following symptoms: burning sensation in the eyes, spatial confusion (disorientation), postural instability (imbalance), and sleepiness.

As Lavoie et al. (Lavoie et al., 2021: 70) state, although numerous studies have identified possible negative effects of using virtual reality, most have focused on physical or physiological aspects. Additionally, variables that examine social and emotional fatigue after using the Internet and digital technology are also highly significant (Petrovic et al., 2025: 19). Therefore, their study broadens the existing body of research by examining the potential psychological and emotional drawbacks of VR use. Additionally, as previously mentioned, cybersickness does not constitute a disease, but rather represents a psychophysiological response of the body to exposure to unusual stimuli in artificially created environments (Bos et al., 2022: 757; Josupeit, 2023: 02; Velickovic et al., 2020: 26, 29). In this context, two additional items of an emotional-physiological category were included, relating to fear and panic (Lundin et al., 2023).

The first part of the instrument consisted of 19 items beginning with the same introductory phrase, *While using virtual reality, I felt:*, which described the symptoms listed in Table 1. Participants reported their experiences using a five-point Likert scale (1 – never, 2 – rarely, 3 – sometimes, 4 – often, 5 – all the time).

Table 1. *Overview of the items included in the final instrument (first part)*

Code	Item	Expanded SSQ (Kennedy et al. 1993) with the same or similar items by:
S1	general discomfort	Punako, 2018; Meyer et al. 2019; Pawełczyk et al. 2025
S2	fatigue	Punako, 2018; Meyer et al. 2019; Petrovic et al. 2025
S3	headache	Punako, 2018; Meyer et al. 2019
S4	dizziness (open eyes)	Punako, 2018; Meyer et al. 2019
S5	dizziness (closed eyes)	Punako, 2018; Meyer et al. 2019
S6	eyestrain	Punako, 2018; Meyer et al. 2019
S7	blurred vision	Punako, 2018; Meyer et al. 2019
S8	burning sensation in the eyes	Velickovic et al. 2020
S9	difficulty focusing	Punako, 2018; Meyer et al. 2019
S10	increased salivation	Punako, 2018; Meyer et al. 2019
S11	nausea	Punako, 2018; Meyer et al. 2019
S12	sweating	Punako, 2018; Meyer et al. 2019
S13	difficulty concentrating	Punako, 2018; Meyer et al. 2019
S14	fullness of the head	Punako, 2018; Meyer et al. 2019
S15	spatial confusion (disorientation)	Johnson 2005; Velickovic et al. 2020
S16	postural instability (imbalance)	Kourtesis et al. 2019
S17	sleepiness	Simón-Vicente et al. 2024;
S18	fear	Lundin et al. 2023
S19	panic	Lundin et al. 2023

Cronbach's alpha was calculated to assess the instrument's reliability, and the obtained value of .923 indicates strong internal consistency (Taber, 2018: 1278), confirming that the instrument is a reliable tool for measuring the intended construct.

The research was structured around four research tasks:
(1) To determine whether statistically significant differences exist between males and females in identifying cybersickness symptoms.
(2) To identify which symptoms are interrelated or whether they can be grouped into latent factors.
(3) To examine the frequency of occurrence of individual symptoms among participants during VR use.
(4) To determine whether participants, despite the presence of certain cybersickness symptoms, express an intention to continue using VR technology in learning.

For the first research task, a nonparametric test (Mann–Whitney) was used to examine gender differences in cybersickness symptoms. In contrast, Factor analysis was applied in the second task to identify latent symptom factors. Since the variable measuring the frequency of cybersickness symptoms was initially assessed using an ordinal (Likert) scale, for the purposes of statistical analysis in the third and fourth tasks, the data were recategorised into two composite groups: *without symptoms* (response never) and *with symptoms* (responses rarely, sometimes, often, and all the time). Accordingly, in the third research task, descriptive statistical methods were used to determine the frequency of cybersickness symptoms, whereas in the fourth task, a chi-square test of independence (χ^2) was applied to examine the association between the variable Behavioural Intention to Use and the presence of cybersickness symptoms.

For the fourth task, data from the second part of the final instrument were used, in which participants expressed their Behavioural intention to use VR in the future. They evaluated the following items BIU1 – Using virtual reality makes learning more engaging; BIU2 – I believe that using virtual reality in school is a good idea; BIU3 – I would like to use virtual reality for learning in other school subjects as well (Lee et al., 2018; Solmaz et al., 2024) using a five-point Likert scale (1 – Strongly agree, 2 – Partially agree, 3 – Neither agree nor disagree, 4 – Partially disagree, 5 – Strongly disagree).

Results and discussion

Research Task 1: Different side symptoms of cybersickness may manifest differently across age groups (Josupeit, 2023:10), and vary according to the gender of participants (Vlahovic et al., 2024: 107). In this regard, it was important to determine whether there is a statistically significant difference between males and females in the identification of cybersickness symptoms (Table 2).

Table 2. *Mann–Whitney U test results for gender differences in cybersickness symptoms*

		U	Z	Sig. (2-tailed)
S1	general discomfort	528.500	-1.587	.113
S2	Fatigue	578.000	-0.500	.617
S3	Headache	545.500	-1.129	.259
S4	dizziness (open eyes)	563.500	-0.672	.502
S5	dizziness (closed eyes)	565.000	-0.969	.332
S6	Eyestrain	592.500	-0.244	.807
S7	blurred vision	504.500	-1.397	.162
S8	burning sensation in the eyes	502.000	-1.784	.074
S9	difficulty focusing	567.500	-0.583	.560
S10	increased salivation	583.000	-0.622	.534
S11	nausea	541.000	-1.292	.196
S12	**sweating**	**492.000**	**-2.126**	**.034**
S13	difficulty concentrating	572.000	-0.605	.545
S14	fullness of the head	586.000	-0.330	.741
S15	spatial confusion (disorientation)	467.500	-1.781	.075
S16	postural instability (imbalance)	606.000	-0.062	.950
S17	sleepiness	598.000	-0.196	.844
S18	fear	480.000	-1.827	.068
S19	panic	567.500	-0.973	.331

The results of the Mann–Whitney U test showed that, for most symptoms, there is no statistically significant difference between male ($N = 33$) and female ($N = 37$) participants. Since the p-value for 18 symptoms exceeded the conventional significance threshold ($p < .05$), it can be concluded that cybersickness occurs with similar frequency in both genders. The only statistically significant difference was observed for the symptom of sweating ($p = .034$).

Research Task 2: This study uses the modified SSQ scale (Kennedy, 1993). Some original items were omitted and new ones added without applying weighting procedures for the subscales or the total score, and without examining symptom intensity according to the three categories (Nausea, Vestibular, Oculomotor) as conducted in some recent studies (Hasan et al., 2024:193; Josupeit, 2023: 3; Punako, 2018: 243). Instead, we focused on investigating the grouping of symptoms or which symptoms tend to occur together and therefore employed factor analysis. The suitability of the data for factor analysis is presented in Table 3 using the Kaiser–Meyer–Olkin (KMO) measure and Bartlett's test of sphericity. The KMO value was 0.906, indicating excellent sample adequacy for factor analysis according to Kaiser's (Kaiser, 1974: 35) criteria. Bartlett's test of sphericity was statistically significant ($\chi^2 = 792.130$, $df = 171$, $p < .000$), confirming the presence of significant correlations among the variables and justifying the use of exploratory factor analysis (EFA) (Chan & Idris, 2017: 403; Zeynivandnezhad et al., 2019: 74).

Table 3. *KMO and Bartlett's Test*

KMO Measure		.906
Bartlett's Test f Sphericity	χ²	792.130
	df	171
	Sig.	.000

Factor analysis was conducted using principal component analysis with Varimax rotation and Kaiser normalization. This provided the rotated factor solution, the proportion of total variance explained by the structure, and the eigenvalues exceeding 1.

Table 4. *Eigenvalues, Percentage of Variance, and Cumulative Percentages for Factors*

Factor	Eigenvalue	% of variance	Cumulative %
1	9.099	45.89 %	17.73%
2	1.421	4.95%	32.29%
3	1.078	3.60%	45.55%
4	1.021	3.20%	57.64%

Based on the results presented in Table 4, four components (factors) can be identified, each with an eigenvalue greater than 1. These four components together explain 57.64% of the total variance, which is an acceptable value for the human sciences (Zeynivandnezhad et al., 2019: 67–68). Based on the guideline that factor loadings of 0.50 or higher are considered practically significant, while loadings above 0.70 indicate a well-defined structure and represent the goal of any factor analysis (Hair et al., 2018: 151) the extracted factors are presented in Table 5.

Table 5. *Factor Analysis (Principal Component Analysis, Varimax with Kaiser Normalisation)*

Code	Item	F1	F2	F3	F4	Cronbach's Alpha
S10	increased salivation	**.712**				.857
S19	Panic	**.650**				
S02	Fatigue	**.626**				
S05	dizziness (closed eyes)	**.516**				
S03	Headache		**.850**			.874
S04	dizziness (open eyes)		**.609**			
S11	Nausea		**.521**			
S09	difficulty focusing			**.653**		.720
S16	postural instability (imbalance)			**.651**		
S15	spatial confusion (disorientation)			**.623**		
S01	general discomfort				**.660**	.692
S06	Eyestrain				**.557**	

Factor analysis identified four factors, corresponding to four groups of symptoms that tend to occur together and reflect the combined physiological, cognitive, and emotional responses of children to the VR environment. Of the 19 variables analysed, 12 were retained because they demonstrated significant intercorrelations, while 7 were excluded because their factor loadings were below 0.5.

The first group of symptoms (F1) shows that increased salivation, dizziness (with eyes closed), and fatigue occur together with an emotional response that induces a feeling of panic. The second group (F2) includes headache, dizziness (open eyes), and nausea, indicating that different somatic reactions often co-occur in response to VR exposure. The third group (F3) comprises difficulty focusing, postural instability (imbalance), and spatial confusion (disorientation), reflecting the simultaneous cognitive–vestibular challenges in children. In the fourth group (F4), general discomfort was associated with eyestrain, suggesting that visual fatigue often accompanies subjective discomfort during VR use.

Alongside the EFA, the reliability of the generated factors was assessed. Cronbach's Alpha (CA) coefficient was applied to assess internal consistency, with 0.70 generally considered the minimum acceptable threshold (Kaplan & Saccuzzo, 2009: 326). However, some authors suggest that values between 0.60 and 0.70 may be regarded as the lower limit of acceptability (Hair et al., 2019: 122). For F4, the CA value falls within the lower limit of acceptability and can be partially justified by the study's specific characteristics. The complexity of organising the use of the Oculus Meta Quest 3 VR device under real classroom conditions, where at least 8–10 minutes per iteration had to be planned for each child, limited the sample size to 70 students, whereas a larger sample would likely have contributed to higher CA values. Additionally, the analysis of cybersickness side effects associated with VR use relied on students' subjective perceptions and experiences, which may have increased response variability and partially explained the measurement's lower reliability.

Research Task 3: To examine the frequency of individual symptoms (Table 6) among participants during VR use, the data were recategorised into two composite variables: without symptoms (response never) and with symptoms (responses rarely, sometimes, often, and all the time).

Table 6. *Frequencies of individual cybersickness symptoms*

Code	Item	Without symptoms (N, %)	With symptoms (N, %)
S1	general discomfort	60 (85,7%)	10 (14,3%)
S2	Fatigue	52 (74,3%)	18 (25,7%)
S3	Headache	57 (81,4%)	13 (18,6%)
S4	dizziness (open eyes)	47 (67,1%)	23 (32,9%)
S5	dizziness (closed eyes)	62 (88,6%)	8 (11,4%)
S6	Eyestrain	43 (61,4%)	27 (38,6%)
S7	blurred vision	40 (57,1%)	30 (42,9%)
S8	burning sensation in the eyes	55 (78,6%)	15 (21,4%)
S9	difficulty focusing	42 (60%)	28 (40%)
S10	increased salivation	63 (90%)	7 (10%)
S11	Nausea	59 (84,3%)	11 (15,7%)
S12	Sweating	58 (82,9%)	12 (17,1%)
S13	difficulty concentrating	53 (75,7%)	17 (24,3%)
S14	fullness of the head	43 (61,4%)	27 (38,6%)
S15	spatial confusion (disorientation)	31 (44,3%)	39 (55,7%)
S16	postural instability (imbalance)	45 (64,3%)	25 (35,7%)
S17	Sleepiness	53 (75,7%)	17 (24,3%)
S18	Fear	46 (65,7%)	24 (34,3%)
S19	Panic	63 (90%)	7 (10%)

Based on the frequency of individual symptoms, it can be concluded that most participants reported not experiencing any of the listed symptoms. However, even a minimal side effect can lead to undesirable consequences, particularly in younger school-age children. Therefore, the symptoms were descriptively categorised into three groups according to low, medium, and high frequency of occurrence:

1) The first group consists of symptoms with very low frequency (in ≤ 20% of participants). A small number of students (7–13) reported experiencing general discomfort, headache, dizziness (with eyes closed), increased salivation, nausea, sweating, and panic, indicating that these symptoms occur sporadically and do not represent a widespread phenomenon in the sample. Although the number of participants reporting these symptoms is relatively small, it is important to pay attention to these occurrences at the individual case level. Nevertheless, their impact is not

pronounced enough to pose a serious obstacle to the implementation of VR technology in education.
2) The second group consists of symptoms with medium frequency (between 20% and 40% of participants), such as fatigue, dizziness (open eyes), eyestrain, burning sensation in the eyes, difficulty focusing, difficulty concentrating, fullness of the head, postural instability (imbalance), sleepiness, and fear. These symptoms occur in approximately one-third of students and indicate a need to monitor and assess children's psychophysiological state, especially when VR is used for the first time for instructional and learning purposes.
3) The third group of symptoms consists of the most frequent ones (experienced by over 40% of participants). Nearly half of the students reported experiencing blurred vision and spatial confusion (disorientation), suggesting that special attention should be given to preventing these symptoms and to further investigating their causes in both health and educational contexts. If these symptoms occur almost every time, they may lead to other health problems and, in any case, hinder learning and the observation of virtual scenarios, which could subsequently condition a recommendation against the use of VR.

Based on these findings, the symptom spatial confusion (disorientation) was the most prominent risk-related symptom, as it was experienced by more than half of the participants, specifically 55.7% of the students. It can be more precisely described as the feeling of *not knowing where I am* or as a loss of sense of space and time. These results corroborate previous studies, in which *disorientation* is associated with the vestibular system and categorised among the symptoms most frequently reported following VR experiences (Johnson, 2005: 28; Josupeit, 2023: 2; Kim et al., 2005: 616; Palmisano & Constable, 2022: 1380; Pawełczyk et al., 2025: 11). Similarly, Simón-Vicente et al. (2024: 704-708) report that participants exposed to a VR environment for less than 10 minutes showed a higher level of disorientation compared to those whose exposure lasted 10 minutes or longer.

Research Task 4: A chi-square test of independence (χ^2) was used to examine the association between the Behavioural Intention to Use variable and the presence of cybersickness symptoms. All of the potential negative symptoms listed may lead to varying degrees of influence on behavioural intention to use VR in the future. Therefore, it is of critical importance to investigate whether participants, despite experiencing specific cybersickness symptoms, still intend to continue using VR technology in instruction.

Assuming that beliefs drive attitudes, which lead to intentions, which result in behaviours (Zhao & Cleesuntorn, 2023: 93), this further suggests the premise that if a VR user believes that VR serves a learning purpose, the presence of side effects may still ultimately result in a defined intention to use VR. All 19 symptoms were cross-tabulated with individual BIU items, and the results presented in Table 7 highlight only the statistically significant values.

Table 7. *Chi-square Test Results: Behavioral Intention to Use* and *Cybersickness Symptoms*

	χ^2	df	p
BIU1*N06	7.982	2	.018
BIU1*N11	7.027	2	.030
BIU2*N11	7.223	2	.027
BIU3*N18	6.429	2	.040

Significant correlations point to the following conclusions: Although participants reported eyestrain ($p = .018$) and nausea ($p = .030$) while using virtual reality (VR), they still consider that VR makes learning more engaging (BIU1). Additionally, despite experiencing nausea ($p = .027$) during VR use, participants believe that using VR in schools is a good idea (BIU2). Furthermore, although some participants reported fear while using VR ($p = .040$), they expressed a desire to use VR in different subjects for learning (BIU3).

Conclusion

Virtual reality is viewed as a technology capable of driving innovative change across all levels of education. Immersive VR environments can enhance learning outcomes by providing experience-based learning and high student engagement. By activating multiple senses, VR helps create long-lasting knowledge and supports the development of both subject-specific and lifelong learning competencies in safe, controlled conditions. However, despite its many advantages, it is essential to consider the potential adverse effects of VR use, especially among younger learners, to ensure its meaningful and responsible application in education.

The paper distinguishes between the concepts of motion sickness, simulator sickness, and cybersickness, highlighting cybersickness as a set of psychophysiological reactions to conflicts among sensory signals from the visual, vestibular, somatosensory, and other systems when the body is exposed to a virtual environment it does not perceive as familiar. Sensory mismatch arises due to the influence of various factors, which can be either intrinsic or extrinsic in origin, with individual differences emerging as one of the dominant factors (Cobb et al., 1999: 184–185; Rebenitsch & Owen, 2016: 103) affecting how a person experiences the virtual environment and responds to it. Numerous theories attempt to explain these phenomena, including the Sensory Conflict, Postural Instability, Rest Frame, Poison, Flow, Adaptation, Sensory Rearrangement, and Vection Conflict theories, as well as the Theory of the Subjective Vertical Conflict.

The primary focus of the research was on the identification of individual cybersickness symptoms and their interrelationships, with an emphasis on their impact on the future intention to use VR technology in education. Through a comprehensive analysis, 19 of the most prevalent cybersickness symptoms in the literature on VR use in education were identified. The initial basis for the study and the development of the research instrument was the Simulator Sickness Questionnaire (SSQ) by Kennedy et al. (1993) which was modified to some extent. The SSQ model was modified by excluding vertigo, stomach awareness, and burping, and by adding the following symptoms: burning sensation in the eyes, spatial confusion (disorientation), postural instability (imbalance), and sleepiness, thereby covering the most significant symptoms from the nausea, oculomotor, and vestibular categories. Considering that the sample consisted of seventy primary school students aged nine to ten, our model was further expanded with two additional emotional–physiological items, fear and panic, which are particularly important from a pedagogical perspective.

The results of the four research tasks indicate that there are no statistically significant differences between males and females in the majority of reported symptoms experienced during VR use. Since the p-value for 18 symptoms exceeds the conventional threshold ($p < .05$), it can be concluded that the frequency of cybersickness is similar for both genders. A statistically significant difference was observed only for the symptom of sweating ($p = .034$).

Based on the results of the Factor analysis, the symptoms were grouped into four factors, arising from the effects of a fully immersive environment on individual perception, particularly in the visual, auditory, tactile, vestibular, and locomotor systems. The student perceives and experiences the virtual scenario as a real space in which they can move, hears sounds integrated into the virtual environment, and interacts with digital objects, which further implies full engagement in the cognitive, emotional, and psychomotor domains. The first factor includes increased salivation, dizziness (with eyes closed), fatigue, and panic; the second factor includes headache, dizziness (with eyes open), and nausea; the third factor comprises difficulty focusing, postural instability, and spatial confusion, indicating simultaneous cognitive–emotional and vestibular challenges in children. The fourth factor connects general discomfort and eyestrain, suggesting that visual fatigue often accompanies subjective discomfort during VR use.

Based on the frequency of individually reported symptoms, it can generally be concluded that fewer participants reported experiencing cybersickness. However, even occasional adverse effects can lead to negative consequences, particularly among younger school-age students. Therefore, these effects were descriptively categorised into three symptom groups: low, medium, and high frequency. The low-frequency group consists of symptoms reported by fewer than 20% of participants, including general discomfort, headache, dizziness (with eyes closed), increased salivation, nausea, sweating, and panic. The medium-frequency group includes fatigue, dizziness (open eyes), eyestrain, burning sensation, difficulty focusing and concentrating, fullness of the head, postural instability, sleepiness, and fear, reported by 20–40% of participants. The high-frequency group comprises the most at-risk symptoms, blurred vision and spatial confusion (disorientation), with more than 40% of participants reporting them. The most prominent risk-related symptom is spatial confusion (disorientation), as it was experienced by over half of the participants (N=39).

The results of the chi-square test of independence (χ^2) indicate that participants, although experiencing some negative effects of VR, still intend to use it in the future. They consider that VR makes learning more engaging, even though they experienced eyestrain and nausea during use. While VR may cause nausea in some cases, participants also believe that using VR in schools is a good idea. They would use VR for learning other school subjects as well, even though virtual environments may occasionally provoke fear.

All of the above support the conclusion that for developing effective pedagogical interventions, an accurate and real-time assessment of cybersickness is immensely important (Long et al., 2025: 2). Therefore, we propose several pedagogical recommendations to overcome and potentially fully mitigate these adverse effects.

Pedagogical recommendations for mitigating symptoms

The complexity of using VR, especially in an educational context, leads us to consider strategically how to maximise this technology's potential while fully acknowledging the underlying assumption that it can induce cybersickness. Starting from the premise that „cybersickness in itself is an adverse experience" (Mittelstaedt et al., 2019: 2), we emphasise the importance of considering all potential side effects and propose measures that may help reduce or eliminate the symptoms.

1) The VR user's static seated position, particularly during the initial attempts at using this technology, may influence the experience. Study such as Pawełczyk et al. (2025: 1) has shown that, despite the potential risk of cybersickness symptoms, experiencing VR in a seated, passive manner can still foster feelings of satisfaction and fulfilment, while enabling participants to interact with the virtual environment actively.

2) Gradual increase in the number of repetitions and duration of VR session leads to a reduction of negative symptoms of cybersickness. Palmisano and Constable (2022: 1384) observed that, as expected, cybersickness tended to grow with longer gameplay sessions but diminished upon a second exposure to the same HMD VR game. According to Johnson (2005), in most individuals, symptoms of simulator sickness subside within 1 hour, while those lasting more than 12 hours are rare. Most users adapt after a few sessions, whereas some require longer and more frequent exposure, and a small percentage (3–5%) never fully adapt. Therefore, it is recommended to gradually increase the time spent in VR and to expose children to virtual scenarios more frequently to facilitate adaptation and reduce cybersickness symptoms. Previous studies (Doty et al., 2024; Risi & Palmisano, 2019) have shown that repeated exposure to VR reduces cybersickness intensity, a strategy referred to in the literature as Cybersickness Abatement from Repeated Exposure (CARE). Riecke and Keshavarz (2025: 56) recommend several proactive strategies to mitigate cybersickness before and between VR sessions. These include gradually adapting to VR through

habituation, preparing according to individual needs, and taking regular breaks while paying attention to bodily signals.

3) Providing higher-quality VR hardware and software helps reduce the frequency and severity of cybersickness symptoms (Lundin et al., 2023: 2; Rebenitsch & Owen, 2016: 102). Although the relationship between cognitive and physical activities and the familiar sensations of cybersickness is not fully understood and can be unpredictable for developers (Setu et al., 2024: 1048), developers should minimise sensory mismatch by offering room-scale environments that allow users to move naturally in both the physical and virtual worlds (Caserman et al., 2021: 1170).

4)To define clear criteria for evaluating VR apps. Vlahovic et al. (2024: 108) emphasise the need to define clear, transparent evaluation criteria for VR, as standardised systems for assessing the comfort of individual VR applications do not yet exist. The evaluation of VR applications, especially those used for educational purposes, should encompass far more comprehensive and sophisticated criteria than those used for standard app store assessments. In this regard, Kaser et al. (Kaser et al., 2019: 66–68) suggest calculating the overall VR rating by averaging scores across six categories, including Motion, Interactivity and Usability, Content, Audio, and Stability. Before reviewing an app, students thoroughly research and test it from an educator's perspective, rather than focusing solely on entertainment. This process involves analysis, categorisation, and evaluation, fostering critical thinking and independent reasoning, while aligning with the principles of Bloom's Taxonomy. For assessing the therapeutic effects of VR and alleviating cybersickness, the literature suggests various approaches, such as applying 10 Hz tACS to the vestibular cortex (Benelli et al., 2023:1805) or using the HEP method to measure motion sickness and new indicators for more precise evaluation of symptoms (Park et al., 2022).

Implications

A systematic review of the literature conducted by Simón-Vicente et al. (2024:704) found that the quality of information on VR-related side effects remains limited. Although Biswas et al. (2024: 284: 2, 26) noted the lack of standardised metrics, recent developments in artificial intelligence and Machine Learning (ML) have helped interpret and validate these measurements, improving our understanding of the mechanisms underlying cybersickness and other VR-related phenomena.

In this regard, future research should employ a variety of tests to measure cybersickness, not only after the immersive experience (self-report measures) but also during the experience itself, using task performance metrics and physiological measurements. Various scales can be applied, such as the Visual Analogue Scale, the Fast Motion Sickness Scale, the Virtual Reality Sickness Questionnaire (Lundin et al., 2023: 2), or the Virtual Reality Neuroscience Questionnaire (Klein Tuente et al., 2018), while Duzmanska et al. (2018: 5) also emphasise the importance of Behavioural measures, such as Postural stability tests. Additionally, measurements can be made more precise by using devices such as electroencephalography (EEG), electrodermal activity (EDA), and electrocardiogram (ECG) (Long et al., 2025: 2). Conduct longitudinal studies to examine the long-term effects of physical and artificial motion on user experiences (Hussain & Heena, 2024: 6), across different participant groups (Josupeit, 2023: 10) and with larger sample sizes.

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