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Virtual reality exposure therapy for reducing students' public speaking anxiety: A systematic review

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Public speaking often imposes a nerve-wracking atmosphere in the L2 classrooms. Consequently, an alternative to the anxiety-arousing activity by using advanced technology for pedagogy is urgent. Prior publications reported the use of virtual reality (VR) for training public speaking and alleviating students' public speaking anxiety (PSA). However, no latest review in this area has been published. This present study employed a systematic review to delineate the trends in the latest decade (between 2011 and 2023), synthesizing research outcomes, methodologies, loci, participants, treatment duration, and research focuses. This systematic review was based on inclusion and exclusion criteria. Conceptual and theoretical studies were removed, yielding 16 studies with empirical data to be thoroughly examined. Most studies indicated the effectiveness of VR for teaching public speaking and reducing speech apprehension. Several gaps were disclosed, such as the inconsistency of the research findings regarding whether the short duration of VR exposure resulted in the statistically non-significant effects, the unequal distribution of research loci which were mostly reported from the US, the UK, and Europe, and the major focus on English as L1 instead of L2 public speaking training. The results of this review suggest that more pertinent studies in countries with EFL or L2 learning contexts and longer treatment duration be conducted and reported in the globally renowned English-language journals to verify the effectiveness of VR technology in treating PSA.

Keywords: virtual reality, immersive, public speaking anxiety, technology-enhanced language learning, computer assisted language learning, L2, English as a foreign language

Introduction

Public speaking constitutes one of indispensable skills students need to hone as they progress through their education, society integration, and more promising professions. However, speaking in public has been mostly reported to cause fear and anxiety among the general population and Western society (Sawyer, 2016; van Veen et al., 2024; Zhou et al., 2021). Such fear comes from the uneasiness of being observed and judged by audiences. Public speaking anxiety (PSA) belongs to social anxiety disorder (SAD) that speakers experience when preparing to deliver ideas in front of other people or giving a speech publicly. As a common phobia faced by public speaking learners, PSA continuously seeks potent relief and treatment. It is urgent as persons who suffer from PSA will have a negative effect on both their emotional and physical wellbeing (Gallego et al., 2021). Early detection of PSA is considered crucial to set forth prevention and necessary steps to cure such anxiety.

A face-to-face public speaking activity has positioned speakers in a confronting environment, leading to inevitable PSA among novice public speakers or English learners. In response to the challenge of performing in-person public speaking and the urge of acquiring public speaking ability as a preparation for job-related positions that mostly require public speaking skills, learners' anxiety during performing public speaking activity should be overcome. Virtual reality (VR) offers a potential environment to facilitate learners to practice in a replica of the world and mitigate learners' anxiety. VR simulates and resembles the real world and provides its users with auditory, visual, and tactile senses to explore; more specifically, it creates a sense of immersion or being teleported into a certain designated environment (Xie et al., 2021). Along their learning stages, not all learners are completely ready to communicate in the real-world setting. VR, hence, serves as a potential environment that instructors can utilize to facilitate their learners' journey to acquire public speaking skills. Exploring a virtual environment by moving their physical body, receiving tactile feedback from the VR scene, and interacting with virtual audiences augments students' virtual experience with real objects in a virtual auditorium (Polydorou, 2021). Rooting back to the issue of speech apprehension in a public speaking activity, the safe environment offered by VR platform is predicted to reduce learners' language anxiety (Lindner et al., 2019; Reeves et al., 2021; Zheng & Cheng, 2018).

Relevant publications from both Web of Science and Scopus databases have shown that the very first empirical study on this area was conducted in 2002 (Harris et al., 2002). Over two decades, the advancement of VR technology has contributed a personalized medication for PSA among students; however, the number of relevant and specific studies remains limited. Previous studies revealed how VR technology has been utilized to potentially treat the students' PSA (Hinojo-Lucena et al., 2020). Not only does VR technology offer

an alternative environment for students' English practices (Oh, 2021; Thrasher, 2022), but it also provides authentic-like environment for more contextualized English speaking activities (Dooly et al., 2023; Hung et al., 2023). Due to the potential benefits of VR environments for English public speaking teaching, VR technology is expected to be more broadly used in the near future. Since its prototypical form in the early 2000s, pertinent research has been published. VR technology has significantly advanced and been increasingly utilized in the past decade and a half (from 2011 to 2023). Most prior studies have reported how VR technology has been developed and utilized to teach public speaking and reduce students' speech apprehension. However, no reviews have been found to have been published most recently. With a dearth of existing reviews on the latest research regarding VR technology as the treatment for students' speech apprehension during performing public speaking using English as both L1 and L2, this systematic review aims at delineating the latest trends between 2011 and 2023 by posing three research questions as follows:

1. What were the results of the previous studies published between 2011 and 2023 regarding the effectiveness of VR treatment to reduce students' PSA?
2. What trends appeared in the VR studies to treat students' PSA? What research methodologies and focuses were selected in the reviewed studies?
3. What concerns and research gaps are found among the reviewed studies?

Literature review

Public Speaking Anxiety (PSA)

Public speaking is one of the soft skills students should acquire to successfully progress from their education to future careers. This is in line with one of the main missions of education that is to provide extensive opportunities for learners to sharpen their social abilities (Najafi et al., 2016). The succeeding term bound to public speaking performance is PSA. PSA is an affective factor that refers to apprehension when facing social situations. Individuals with PSA or SAD affectively tend to worry about their performance in public, either for behaving embarrassingly or being judged negatively by other people (Kampmann et al., 2016). In addition, individuals with this social phobia will typically show a persistent and marked distress of performance in social situations that expose them to the scrutiny of others (Makkar & Grisham, 2011). Their self-underestimation to perform effectively results in the inability to perform well during oral presentations (Leviton et al., 2012).

Marked by intense avoidance and fear, individuals with PSA will find it hard to adjust to social situations. A misperception that their target audiences always expect adept speaking skills will cause speakers to be maladaptive to social settings. The misperception fosters the detriment of self-confidence and efficacy to speak up in general public (Lipton et al., 2020). These individuals are prone to describe themselves as always being nervous in public speaking

situations. The negative perception will accordingly influence the efficiency of speech productions (Robinson & Gilabert, 2007). Failure to adapt to depressing situations of public speaking will worsen the impact of this social anxiety disorder. The fluent speech productions as well as the competency of interpersonal and communication skills are at stake (Tejwani et al., 2016).

Introducing students who grapple with PSA problems to some communication knowledge and skills will train them to be capable of speaking publicly and competently about key issues in their society (LeFebvre et al., 2018). With the major aim to resolve the critical barriers to competent public speaking, providing the necessary support to anxious learners should be approached from conceiving anxiety as a pervasive psychological emotion of the learners (Zheng, 2008). Teachers should seek and implement anxiety-reducing strategies when conducting public speaking trainings. Teacher intervention plays a vital role in significantly decreasing the level of learners' speech apprehension (Alrabai, 2014). Therefore, there is an urgent need to find an alternative setting for teaching public speaking while addressing learners' apprehension.

Virtual reality technology in L2 public speaking pedagogy

One of the technology tools that aids classroom practices is virtual reality (VR), which is currently termed as an immersive VR environment. These two terms, VR and immersive VR, need to be clearly defined. VR is the former term used to describe the technology that digitizes the real world into a virtual scene. The virtual scene is accessible through a computer desktop with a built-in, visualized, and digitalized computer system (Martín-Gutiérrez et al., 2017; Melchor-Couto, 2016). The recent development of VR has introduced immersive technologies that incorporate both visualization and interaction in VR environment (Radianti et al., 2020). This current VR platform is labeled as immersive VR that is accessible via a head-mounted display (HMD) device. Immersive VR allows its users to experience a higher degree of immersion in a virtual environment compared to the PC-based VR screens.

The sense of presence and immersion in VR technology represented by avatars imparts extensive opportunities for experiential learning and engagement to occur upon learning (Jaller & Serafin, 2020; Schott & Marshall, 2018) via the simulation of real-life interaction. The interaction with virtual objects or characters incorporates advanced scenography, live performance, and spatial sound to enable its users to transition into heightened real-time and real-life environments (Chien et al., 2020). Virtual scene is also believed to devise a learning environment that is intelligibly leading to a better recall of language as compared to learning from a conventional setting (Krokos et al., 2018; Lee, 2022a). Due to the enhanced immersion, accessing virtual scenes by utilizing HMD has been proven to amplify memory recall better than a mere traditional desktop scene.

With a strong emphasis on creating a learning environment that will submerge students into real settings for naturalistic, authentic, and contextualized learning (Brown & Lee, 2015; Saville-Troike & Barto, 2017), the use of

immersive VR technology can be maximized in L2 classrooms. By utilizing a customizable VR-based metaverse platform and putting on an HMD with a head-tracking feature, constructivist L2 learning principles such as interactive, motivating, and contextualized learning can be grounded to facilitate L2 learners to explore and learn in the VR-based space (Lee, 2023). In this way, learners will have more memorable learning experiences as they are exposed to vivid and context-based context based L2 speaking practices in this digitalized world. Regarding pressures in performing L2 public speaking, it is expected that teleporting prospective public speakers into a non-threatening learning environment would lower and resolve their anxiety (PSA). Immersive VR technology potentially relieves students' anxiety levels because the virtual environment cultivates a safe environment and stress-free atmosphere for oral practice and public communication (Melchor-Couto, 2016). Avatar-represented presence brings up the sense of being "shielded" and anonymous, which in turn favors learners with PSA to increase their self-confidence to communicate along their decreased apprehension (Deutschmann & Panichi, 2013; Di Natale et al., 2020; Sadler & Thrasher, 2023). Following the lowered speech apprehension, L2 learners are conditioned to be more active and vocal in their public speaking training. Immersive VR platform enhances the engagement between content and context of learning and the opportunity to interact more with other students (Lloyd et al., 2017).

Method

Researchers and educational practitioners should have ample insight and information regarding the trends of technology-enhanced instructional activities that are effective to facilitate students' learning. However, it will take considerably long time and abundant effort to search and read through each previous study and relevant literature before determining to utilize certain technology in the classrooms. Accordingly, a well-designed systematic review will save researchers' and teachers' time and energy by presenting pre-filtered evidence regarding the topic of their interest (Hinojo-Lucena et al., 2020; Lee, 2022b). A systematic review synthesizes the results of various germane studies by adhering to scientific and systematic principles. A systematic review makes sense of large bodies of outputs and contributes information about what has worked well and has not across the reviewed studies (Cruz-Benito et al., 2019; Petticrew & Roberts, 2006). The current study adapted a systematic review to provide synthesized evidence from a number of previous studies on the use of VR technology to reduce students' speech apprehension (PSA).

Search strategy

The search of this systematic review was established from the application of descriptors in major academic journal databases, namely: Web of Science (WoS), Scopus, Science Direct, EBSCO, ProQuest, and Google Scholar. These major databases have globally recognized impact indices, such as: Journal

Citation Reports (JCR) for WoS and Scimago Journal and Country Rank (SJR) for Scopus (Aznar et al., 2018). The descriptors were set and applied in the search engine of all databases by using the following keywords: “virtual reality”, “immersive”, “virtual reality exposure therapy (VRET)”, “virtual reality exposure intervention (VRED)”, “public speaking”, “public speaking anxiety”, and “speech apprehension”. The search covered journals or articles published from 2011 to 2023 to tap the trends during the latest decade. In addition to the search through the major databases, a manual search of a number of journals was conducted to collect additional sources. The sources included ReCALL journal, MDPI, CALICO Journal, Cyberpsychology & Behavior, International Journal of Emerging Technologies in Learning, CyberTherapy and Telemedicine, Frontiers in ICT, Computers and Education, and Journal of Anxiety Disorders. The process of article selection was guided by the inclusion and exclusion criteria as shown in Table 1.

Table 1. Inclusion and exclusion criteria of the reviewed studies

Inclusion criteria	Exclusion criteria
journal articles	conference proceedings, book chapters, or other non-peer-reviewed publications
empirical studies	conceptual and theoretical studies
globally renowned academic papers written in English	non-English-written articles
utilizing VR technology for treating PSA	not mainly using VR technology for reducing PSA
students as the participants	non-students as the participants

Data collection and analysis

The articles that investigated public speaking training without incorporating the use of VR as the main treatment for speech apprehension were removed in the first round of the search, filtering 39 articles. The second stage was reviewing all those initial 39 articles and eliminating 7 articles that were conference proceedings or non-peer-reviewed publications. This stage resulted in 32 studies. After reviewing 32 studies, 16 studies were removed because they dealt only with the conceptual, theoretical, architectural, technical, and hardware constructs of VR technology, rather than experiments that resulted in empirical data on the effectiveness of PSA therapy using the technology. At the final step of the data collection, 16 articles were selected to be included in this systematic review. The number of publications regarding the use of VR technology for language learning specifically for public speaking training was not as many as expected, given the paucity of VR facilities and the issue of affordability of VR technology to serve students in all countries. The procedure of the research method including article screening and data collection was summarized in Figure 1.

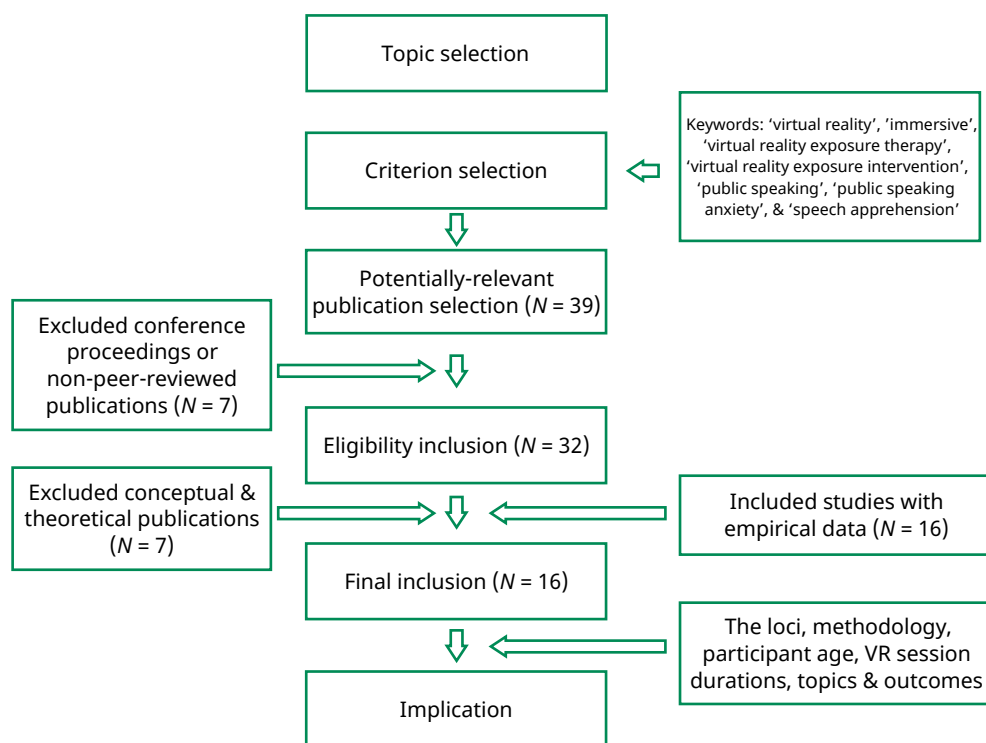


Figure 1. Flow diagram of research method

The systematic review employed some data analysis stages. The strategy used for the analysis was mainly comprehensive reading. In the first stage, the key information about each reviewed study was recorded in a spreadsheet, extracting publication information, loci, methodology, participants, treatment duration, topics, learning context, and outcomes. The second stage was calculating the frequency of each information to depict the trends of the reviewed studies. Finally, all reviewed studies were categorized based on each investigated domain and presented as the answers to the three research questions of this systematic review. The gaps in several domains were identified to propose implications of the current study.

Results

The current study revealed the trends of the previous studies on the use of VR technology as a personalized treatment for students' speech apprehension over the past decade. The trends included the research outcomes, methodologies, demographic information related to the countries as the research loci and the ages of the participants, the lengths of VRET/VREI sessions, and the topics/foci of the research.

Regarding the effectiveness of immersive VR-based instruction to treat the students' PSA, this systematic review classifies the previous studies into two groups, those with the significant effect ($N = 13$) and non-significant effect of VRET ($N = 3$). The majority of previous studies found statistically significant differences between the experimental group and control group or between the pre- and post-test scores of the participants. Immersive VR has been proposed to be a potential learning environment to alleviate speech apprehension among the students (Dubiago et al., 2017; Morina et al., 2015; Parrish et al., 2016; Rodero & Larrea, 2022; Sülter et al., 2022). Other previous studies revealed the efficacy of immersive VR environments to reduce the students' speech apprehension (Kahlon et al., 2019; Lindner et al., 2019; Stupar-Rutenfrans et al., 2017). These studies highlighted significant decreases of the self-reported PSA with the strong decrement evident in the students with formerly high apprehension levels. Their findings corroborated the efficacious effects of virtual reality hardware and software to cure the students' PSA.

After a series of the virtual exposure training, five previous studies additionally reported that the students' anxiety symptoms were significantly lessened. The lessening of the anxiety symptoms was detected along with the students' increased self-confidence to perform more presentations and discussions in various public speaking settings (Kahlon et al., 2019; Kaplan-Rakowski & Gruber, 2023; Lindner et al., 2019; Premkumar et al., 2021; Sülter et al., 2022). These previous studies physiologically and psychologically measured the anxiety symptoms such as rapid heartbeat, nervousness, and sweaty hands of the students during performing the public speaking activities. Along with the decreased speech apprehension symptoms, the results showed significantly positive improvements of the students' public speaking performance after the implementation of the self-guided VR exposure.

Based on the review on the effectiveness, efficacy, and effects of immersive VR-based training to relieve the students' speech apprehension, most of the previous studies have proven to yield statistically significant results. The significant results were also accompanied with a statistically significant reduction of fear of negative evaluation (FNE) from the audiences. Accordingly, VRET/VREI could be proposed as a potent and cost-effective solution for coping with the students' PSA and FNE (Nazligul et al., 2019; Reeves et al., 2021). The students under the investigation of one previous study also reported to be more willing to communicate in public and were equipped with higher levels of self-perceived communication competence (Heuett & Heuett, 2011). Compared to the traditional intervention, VRET/VREI has been proclaimed to specifically lower the levels of the students' speech apprehension, encourage them to communicate in the public speaking setting, and improve the self-perceptions of their communication ability.

The potential use of immersive VR to simulate the students' real-life experiences and cope with their affective factors was also underpinned by the findings of other previous studies. The students' self-efficacy (Morina et al., 2015; Parrish et al., 2016) and emotion regulation strategies (Stupar-Rutenfrans et al.,

2017) were reported to statistically increase along with the reduced PSA after VRET/VREI. The students were more confident about their ability to accomplish the public speaking tasks and could devise some strategies to cope with their emotion and stress levels. Regarding gender differences, in addition to proving the significant effect of the immersive VR trainings on reducing the students' PSA, one previous study found a significant difference between male and female students (Rodero & Larrea, 2022). Male students showed a higher level of anxiety than their female counterparts. This finding broke the stereotype that men were less anxious than women in public speaking activities. In this previous study, the immersive VR trainings were found to be more effective to reduce PSA among the female than male students.

While most of the previous studies resulted in the statistically significant differences between the experimental group and control group or between the pre- and post-test scores of the participants, three previous studies found contradictory results. The implementation of VRET/VREI to alleviate the students' PSA yielded a non-significant effect. After teleporting the students to a mock public speaking setting in a virtual space, the speech apprehension of the students was not statistically reduced (Wilsdon & Fullwood, 2017). They found that the students' PSA was not affected after participating in the immersive VR public speaking tasks and the increased immersion (simulation fidelity) did not significantly reduce the students' fear of public speaking. However, the students reported a positive mood shift during their immersion in the VR environment. The researchers predicted that the short duration of exposure to the immersive VR-based environment, within merely one session, was the contributing factor to this insignificant finding.

The other two studies also reported the non-significant effect of VR-based public speaking training as a form of VRET/VREI on PSA and the insignificant improvement of the participants' confidence (Poeschl, 2017; Poeschl & Doering, 2014). Investigating the effect of VR simulation fidelity on the presence and experience of the users in a public speaking application, this experimental study resulted in a null effect (Poeschl & Doering, 2014). The predictor for this insignificant result was the indication that the application did not seem to be realistic enough and was presented in a simple and prototypical alpha version. Further development of the public speaking application needs to be tested for measuring potential effects. In the succeeding year, the students were teleported into a virtual public speaking setting and exposed them to an immersive VR-based lecture room. Using the QUEST-VR framework, focusing on the system, characteristics of users, and system-user interactions, this study also yielded a non-significant effect (Poeschl, 2017). The absence of a virtual training session ahead of the treatment, which could serve as the background experience for the participants with this system, was predicted to cause task difficulty. Task difficulty apparently had a large effect on the public speaking performance.

The outcomes of the reviewed studies with the statistically significant and non-significant results of VRET/VREI in reducing the students' speech apprehension are presented in Table 2 below.

Table 2. Outcomes of the reviewed studies

Researchers	Years	Statistically significant effect	Statistically non-significant effect
Heuett, B. and Heuett, K.	2011	✓	
Poeschl, S. and Doering, N.	2014		✓
Morina et al.	2015	✓	
Parrish et al.	2016	✓	
Dubiago et al.	2017	✓	
Stupar-Rutenfrans et al.*	2017	✓	
Poeschl, S.	2017		✓
Wilsdon, L. and Fullwood, C.	2017		✓
Lindner et al.	2019	✓	
Nazligul et al.	2019	✓	
Kahlon et al.	2019	✓	
Reeves et al.	2021	✓	
Premkumar et al.*	2021	✓	
Rodero, E. and Larrea, O.	2022	✓	
Sülter et al.	2022	✓	
Kaplan-Rakowski, R. and Gruber, A.*	2023	✓	

Note. *Reviewed studies related to L2 learning

Research methods

In terms of research methodologies, all reviewed studies employed a quantitative method. All studies conducted experiments to statistically verify whether VRET/VREI could reduce the students' speech apprehension. A closer investigation on the methodologies inferred and categorized the reviewed studies into two types of experiments: a) with two groups of students ($N = 6$) and b) with one group of students ($N = 10$). The first design divided the students into two groups, the experimental and control groups. The experimental groups received the exposure to virtual reality environment as the treatment of PSA; while the control groups were treated using usual trainings for public speaking such as in-class oral presentations, cognitive behavior therapy, and Zoom meeting platform (Heuett & Heuett, 2011; Kaplan-Rakowski & Gruber, 2023; Nazligul et al., 2019; Reeves et al., 2021; Rodero & Larrea, 2022; Sülter et al., 2022).

The second design dealt with one group of students. All students received the same virtual reality treatment to cope with their speech apprehension. This design employed pre- and post-tests to the whole participants to attest the effectiveness of VRET/VREI in reducing their PSA (Dubiago et al., 2017; Kahlon et al., 2019; Lindner et al., 2019; Morina et al., 2015; Parrish et al., 2016; Poeschl, 2017; Poeschl & Doering, 2014; Premkumar et al., 2021; Stupar-Rutenfrans et al., 2017; Wilsdon & Fullwood, 2017). Because all reviewed studies investigated the students' speech apprehension levels across the treatments, a self-reported public speaking anxiety scale was the most common data collection instrument.

Inferential statistics such as t-test, Wilcoxon signed-rank test, Mann–Whitney U-test, ANOVA, and ANCOVA were most frequently employed. In this systematic review, there was no qualitative study found. All studies measured the statistically significant effects of VRET/VREI on reducing speech apprehension, and thus experimental studies.

Figure 2 showcases the trend of the quantitative method in the reviewed studies based on the designs of experiments.

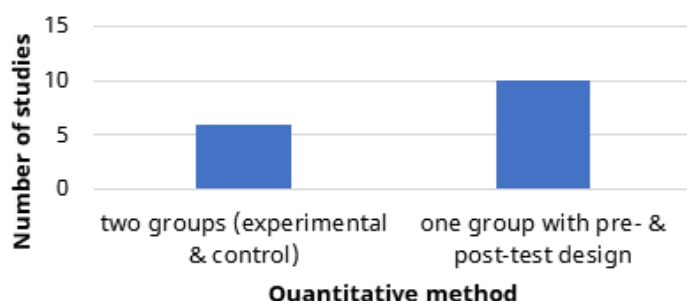


Figure 2. Designs of quantitative method in the reviewed studies

Demographic data

Another highlight of the review was the trend of the countries where the pertinent studies were conducted. All reviewed studies were largely conducted in the Western countries, namely: the United States (US), the United Kingdom (UK), Germany, the Netherlands, Sweden, Norway, Turkey, and Spain. Most of the reviewed studies reported the use of VR-based environments to cure speech apprehension in European countries (Hinojo-Lucena et al., 2020). Two previous studies in this field were conducted in the US (Heuett & Heuett, 2011; Parrish et al., 2016). In addition to the US, the use of VR technology to cure PSA has been investigated in the UK. The first study was reported to be conducted in Wolverhampton (Wilsdon & Fullwood, 2017). Another study conducting VREI using 360° Video application was tested in Queen’s University Belfast, North Ireland (Reeves et al., 2021). In the same year, the other study on self-guided VRET for speech apprehension was conducted in London and Nottingham (Premkumar et al., 2021). In this way, three reviewed studies reporting the use of immersive VR for curing PSA were accrued from the British researchers ($N = 3$).

Other researchers in Europe have also been interested in scrutinizing the effectiveness of VR-based exposure to reduce PSA for almost one decade. Germany started this research trend in Europe. Three studies were reported from Ilmenau University of Technology, Germany. The first study was conducted by two German researchers (Poeschl & Doering, 2014). In the succeeding year, another study was conducted by one similar researcher to the previous study in the mid-sized Germany university (Poeschl, 2017). The other study was reported by three German researchers; two of whom were the same research team members as the first two previous studies (Dubiago et al., 2017). The most

recent study added the list of German researchers who conducted the intervention of the high-immersion VR environment to treat PSA (Kaplan-Rakowski & Gruber, 2023). To this point, four reviewed studies were recorded in Germany ($N = 4$).

Neighboring Germany, the Netherlands also contributed a number of research reports in this area. One project was run as a proof-of-concept pilot study to use VR technology to reduce the students' PSA (Morina et al., 2015). Another study was conducted in the Dutch and International Universities in the Netherlands (Stupar-Rutenfrans et al., 2017). The latest study designed, utilized, and tested a virtual reality application to decrease the Dutch elementary school students' general speech apprehension (Sülter et al., 2022). Thus far, three reviewed studies have been recorded in the Netherlands ($N = 3$). Other than Germany and the Netherlands, the following studies reported on the adaptation of immersive VR-based environments to reduce speech apprehension in other European countries. The study reports were collected from Sweden, Norway, Turkey, and Spain. One of the reviewed studies in this area was reported by Swedish researchers who conducted their study in Stockholm (Lindner et al., 2019). In Norway, one study of VRET was targeting the onset of speech apprehension (Kahlon et al., 2019). Another study was reported by Turkish researchers (Nazligul et al., 2019). Turkey is included in the regional category of European countries considering its geographical location as a trans-continental country bordering Southeastern Europe and Western Asia. The other experiment to treat speech anxiety using the immersive VR technology was conducted by Spanish researchers in Barcelona (Rodero & Larrea, 2022). In total, there were eleven reviewed studies recorded across the European continent ($N = 11$).

The distribution of the countries where VRET/VREI has been conducted to cure the students' speech apprehension is shown in Figure 3.

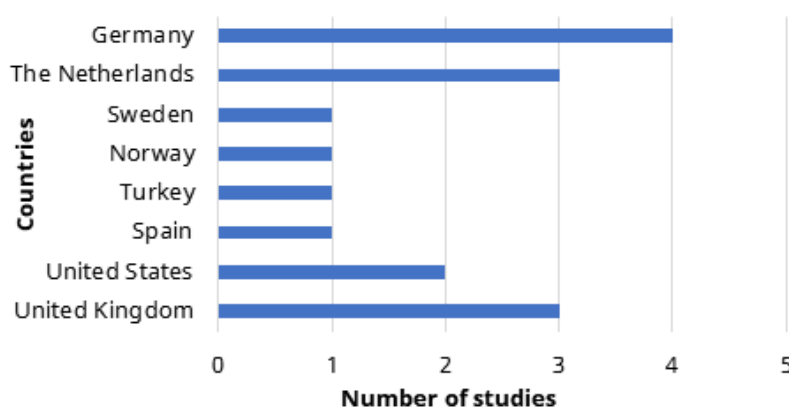


Figure 3. Country distribution of the reviewed studies

Based on the age ranges of the participants, the reviewed studies could be categorized into three different target participants, namely: college students, adolescents, and children. Most of the reviewed studies ($N = 13$) recruited university

students as the research subjects (Dubiago et al., 2017; Heuett & Heuett, 2011; Kaplan-Rakowski & Gruber, 2023; Lindner et al., 2019; Morina et al., 2015; Nazligul et al., 2019; Poeschl, 2017; Poeschl & Doering, 2014; Premkumar et al., 2021; Reeves et al., 2021; Rodero & Larrea, 2022; Stupar-Rutenfrans et al., 2017; Wilsdon & Fullwood, 2017). The college students' ages ranged from nineteen to twenty-four years old. The mean age of the participants in most reviewed studies was around 21.0 to 22.3. The major trend of implementing VRET/VREI to reduce PSA in the tertiary level of education is predictable. It is rationally explainable through the setting that university is the education stage that sharpens the students' public speaking skills. College or university students are to be prepared for their future professions. Most promising jobs require an adept demonstration of public speaking abilities. Additionally, most school-teachers are not researchers; most university professors are. Therefore, it is much more likely that they will conduct studies on their own students at the universities, rather than reaching out to high schools and elementary schools. The other consideration is that virtual reality has age restrictions.

Other studies ($N = 2$) recruited adolescents as the subjects. A number of American adolescents with the ages ranging from thirteen to eighteen years old were identified to be socially anxious (Parrish et al., 2016). The average of the participants' age was 16 years old ($SD = 1.65$). Similarly, the other study dealt with high school students. The ages of the adolescents who underwent VRET in this study ranged from thirteen to sixteen years old (Kahlon et al., 2019). They were recruited from two high schools and studying in the eighth, ninth, and tenth grades. The researchers believed that coping with the speech apprehension among highschoolers would serve as the preparatory endeavor to confidently perform more public speaking activities in their upcoming higher education level. One study in the Netherlands designed an immersive VR application for elementary school students (Sülter et al., 2022). The ages of the pupils ranged from nine to twelve years old (Mean = 10.46, $SD = 0.88$). They attended the fourth, fifth, and sixth grades. The researchers believed that it was necessary to prevent PSA from further development on kids by means of early training and exposure to VR-based public speaking environments.

Figure 4 displays the summary of the reviewed studies based on the three different age ranges of the participants.

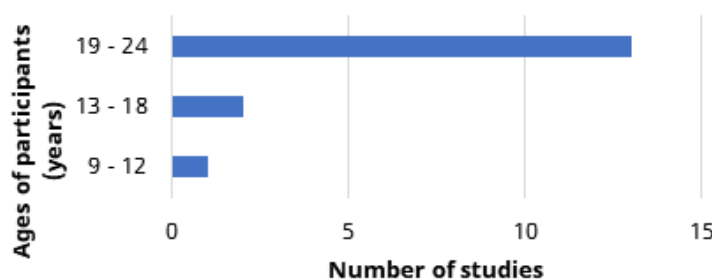


Figure 4. Age ranges of participants in the reviewed studies

Lengths of treatment

The next domain of the review of the previous studies is the duration of VR-based treatments. The reviewed studies conducted VR-based treatments within the specific durations that varied across studies. The number of the VR sessions ranged from one to five sessions. The shortest period of each VR-based public speaking training was recorded to be three minutes (Rodero & Larrea, 2022). The longest period of each VR-based instruction was ninety minutes (Kahlon et al., 2019). Regarding the number of sessions, the longest VR treatment scenario was executed in five sessions, 30 minutes for each session, and lasted for 150 minutes in total (Lindner et al., 2019).

Table 3 shows how VRET/VREI treatments are diverse across the reviewed studies.

Table 3. Lengths of VRET/VREI across the reviewed studies

Researchers	Years	Treatment duration (minutes)
Poeschl, S. and Doering, N.	2014	3–10
Parrish et al.	2016	
Poeschl, S.	2017	
Dubiago et al.	2017	
Wilsdon, L. and Fullwood, C.	2017	
Rodero, E. and Larrea, O.	2022	
Heuett, B. and Heuett, K.	2011	11–20
Stupar-Rutenfrans et al.	2017	
Reeves et al.	2021	
Kaplan-Rakowski, R. and Gruber, A.	2023	
Nazligul et al.	2019	21–30
Premkumar et al.	2021	31–40
Morina et al.	2015	51–60
Sülter et al.	2022	71–80
Kahlon et al.	2019	81–90
Lindner et al.	2019	> 100

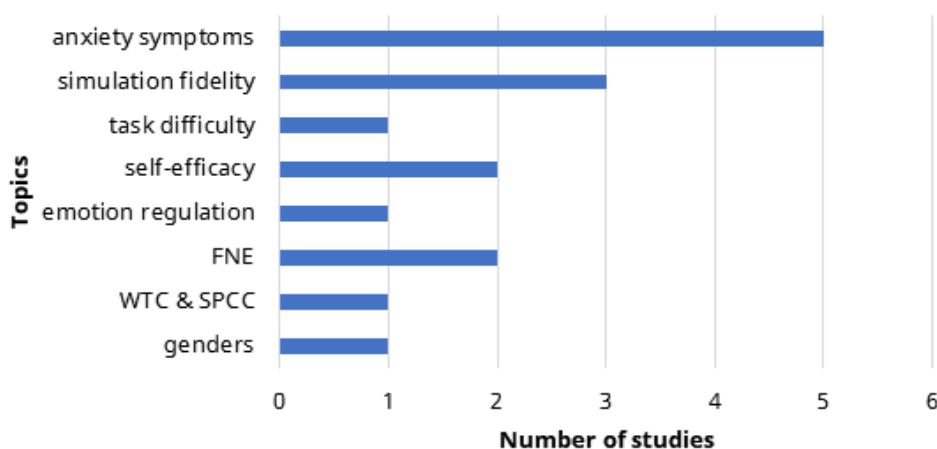
Research focuses

The other domain of the review is the topic/focus of the studies. In addition to the major focus on reducing the speech apprehension or the PSA levels of the students by using VRET/VREI, the reviewed studies had the additional foci to investigate. The additional variables to test included: physiological measurements of anxiety symptoms, simulation fidelity, task difficulty, self-efficacy, emotion regulation, fear of negative evaluation (FNE), willingness to communicate (WTC), self-perceived communication competence (SPCC), and gender differences. First, regarding the physiological measurements of anxiety symptoms, the present study grouped five previous studies into the first category. Heart rate was mostly investigated and measured along with the students' PSA (Kahlon et al., 2019; Kaplan-Rakowski & Gruber, 2023; Premkumar et al., 2021).

The other reviewed studies broadened the scopes of anxiety symptoms into rapid heartbeat, nervousness, and sweaty hands during the public speaking tasks (Lindner et al., 2019; Sülter et al., 2022).

The second topic categorization of the reviewed studies highlighted the additional variable of simulation fidelity. Simulation fidelity, also termed as simulation realism, refers to the realness degree of the replicated real-life objects and environments in VR-based scenes. Three studies measured whether higher immersion or graphical fidelity affected the students' PSA after participating in VR-based mock public speaking training (Dubiago et al., 2017; Poeschl & Doering, 2014; Wilsdon & Fullwood, 2017). The third variable to investigate in relation to speech apprehension in a public speaking setting was task difficulty, predicted to affect the students' speech performance and anxiety (Poeschl, 2017). The fourth topic, self-efficacy, was closely connected to the students' speech apprehension. The students' belief in their ability to succeed in accomplishing the public speaking tasks would affect their anxiety levels. Two reviewed studies investigated whether VRET could increase self-efficacy and at the same time reduce PSA (Morina et al., 2015; Parrish et al., 2016). The fifth topic categorization was the assessment of emotion regulation. One study investigated whether the lowered PSA could improve the students' emotion regulation strategies to cope with their stress levels (Stupar-Rutenfrans et al., 2017). Similarly dealing with the affective factors, the other reviewed studies measured the fear of negative evaluation (FNE) along with the students' PSA levels ($N = 2$). These studies statistically tested the decrement of both the students' PSA and FNE (Nazligul et al., 2019; Reeves et al., 2021). The reduced FNE expectedly makes the students less worried about what their audiences think about their public speaking performances.

Figure 5 presents the topics of the reviewed studies that were entwined to the students' PSA.



Note.

FNE = Fear of Negative Evaluation; SPCC = Self-Perceived Communication Competence;
WTC = Willingness to Communicate

Figure 5. PSA-related topics of the reviewed studies

The other pertinent topics were correlated with the students' PSA, such as willingness to communicate (WTC) and Self-Perceived Communication Competence (SPCC). One study attested whether the reduced speech apprehension could increase the students' WTC in social interaction settings and their communication competence (Heuett & Heuett, 2011). These two variables dealt with the students' self-perceptions of their choices to communicate in certain situations and their ability to indicate how competent they could be to communicate in each situation. The last topic of the reviewed studies was viewing PSA based on gender differences ($N = 1$). One study investigated whether the immersive VR trainings for treating PSA were more effective for male or female students (Rodero & Larrea, 2022). The researchers believed that approaching and alleviating the speech apprehension in public speaking settings also needed to consider the genders of the students.

Discussion

The present study investigated the trends that appeared in the previous VR studies to treat PSA published between 2011 and 2023. The systematic review drew significant conclusions and gaps of the previous studies. To date, most of the reviewed studies have proven the effectiveness of immersive VR technology in reducing the students' PSA. However, their studies were mostly targeting public speaking activity and speech apprehension in L1 learning contexts. English as L1 occupies most concern among the researchers as their studies were majorly conducted in English speaking countries as in the US and the UK (Heuett & Heuett, 2011; Parrish et al., 2016; Premkumar et al., 2021; Reeves et al., 2021; Wilsdon & Fullwood, 2017). Very few studies have reported the use of immersive VR environments for treating PSA in L2 learning contexts. There were merely three reviewed studies with the focus on L2 learning conducted in the Netherlands, Germany, and the UK (Kaplan-Rakowski & Gruber, 2023; Premkumar et al., 2021; Stupar-Rutenfrans et al., 2017). In this regard, the adaptation of immersive VR technology in the L2 learning setting remains under-researched.

Regarding the durations of the sessions, the reviewed studies have shown that their treatments differed from one study to the others. The numbers of the VR sessions ranged from one session to five sessions. The longest exposure was conducted within five sessions, accruing for a total of 150 minutes (Lindner et al., 2019). Some studies conducted shorter periods of VR exposure and resulted in statistically non-significant effects on the students' reduced PSA (Poeschl, 2017; Poeschl & Doering, 2014; Wilsdon & Fullwood, 2017). However, the issue of short duration of treatment as the sole contributing factor to the insignificant effects is challenged. It is true that some short-term treatments have been proven to statistically yield non-significant effects on reducing PSA. Contradictorily, some other studies with the similarly short-term treatments resulted in the statistically significant effects (Dubiago et al., 2017; Parrish et al., 2016; Rodero & Larrea, 2022). These different findings have implied the inconsistencies in terms of VRET/VREI durations towards the effectiveness of

curing PSA. Such a condition does not necessarily neglect the need to expose the students to the immersive VR-based environments within a longer period. Short duration remains one of the predictors of failure because the students have not been completely familiar with the virtual scene and fully immersing in the virtual environment (Wilsdon & Fullwood, 2017). In fact, longer periods of VRET/VREI have not been conducted yet to treat students' PSA, particularly in L2 learning context.

In terms of the research locations, all the reviewed studies were conducted in the US, the UK, and European countries such as Germany, the Netherlands, Sweden, Norway, Turkey, and Spain. In other words, the Western countries were aware of the potential of VR-based instructions to treat their students' speech apprehension for the past decade. This study clarifies that no research paper from regions outside North America and Europe was found within the scope of the study, academic reports published in the globally renowned journals and written in English. The finding of this study resonates with the finding of the previous systematic review (Hinojo-Lucena et al., 2020), figuring the distribution of the countries as the research loci. It means that even three years after the last systematic review, the trend of immersive VR to cope with PSA is still reported in English-written publications by Western researchers. They have strongly identified speaking in public as the major cause of fear among their student population (LeFebvre et al., 2018; Sawyer, 2016; van Veen et al., 2024; Zhou et al., 2021) and adapted the technology of advanced scenography and heightened real-time virtual reality to cope with the students' speech apprehension (Chien et al., 2020; Dooly et al., 2023).

Learners in countries with EFL contexts are predicted to strive harder to acquire English, let alone to perform a demanding public speaking activity in the target language (Yen et al., 2015). It is further revealed that English learners in Asian cultures, for instance, mostly have higher levels of speech apprehension (Wu et al., 2021), compared to the students in the Western countries where English is used as the first language. The unavailability, unaffordability, and inadequacy of HMDs due to the high cost of gears to serve a large number of students in a classroom could pose a tremendous challenge to the implementation of VRET/VREI for alleviating speech apprehension in L2 public speaking activities (Lan, 2020; Mulders et al., 2020).

Based on the focuses of the reviewed studies, additional variables other than the students' PSA were investigated. Among those variables were the anxiety symptoms, simulation fidelity, task difficulty, self-efficacy, emotion regulation, fear of negative evaluation, willingness to communicate, self-perceived communication competence, and gender differences. Most of the variables belonged to the affective factors. Very few studies dealt with the cognitive aspect of the students; only one reviewed study measured the communication competence after VRET/VREI. However, the measurement of the communication competence was solely based on the students' self-perceptions using a self-rated scale (Heuett & Heuett, 2011). Further studies need to fill this gap by measuring the students' communication competence by at least two external raters who could objectively score the students' speaking performance (Fulcher, 2014;

Fulcher & Davidson, 2007). The other consideration for supplementing self-ratings with external ratings is to eliminate the assumption of false emotions and perceptions. In other words, both the affective factor and cognitive competence are to be measured to contribute more robust findings on the effectiveness of the immersive VR-based environment for the therapeutic purpose of reducing anxiety and improving learning outcomes.

Finally, the current study revealed the concerns and gaps among the reviewed studies, and suggested implications for further studies as follows: (1) The inconsistency of the research findings regarding whether the short duration of VRET/VREI resulted in the statistically non-significant effects on reducing PSA recommends that further studies train students in the VR-based environment with much longer exposure to the virtual public speaking tasks to lessen their speech apprehension. (2) Inferring the limited studies in this area reported from other continents outside of North America and Europe, more empirical studies on the implementation of VR-based public speaking training to treat PSA should be conducted in countries with EFL contexts and published in the globally renowned English-language journals. (3) Considering that very few studies measured the improvement of the students' cognitive domain, but affective factors, it is recommended that further studies fill this gap by measuring the students' public speaking competence through external raters who could objectively score the students' L2 public speaking. (4) Since most of the reviewed studies focused on English as L1, further studies should address the lack of empirical evidence in the L2 learning context by investigating how immersive VR technology could be used to deal with the students' PSA and improve learning outcomes, specifically in EFL classrooms.

Conclusion

The advent of VR technology could set an environment that resembles a hall for prospective public speakers to practice their public speaking skills. In other words, VR technology platforms have offered alternative environments for language instructions (Oh, 2021; Vesisenaho et al., 2019). This current study synthesized a number of publications regarding the use of VR technology for training students public speaking and reducing their PSA. After a closer look at the previous studies, the current study discovered the inconsistency regarding whether the length of VRET/VREI treatments affected the positive, negative, or neutral results in reducing the students' speech apprehension. A few prior studies reported negative results and claimed the short-term exposure to VR environment as the contributing factor to their insignificant findings. The other reviewed studies reported positive results despite the short-term VR treatments to cure the students' PSA (Dubiago et al., 2017; Parrish et al., 2016; Rodero & Larrea, 2022). With such inconsistency, it is time to be aware of this issue and recommend that more studies investigating various durations of VR exposure to treat PSA be conducted. Another highlight of the current study was that very few previous studies targeted L2 public speaking context. Most of the prior studies were conducted to train public speaking and alleviate speech apprehension

in the context of English as L1. A dearth of studies adapting immersive VR technology to reduce the higher level of anxiety among English learners in the EFL context should be addressed by future researchers. Accordingly, immersive VR technology could have a profound impact on L2 public speaking instruction, particularly in alleviating the anxiety of L2 learners.

The limitations of this study are the inability to measure the effect size of VRET/VREI for alleviating PSA and the considerably few numbers of publications to review. Further review studies should be accompanied with meta-analysis to statistically calculate an effect size and measure the effectiveness of VRET/VREI to treat speech apprehension. In addition, this study excluded papers on hardware reviews and limitations, and focused on the papers written in English. As more studies in this area are expectedly conducted in the near future, more publications can be reviewed elaboratively. All things considered, more research on the use of immersive VR technology especially in L2 learning context should be garnered and continued to be investigated to develop students' English public speaking. The research methodologies could vary from quantitative, qualitative, to mix methods to contribute more vigorous results. By conducting more research in this area, more EFL learners will reap the benefits of this technology to reduce their speech apprehension, improve their L2 learning outcomes, and prepare them for the promising job market that requires public speaking skills.

Disclosure statement

No conflict of interest was reported by either author.

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