MAPPING THE RESEARCH AGENDA IN VIRTUAL REALITY STUDIES WITHIN EDUCATION

Dr. Ezgi DOGAN
ORCID: 0000-0001-8011-438X
Faculty of Education
Van Yuzuncu Yil University
Van, TURKIYE

Dr. Ferhan SAHIN
ORCID: 0000-0003-4973-9562
Faculty of Education
Agri Ibrahim Cecen University
Agri, TURKIYE

Received: 29/01/2024 **Accepted:** 24/04/2024

ABSTRACT

This systematic literature review (SLR) scrutinizes the trends and interrelationships prevalent in Virtual Reality (VR) applications within educational frameworks, analyzing a comprehensive pool of 43 theses conducted in a Eurasian country. The primary objectives encompass investigating learning-teaching theories, learning domains, design elements, VR typology, and the departments undertaking VR research. Findings from the SLR underscore a significant concentration of VR research activities within technology-oriented departments. The prevalent approach involves experimental assessments of diverse variables within VR learning environments, yet a conspicuous dearth of design-centric investigations is observed. This highlights a critical need for comprehensive studies elucidating the design and developmental processes within VR applications, especially in light of the current characterization of VR research as lacking established standards. Moreover, a noteworthy revelation is the prevalent absence of a robust theoretical framework across the majority of studies. This absence may pose impediments to the widespread adoption of VR within educational paradigms, given the pivotal role of learning-teaching theories in guiding pedagogical processes. Examination of design elements highlights the prominence of realistic experiences, passive observation, mobility, and interaction with the environment. Recognizing the potential impact of diverse design elements on enhancing realism, aligning specific elements with distinct learning domains holds promise for augmenting the immersive quality of VR experiences. This research emphasizes the critical need for more comprehensive, theory-guided, and design-focused VR studies to propel its integration effectively within educational landscapes.

Keywords: Design element, learning domain, learning, theory, systematic literature review, virtual reality.

INTRODUCTION

Virtual Reality (VR) environments have seen rapid development in recent years, extending their use across diverse fields such as medicine, education, advertising, and gaming. The integration of VR technology beyond entertainment began in the 1980s, notably in vocational training like flight simulation (Hawkins, 1995). By the early 1990s, initiatives such as Science Space, Security World, and others paved the way for VR's introduction into K12 and higher education, offering educational advantages like three-dimensional visualization, tangible representation of abstract concepts, and the exploration of dynamic relationships within systems (Youngblut, 1998; Chen, 2007).

Numerous studies advocate for the integration of VR applications in education due to their ability to provide multiple perspectives and facilitate experiences otherwise constrained by factors like distance, time, cost, or safety concerns (Alhalabi, 2016; Blyth, 2018; Koivisto, 2018). Existing literature has conducted comprehensive reviews on VR's educational impact, focusing on various databases, time frames, and specific variables (Chavez & Bayona, 2018; Radianti et al., 2020; Suh & Prophet, 2018; Wohlgenannt et al., 2019). For instance, Chavez and Bayona (2018) delved into VR's unique features in learning processes by surveying IEEE Xplore Digital Library, ScienceDirect, PsycINFO, and other databases. Radianti et al. (2020) explored immersive VR in higher education through examination of IEEE Xplore Digital Library, ProQuest, Scopus, and Web of Science databases. Similarly, Suh and Prophet (2018) focused on education, health, and marketing research on immersive VR using Scopus and Social Sciences Citation Index databases, while Wohlgenannt et al. (2019) reviewed immersive VR studies in higher education via the ProQuest database.

Despite these extensive reviews, the literature lacks research that examines the relationship between learning theories, domains, design elements, VR types, and departmental contexts across educational levels (K12, higher education, adult learning, etc.). Consequently, this research aims to discern current trends in VR applications within the education sector and investigate the correlations between the mentioned variables (learning theories, domains, design elements, VR types). The research questions determined for this purpose are listed below:

1. Departmental and Temporal Focus of VR Research in Education:
    - In which academic departments and during which time periods are VR research studies predominantly conducted within the field of education?
2. Research Methodology Preferences in VR Education Studies:
    - What are the prevalent research designs, participant demographics, data collection methodologies, and analytical approaches favored in VR research within educational contexts?
3. Preference for VR Types and Technologies in Education:
    - Which specific types of VR and technological platforms are commonly preferred and utilized in educational VR research?
4. Investigated Learning Domains in VR Education Studies:
    - What specific learning domains or subject areas are frequently studied within the realm of VR research in education?
5. Underlying Learning-Teaching Theories in VR Education Studies:
    - Which pedagogical and learning theories serve as foundational frameworks for VR research conducted in educational settings?
6. Preferred VR Design Elements in Education:
    - What are the primary design elements and features that are commonly emphasized and favored in VR research within educational contexts?
7. Relationship between Departmental Context and Research Design:
    - How does the departmental affiliation of researchers conducting VR studies in education correlate with their chosen research methodologies and designs?
8. Correlation between Department and Investigated Learning Domains:
    - What connections exist between the academic department affiliations of VR researchers in education and the specific learning domains or subject areas they investigate?
9. Alignment between Department and Learning-Teaching Theory:
    - Is there a discernible relationship between the academic department where VR education research is conducted and the theories of learning and teaching employed in these studies?
10. Association between Design Elements, VR Type, and Learning Domains:
    - How are the preferred design elements in VR education research associated with the chosen type of VR technology and the specific learning domains being explored?

These refined research questions aim to provide a clearer understanding of the interdisciplinary aspects, methodological preferences, theoretical frameworks, and thematic alignments within VR research conducted in educational settings. By addressing these questions, this study endeavors to contribute to a comprehensive understanding of the multifaceted impact and utilization of VR technology.

THEORETICAL BACKGROUND

Virtual Reality

Technologies that facilitate user interaction within simulated environments, providing a sense of physical and mental presence, constitute VR (Dogan & Sahin, 2023). VR encompasses two primary categories: Nonimmersive VR and immersive VR. Nonimmersive VR involves users accessing virtual environments through conventional interfaces like keyboards, mice, and monitors. Conversely, immersive VR utilizes technologies like cave automatic virtual environments (CAVEs) or head-mounted displays (HMDs) equipped with motion tracking systems, enabling users to fully engage with the virtual world while disconnected from the physical environment (Wojciechowski & Cellary, 2013).

The VR name was created by Lanier and proposed in the early 1980s (Chavez & Bayona, 2018) The Gartner hype cycle, which represents the maturity, adoption, and social application of certain technologies, first demonstrated VR in 1995 during the peak of inflated expectations period (Figure 1). While VR navigated the trough of disillusionment until 2016, it gradually advanced into the slope of enlightenment in 2016 and 2017. This evolution underscores VR's trajectory from initial hype to more realistic expectations and maturation within technological landscapes.

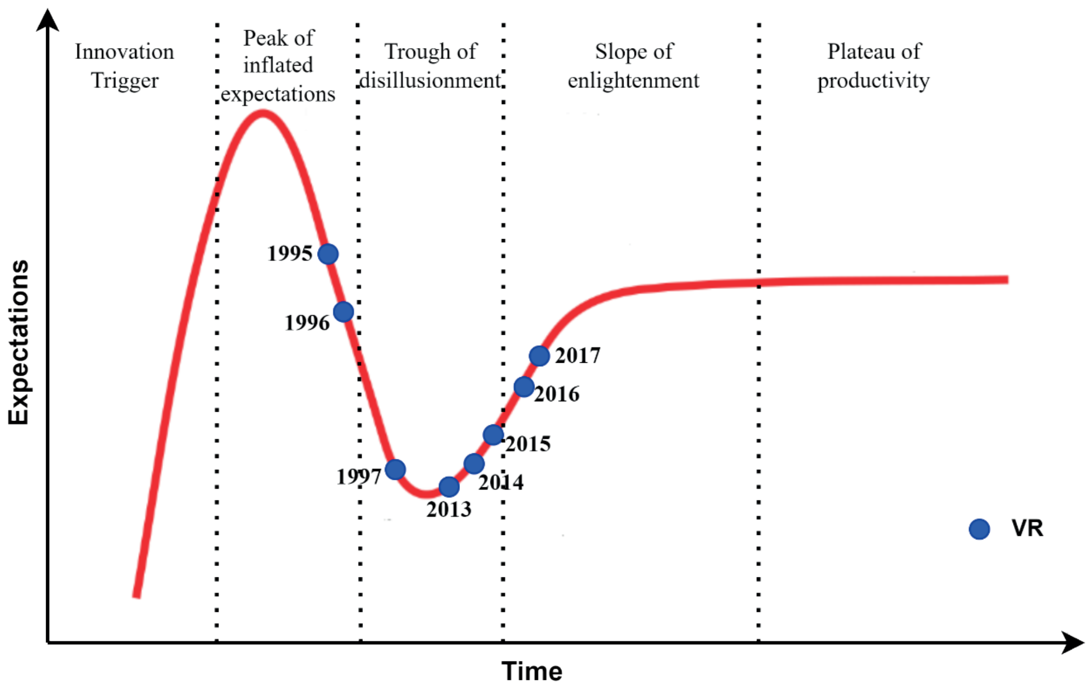


Figure 1. VR's position in the hype cycle (https://www.gartner.com/en)

In the Gartner hype cycle, each phase represents distinct stages in the adoption and perception of a technology. The peak of inflated expectations phase occurs early after a technology's launch, characterized by extensive exploration and evaluation. During this time, unsuccessful applications often outnumber successful ones. The subsequent phase, the trough of disillusionment, signifies dwindling interest in the technology, and its survival depends on successful applications that sustain demand. Moving forward, the slope of enlightenment marks a period of clarity regarding the technology's benefits. As illustrated in Figure 1, VR initially emerged as a new technology with predominantly unsuccessful applications between 1995 and 1996. Subsequently, between 1997 and 2015, it experienced a decline in user interest. However, in 2016-2017, VR was recognized for its utility and potential.

Projections in 2017 anticipated VR's transition to the plateau of productivity within 2-5 years, indicating its imminent adoption by larger masses—highlighting the significance of research conducted during this period. This forecast underscores the critical importance of studying VR during its transformative phase, poised for widespread utilization in contemporary times.

Learning Domain

Various classifications outline the domains in which the learning process unfolds. Gagne (1972) categorizes learning domains into motor skills, verbal knowledge, intellectual skills, cognitive strategies, and attitudes. Acquiring motor skills involves repetitive practice, while retaining verbal information necessitates organized and contextually meaningful presentation. Intellectual skills encompass not just learning a definition but employing it effectively. Cognitive strategies evolve as learners practice recalling, identifying, and problem-solving, whereas attitudes develop gradually through observation and experience.

During the learning process, activities often aim to develop multiple learning domains. To facilitate a more practical discussion of these domains, they are elaborated as declarative knowledge, problem-solving, procedural knowledge, soft skills, language acquisition, and behavioral impacts. Declarative knowledge comprises theories, facts, and data—typified by materials like textbooks—and is required for verbal knowledge and intellectual skills. Procedural knowledge, on the other hand, involves the application of declarative knowledge (Kochin et al., 2005), encompassing insights into domains like motor skills and cognitive strategies. Problem-solving cultivates analytical skills, critical for intellectual skills and cognitive strategies. Soft skills relate to communication and collaboration, while language acquisition intertwines declarative, procedural, and soft skills. Behavioral impacts align with attitudes and elucidate individual behavioral changes. Makransky and Petersen (2021) assert that VR enhances factual knowledge (akin to declarative knowledge) through its immersive, controlled, and faithful representations. It also facilitates conceptual knowledge (a more intricate form of declarative knowledge), procedural knowledge, and transfer of learning (encompassing all domains). However, for comprehensive development across these learning domains, the design and implementation of VR applications in education necessitate a strong theoretical foundation.

Theoretical Foundations in VR Applications

Mulders et al. (2020) presented a framework rooted in the cognitive theory of multimedia learning, offering guidelines for leveraging VR within learning environments. According to this framework:

1. Immersion and Learning Purpose: Optimal immersion levels in the virtual environment should align with the learning objectives. If high immersion does not serve the learning purpose, a lower level should be preferred.
2. Learning-Oriented Interactions: Virtual environments should facilitate learning-centric interactions to enhance educational outcomes.
3. Task Complexity Management: Complex tasks within the virtual environment should be deconstructed into smaller, more manageable units to support learning effectiveness.
4. Guidance and Information Provision: Adequate information and guidance must be available within the virtual environment to aid learners' understanding and progress.
5. Knowledge Integration: New information presented in the virtual environment should be balanced with and built upon learners' existing knowledge to foster deeper understanding.
6. Constructivist Learning Activities: Emphasis should be placed on constructive learning activities wherein learners play an active role in constructing knowledge.

Constructivism, central to this framework, asserts that knowledge is actively constructed rather than passively transferred. Students take an active role in their learning process, exploring and managing the learning environment (Duffy & Cunningham, 1996; Johnson & Johnson, 1996; Jonassen, 1992; Jonassen, 1999). 3D virtual learning environments offer a transparent interface, allowing direct user control over the virtual world (Hedberg & Alexander, 1994), a pivotal aspect supporting the constructivist learning paradigm.

Moreover, Dalgarno and Lee (2010) emphasize that VR, with its high representational fidelity and interactive features, provides significant opportunities for experiential learning. The constructivist paradigm encompasses theories like experiential learning, discovery learning, situated learning, self-regulated learning, scenario-based learning, game-based learning, and flipped learning (Bruner, 2009; Kolb, 1984; Lave, 1991; Prensky, 2003; Sams & Bergmann, 2013; Schraw, 2010). This diversity of theories underscores the robust theoretical foundation that can underpin VR research and applications. In addition to delineating learning domains and theoretical frameworks, the selection of design elements for VR applications plays a crucial role in ensuring their effectiveness within educational settings.

Design Elements

When exploring theories, models, and frameworks pertaining to the design of virtual environments, several prominent elements emerge (Chavez & Bayona, 2018; Dogan & Sahin, 2023; Makransky & Petersen, 2021; Mulders et al., 2020; Radianti et al., 2020; Suh & Prophet, 2018; Wohlgenannt et al., 2019):

- Immersion,
- Presence,
- Realism,
- Interactivity,
- Usability,
- Feedback,
- Media richness,
- Moving ability,
- Informing,
- Virtual awards,
- Assembling,
- Making meaningful choices,
- Role management,
- User generated content,
- Knowledge test,
- Aesthetic, ergonomic and universal design.

Upon analysis, the incorporation of the aforementioned elements into VR applications is intricately linked to the level of immersion these applications offer. Consequently, it becomes crucial to establish correlations between the learning domain, theoretical underpinnings, design elements, and the type of VR (immersive or nonimmersive) within VR research.

METHOD

Research Design

To fulfill the research objectives, a Systematic Literature Review (SLR) was conducted. SLR stands as a meticulous, transparent, and replicable approach aimed at identifying, synthesizing, and evaluating a collection of completed scientific research (Fink, 2005; Okoli & Schabram, 2010). This method enables the synthesis of evidence from research, facilitating the identification of research gaps (Petticrew & Roberts, 2006). The term systematic in SLR signifies adherence to a structured process governed by specific rules, emphasizing objectivity, transparency, and repeatability (Boell & Cecez-Kecmanovic, 2015). Recommended steps for conducting an SLR involve (1) determining the purpose, (2) creating a review protocol and training reviewers, (3) literature search, (4) screening for inclusion, (5) screening for exclusion, (6) data extraction, (7) synthesis of studies, (8) writing the review (Okoli & Schabram, 2010). Each of these steps encompasses specific operations, detailed under the respective headings to delineate the comprehensive methodology employed in this SLR.

Purpose of the Study

The primary objective of this SLR is to discern the prevailing trends within VR research in the field of education. Additionally, it aims to investigate the correlations and interdependencies between design elements, learning domains, research methodologies, and learning-teaching theories prevalent in these studies.

Creating the Review Protocol and Training Reviewers

At this stage, researchers outlined the designated database to conduct the SLR aligned with its intended objectives. They established stringent criteria that each study must meet to qualify for inclusion. Additionally, researchers delineated specific thematic focuses within the studies, emphasizing technologies, research methodologies, learning domains, learning-teaching theories, and design elements utilized in VR applications within the educational context. Consequently, these researchers drew insightful inferences regarding these thematic elements derived from the comprehensive literature review.

Literature Search

The research scrutinized masters and doctoral theses conducted in Turkiye, employing the National Thesis Center of the Council of Higher Education as the primary database during the literature search phase. This repository encompasses theses completed across universities in Turkiye, ensuring comprehensive access to relevant sources aligned with the research objectives. Hence, it can be stated that the study has accessed all pertinent sources essential for fulfilling its research aims.

Screening for Inclusion and Exclusion

The inclusion criteria for the SLR required studies to pertain to the field of education and encompass VR applications. Initially, a keyword search for "virtual reality" within the National Thesis Center yielded 943 master's and doctoral theses conducted between 1996 and 2023. Subsequently, a filtering process focusing on the "education and training" research subject reduced the pool to 106 studies. Researchers further scrutinized these studies, excluding descriptive, screening, and meta-analysis studies, as well as those lacking a VR application. Following this curation, a total of 43 theses (comprising 19 doctoral and 24 master's theses) met the criteria and were included in the SLR.

Data Extraction

In the data extraction stage, the researchers extracted the following data regarding the 43 studies identified in the previous stage:

- Year
- Department
- Research design
- Participants
- Data collection tools
- Analysis methods
- VR technology
- Learning domain
- Learning-teaching theory
- Design elements

The study classified the VR technology into two categories: immersive and nonimmersive, and categorized the hardware used into subsets such as HMD, HMD sets, mobile, and desktop. To ascertain the learning domain served by the VR applications, a coding system aligned with the framework established by Radianti et al. (2020) was employed (Table 1). Notably, while coding according to this framework, the data also revealed patterns in the grouping of learning-teaching theories (Table 2).

Table 1. Learning domain examples

Domain	Example
Problem-solving	Solving a math problem, coding a computer program, or deciding which medication to give a patient
Soft skills	Speaking in public, working in teams
Procedural knowledge	Knowing how to prepare operating room sets, learning fire extinguishing procedure
Declarative knowledge	Learning the names of underground mines, listing the names of the planets
Learning a language	Learning listening, writing and speaking skills for a foreign language
Behavioral impacts	Developing motivation and attitude (etc.) towards a course

According to Table 1, the learning domains addressed by VR applications are listed as problem-solving, soft skills, procedural knowledge, declarative knowledge, learning a language and behavioral impacts.

Table 2. Learning theories/approaches

Theory	Definition
Constructivism	Learner; makes sense of the environment he lives in by comparing, combining and structuring old and new information he has learned (Appleton, 1997).
Experiential learning	Learner; directly acquires and applies knowledge, skills, and emotions in an authentic learning environment (Kolb, 1984).
Multimedia learning	Learner; better understand, process, and remember information by incorporating multimedia elements that involve multiple sensory channels (Mayer, 2009).
Self-regulated learning	Learning occurs when planning, monitoring and controlling abilities are combined (Schraw, 2010).
Distance education	Learning takes place through media in an environment where learners and teachers do not meet face to face (Holmberg, 2005).
Scenario based learning	It is a learning approach in which the learner is an actor, and the achievements are constructed within the framework of a scenario (Veznedaroglu, 2005).
Behavioral skills training	It is the process of acquiring behavioral skills by following the steps of teaching, modeling, rehearsal and feedback in learning environments where the learner is active (Himle & Miltenberger, 2004).
Game-based learning	It improves the acquisition of knowledge and skills through game content and game playing, and game activities provide players (learners) with the opportunity to solve problems (Prensky, 2003).
Flipped learning	It allows educators to modify traditional classroom environments to introduce course content and learning outcomes to learners before meeting in the classroom and use classroom time to guide each student through active learning experiences (Sams & Bergmann, 2013).
Task based language teaching	Instructional tasks are intended to be authentic, and the activities designed consist of real-world tasks that learners are expected to perform outside the classroom (Bygate, 2016).
Discrete trial training	It is based on the principle of teaching appropriate behavior to the child by applying consecutive trials consisting of the premise of the behavior, the behavior and the result of the behavior (Tarbox & Najdowski, 2008)

Table 2 presents a comprehensive overview of 12 distinct theories underpinning the utilization of VR applications within the learning-teaching processes as observed in the studies encompassed by the SLR. Moreover, data detailing the design elements encapsulated within VR applications have been coded according to frameworks outlined by Dogan and Sahin (2023) and Radianti et al. (2020), elucidating the various structural components (Table 3).

Table 3. Design elements

Design element	Description
Realistic experience	Realistic design of characters, environment, voice-over, animations and scene transitions.
Interaction with environment	Creating a structure that allows basic interaction with characters and objects in the virtual environment.
Interaction with other users	Ability to interact with users in the virtual environment with their own virtual characters.
Informing in virtual environment	Presenting information about the application in a virtual environment, such as a tutorial or FAQ.
Making meaningful choices	Having a scenario shaped according to the user's choice.
Feedback	The user receives visual, auditory or haptic feedback from within the virtual environment.
Knowledge test	There is a structure within the VR application that allows the learner to evaluate himself.
Virtual rewards	Incorporating a reward system with virtual objects for tasks performed in the virtual environment.
Passive observation	Just following a stream of events in the virtual environment, no interaction.
Moving around	Being able to move in the virtual environment with physical movements or a game controller.
Role playing	Performing any role by the user in tasks prepared within a scenario.
User generated content	Apart from the virtual objects already existing in the virtual environment, users can also create new objects.
Screen sharing	Users can share their virtual environments with other users.
Assembling objects	Virtual objects can be transformed into new forms by combining and separating them.

Table 3 showcases the coding of data related to the design elements present within the VR applications examined for this SLR, categorizing them into 14 distinct categories. Furthermore, the evaluation of research designs, participant demographics, data collection tools, and analysis methods employed in the studies were conducted using established methodologies widely recognized in the literature (Table 4).

Table 4. Research designs, participants, data collection tools, data analysis

Research design	Description
Experimental research	Quantitative research, consisting of experimental and control groups, in which changes in the dependent variable are observed by intervening in the independent variable, and aiming to determine the cause-effect relationship.
Qualitative research	Research that reports narrative data on why and how a phenomenon occurs, using methods such as case studies and phenomenology.
Design and development research	Research that collects data through stages such as planning, design, implementation and development and reports the entire process.
Single subject research	Research that determines the cause-effect relationship by examining the changes in single subject over time and depending on the intervention.
Participant	Description
K-12	Students from kindergarten to 12th grade
Higher education	Undergraduate, master's and doctoral students
Teacher	Participants who teach in K-12
Expert	Participants who have a bachelor's, master's or doctoral degree in a subject
Adult	Participants who are over 18 years old but are not students
Data collection tool	Description
Test	Tools that are mostly multiple choice and measure success etc. (success testing, usability testing, etc.)
Scale	Valid and reliable tools used to measure structures that are mostly related to the affective domain, such as motivation

Survey	Tools that are used to quantitatively determine opinions on a subject, may include items such as multiple choice, open-ended, and graded, and whose construct validity is not required.
Interview	Tools generally used in qualitative designs that aim to determine participants' opinions through structured or unstructured questions.
Observation	Tools used to determine participant behavior and relationships by observing them.
Research diary	Tools based on data recorded by the researcher or participants regarding a topic during the research process.
Log	Tools that can store all kinds of data regarding participant behavior (lesson duration, attendance record, etc.), usually kept by an information system.
Rubric	These are tools that help determine participant data within specified criteria.
Document	Tools that provide valuable information (visual, audio, etc.) to understand the situation addressed in the research.
Data analysis	Description
Parametric	Analyzes aimed at determining the relationship between variables or the difference of the variable according to groups (e.g ANOVA, regression), depending on the prerequisite of ensuring various assumptions for the data set (normal distribution, etc.).
Nonparametric	Analyzes aimed at determining the relationship between variables or the difference of the variable according to groups when the prerequisites of parametric analyzes are not met (Mann Whitney U, Friedman, etc.).
Descriptive statistics	Analyzes aiming to obtain information about the distribution of a data set through measurements such as mean and standard deviation.
Descriptive analysis	Deductive approach used in the analysis of qualitative data when themes are predetermined.
Content analysis	Inductive approach to the analysis of qualitative data in which themes are revealed during analysis.

Upon reviewing Table 4, it becomes apparent that the studies included in this SLR were categorized based on four distinct research designs, encompassing five participant groups, utilizing nine varied data collection tools, and employing four diverse data analysis methods.

Synthesis of Studies

In this phase, researchers convened to engage in discussions, organize, and compare the gathered results. The objective was to achieve a comprehensive and coherent synthesis of information as advocated by Okoli & Schabram (2010). As articulated by Webster and Watson (2002), this synthesis stage entails a shift toward a concept-centered focus, involving the amalgamation of similar features within the data obtained. Hence, the researchers collaboratively organized the data extracted from the studies encompassed in the SLR, constructing a conceptual map aligning with the research questions. To achieve this, percentage calculations, frequency analyses, and cross-tabulations were employed, facilitating the visualization of results through pie charts, line charts, and bubble charts.

Writing the Review

The concluding stage involved a detailed and comprehensive report outlining the entire SLR process. This entailed establishing the relationship between the research gap and the research objectives, specifying the suitable database used for the inquiry, explicating the inclusion and exclusion criteria, elucidating the frameworks and rationales underpinning the data extraction stage, and outlining the methodologies employed for data analysis. The aim was to provide a comprehensive account of the entire SLR process, meticulously detailing each step taken in conducting the review.

RESULTS

The analyzes carried out to answer the research questions are presented in the form of graphs. Explanations of abbreviations in bubble charts are given in Table 5.

Table 5. Abbreviation in bubble charts

Abbreviation	Definition
Department 1	Instructional/Educational technology
Department 2	Science education
Department 3	Special education
Department 4	Educational science
Department 5	Mathematics education
Department 6	Primary school teaching
Department 7	Physical education and sports teaching
Department 8	Graphic education
Department 9	English language teaching
Department 10	Social sciences teaching
Department 11	Turkish teaching
Department 12	Management information systems
Design 1	Single subject research
Design 2	Design and development research
Design 3	Qualitative research
Design 4	Experimental research
Domain 1	Behavioral impacts
Domain 2	Learning a language
Domain 3	Declarative knowledge
Domain 4	Procedural knowledge
Domain 5	Soft skills
Domain 6	Problem-solving
Theory 1	Constructivism
Theory 2	Experiential learning
Theory 3	Multimedia learning
Theory 4	Distance education
Theory 5	Discrete trial teaching
Theory 6	Behavioral skills training
Theory 7	Flipped learning
Theory 8	Game based learning
Theory 9	Self-regulated learning
Theory 10	Scenario based learning
Theory 11	Task based language teaching
Element 1	Realistic experience
Element 2	Passive observation
Element 3	Moving around
Element 4	Interaction with environment
Element 5	Assembling objects
Element 6	Interaction with other users
Element 7	Role playing
Element 8	Screen sharing
Element 9	User-generated content
Element 10	Informing in virtual environment
Element 11	Feedback
Element 12	Knowledge test
Element 13	Virtual rewards
Element 14	Making meaningful choices

Figure 2 illustrates that among the 43 studies reviewed in this SLR, a majority were conducted within the instructional/educational technology department (n=17) and the science education department (n=11). Following closely are departments such as special education (n=3), educational science (n=2), mathematics education (n=2), and primary school teaching (n=2), respectively.

Additionally, individual studies were identified within specific fields such as physical education and sports teaching, graphic education, English language teaching, social sciences teaching, Turkish teaching, and management information systems, each representing a solitary study within this SLR. Notably, Ceken's study (2023), despite being conducted within the management information systems department, was included in this review due to its substantive focus on the impact of virtual reality on learning outcomes, aligning closely with the SLR's thematic focus.

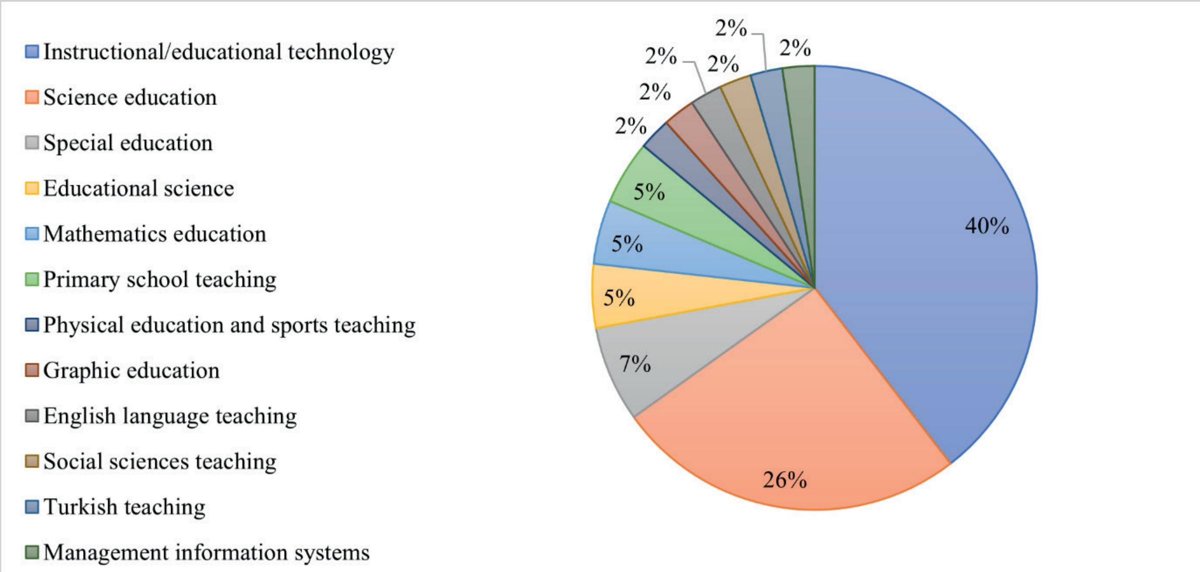


Figure 2. Distribution of VR research according to department

It was determined that studies on the use of virtual reality in education started in 2011 (Figure 3). Until 2017, there were a few master's thesis and PhD dissertations on the subject, but it has been observed that this number has increased since 2018. While the increase in the number of studies was noticeable in 2019 (n=10), there have been a total of 15 VR studies conducted in the field of education in the last two years (2022-2023).

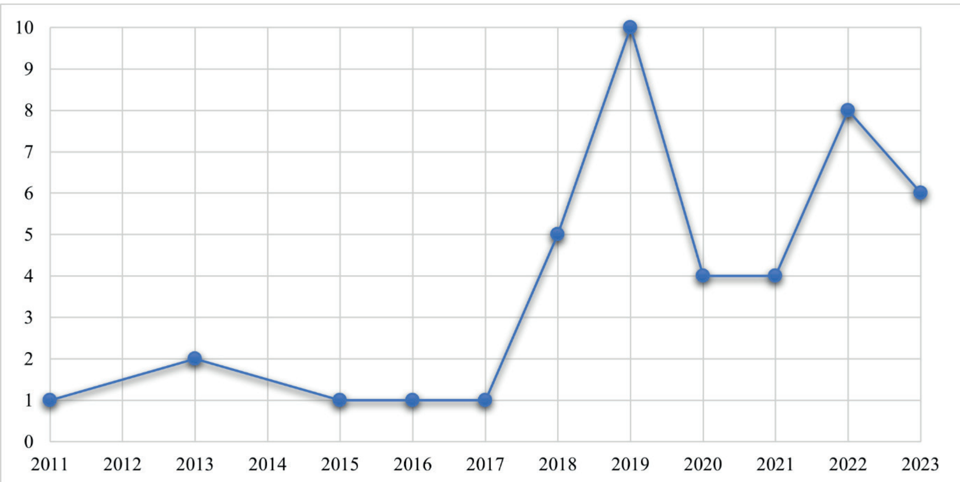


Figure 3. Distribution of VR research according to year

Figure 4 demonstrates the distribution of VR studies based on research design, showcasing a prevalent preference for experimental (n = 23) and qualitative (n = 18) methodologies. Notably, 11 studies (Abdusselam, 2022; Akbiyik, 2020; Akman, 2019; Bozdemir, 2022; Dogdu, 2023; Durukan, 2018; Guler, 2021; Gunduz, 2022; Kalkan, 2020; Ozonur, 2013; Saricam, 2019) employed mixed methods, integrating both experimental and qualitative designs. Additionally, four studies pursued design and development research methodologies. Furthermore, Kurtca's study (2021) was specifically structured on the basis of a single subject research approach.

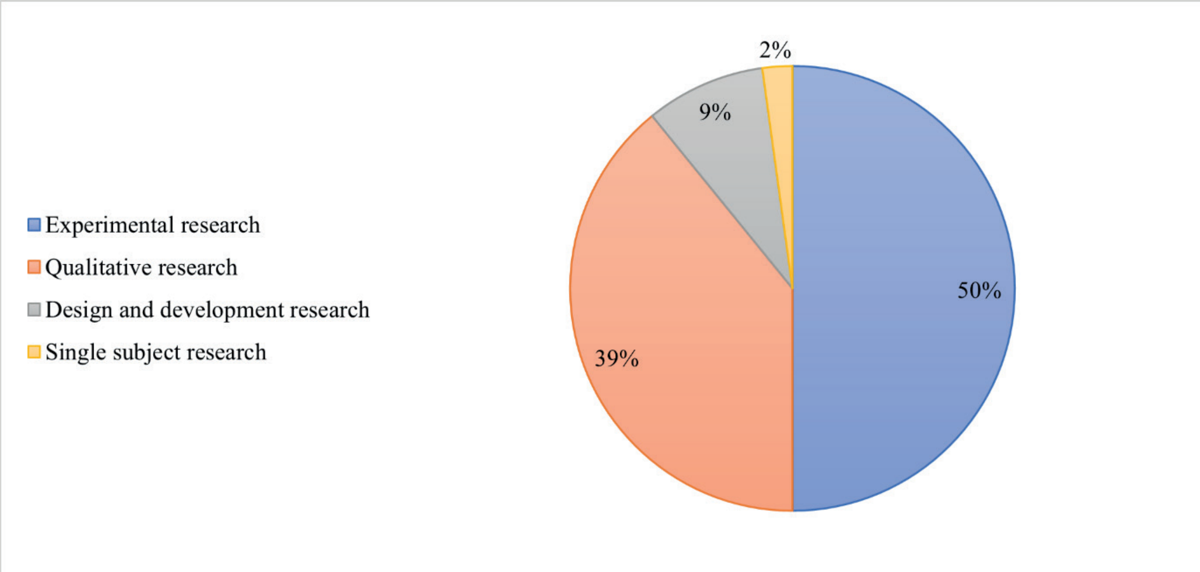


Figure 4. Distribution of VR research according to research design

Analysis of participant groups involved in VR research reveals a predominant focus on participants at the K12 level (n=21) and higher education level (n=18), as depicted in Figure 5. Notably, research conducted with experts amounted to two studies, while studies involving adults and teachers were limited to one each.

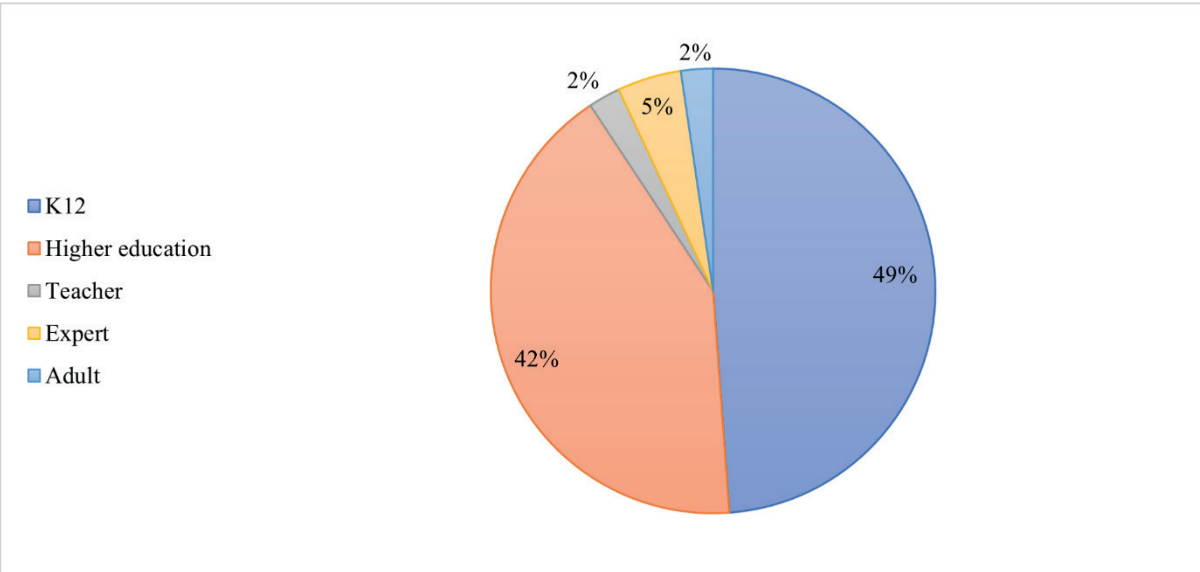


Figure 5. Distribution of VR studies by participant group

Figure 6 presents an overview of data collection techniques employed in VR research, indicating a balanced usage of both quantitative and qualitative approaches. Notably, the most favored data collection tools include tests (n=28), scales (n=28), and interviews (n=27). Conversely, less commonly utilized methods comprise documents (n=4), research diaries (n=3), system logs (n=3), and rubrics (n=3). Additionally, observations (n=14) and surveys (n=7) were also employed as data collection methods across several studies.

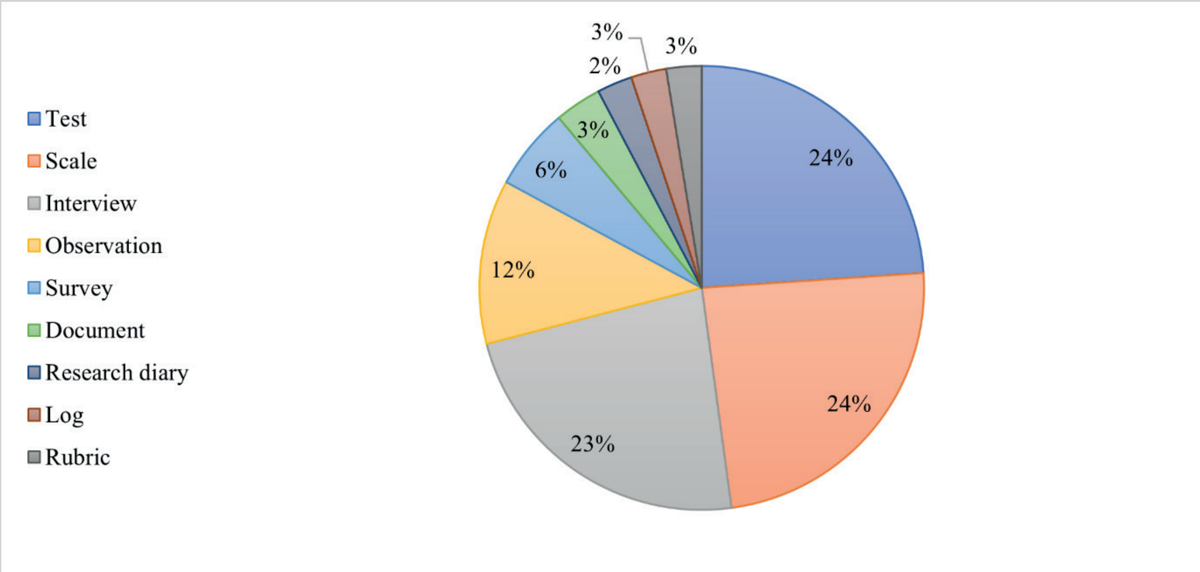


Figure 6. Distribution of VR research according to data collection tool

Figure 7 categorizes the data analysis methods employed in research into five distinct groups. Parametric test statistics emerged as the most preferred analysis method (n=28), closely followed by content analysis (n=18), descriptive statistics (n=14), nonparametric test statistics (n=12), and descriptive analysis (n=10).

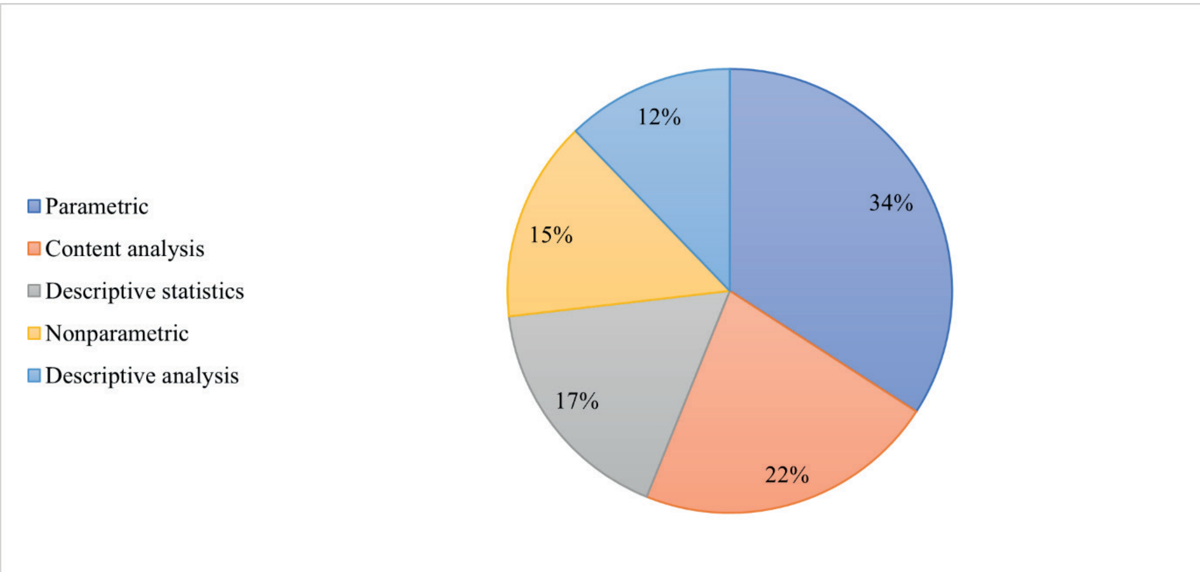


Figure 7. Distribution of VR research by data analysis

Figure 8 illustrates a notable distribution among the studies included in the SLR based on VR type, revealing a substantial preference for immersive VR (n=37). Conversely, nonimmersive VR was employed in the research process in only five studies, while one study lacked specific information regarding the utilized VR application.

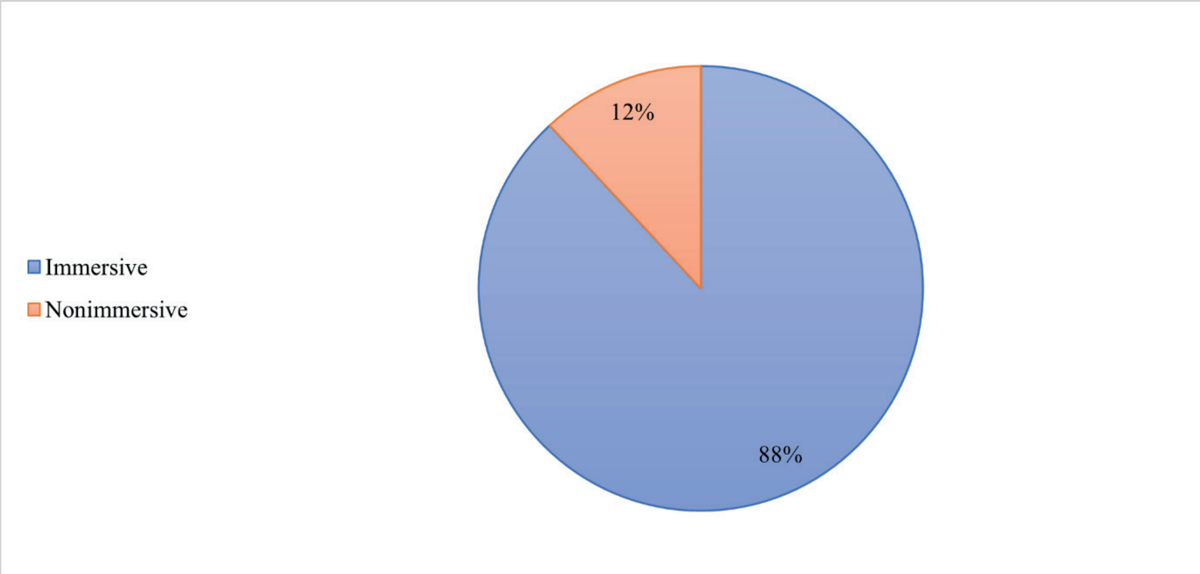


Figure 8. Distribution of VR research by VR type

Figure 9 presents the distribution of VR technologies utilized in research. Predominantly, the most favored technology is HMDs (n = 36). Among these, 20 studies exclusively utilized HMDs, while 16 studies incorporated a joystick in conjunction with HMDs. Additionally, other technologies, such as desktop (n=4), game console (n=1), and mobile phone (n=1), were less frequently employed. Notably, in one study, specific information regarding the utilized VR technology was not available.

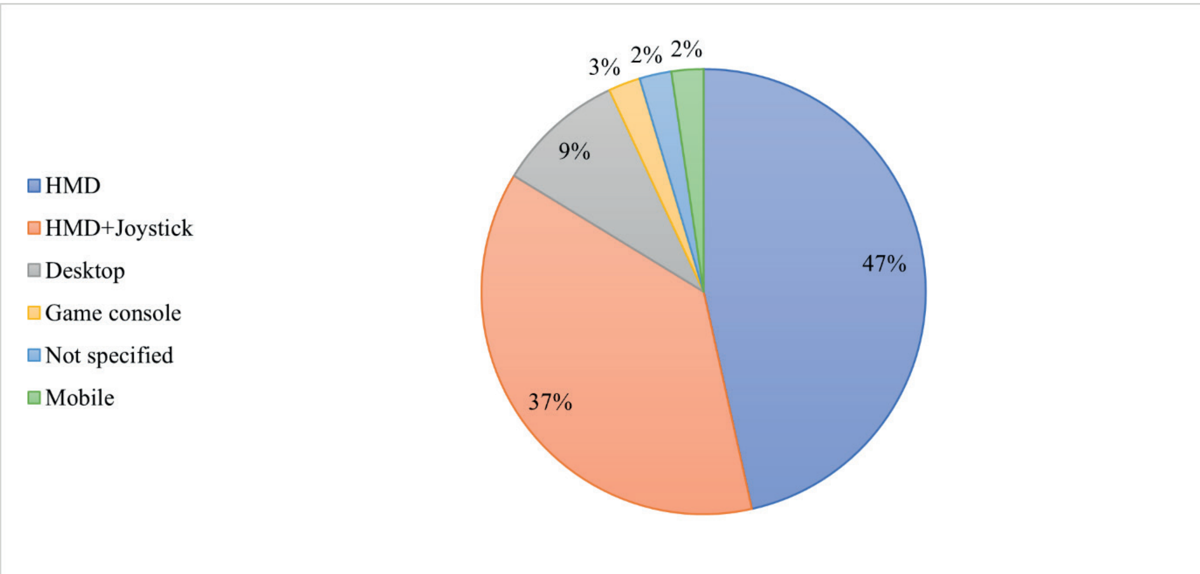


Figure 9. Distribution of VR research by VR technology

Figure 10 illustrates the distribution of learning domains targeted for enhancement through VR utilization within the studies included in the SLR. Notably, the predominant focus lies on improving declarative knowledge (n = 18). For instance, Tugtekin's research (2019) exemplifies this, employing VR applications to elucidate the lightning formation process, enabling participants to comprehend its stages. Following closely, problem-solving skills (n=10) emerge as the second most addressed domain. For instance, Dogan (2021) aimed to simulate scenarios where participants, acting as pharmacists, plan treatment processes based on virtual patient responses, prompting analysis and solution provision. Procedural knowledge (n=6) stands as another targeted area, as demonstrated in Tacgin's research (2017), where participants engage in procedures related to preparing surgical sets used in operating rooms. However, relatively fewer studies focus on learning a language (n=5), behavioral impacts (n=5), and soft skills (n=3). For instance, Dalak (2022) delved into the behavioral implications, examining participants' self-regulation behaviors, while Kocbug (2018) explored VR's impact on word learning, representing learning a language. Additionally, Akbiyik (2020) investigated VR's efficacy in teaching communication initiation and maintenance for individuals with autism spectrum disorder (ASD), contributing to the domain of soft skills learning.

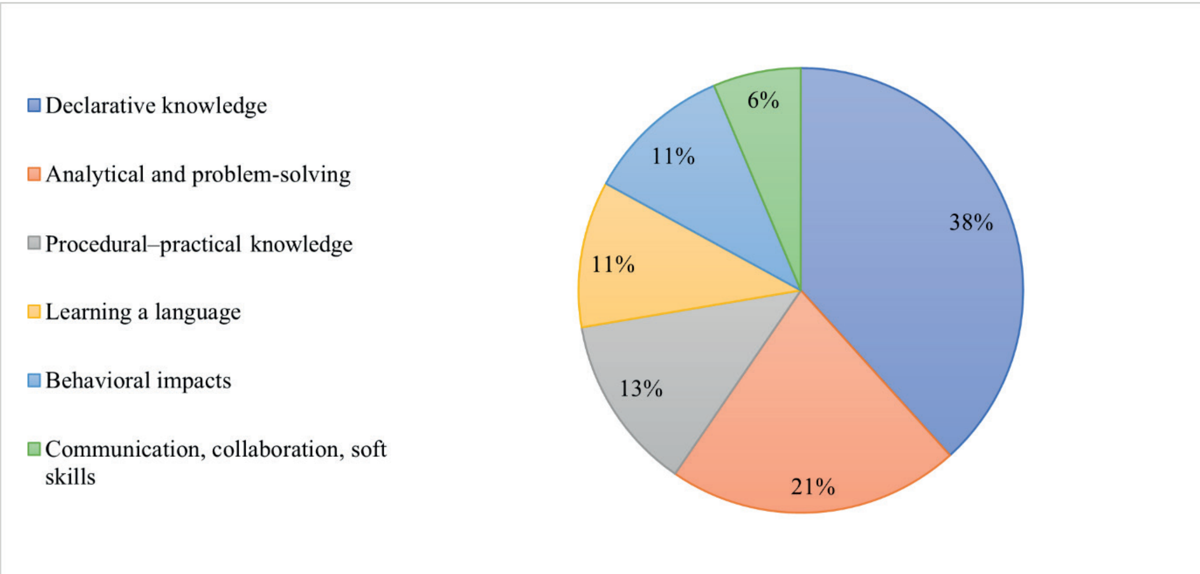


Figure 10. Distribution of VR research by learning domain

Figure 11 portrays the distribution of learning-teaching theories forming the basis of VR research in the education domain. Notably, in constructing the theoretical frameworks, the most favored theory observed was constructivism (n=11). Following this, there were three studies each grounded in experiential learning and multimedia learning, along with two studies rooted in distance education theories. Moreover, individual studies were designed based on discrete trial teaching, behavioral skills training, flipped learning, game-based learning, self-regulated learning, scenario-based learning, and task-based language teaching. A noteworthy finding from this analysis is the absence of any explicitly mentioned learning-teaching theory in 17 studies within VR research frameworks.

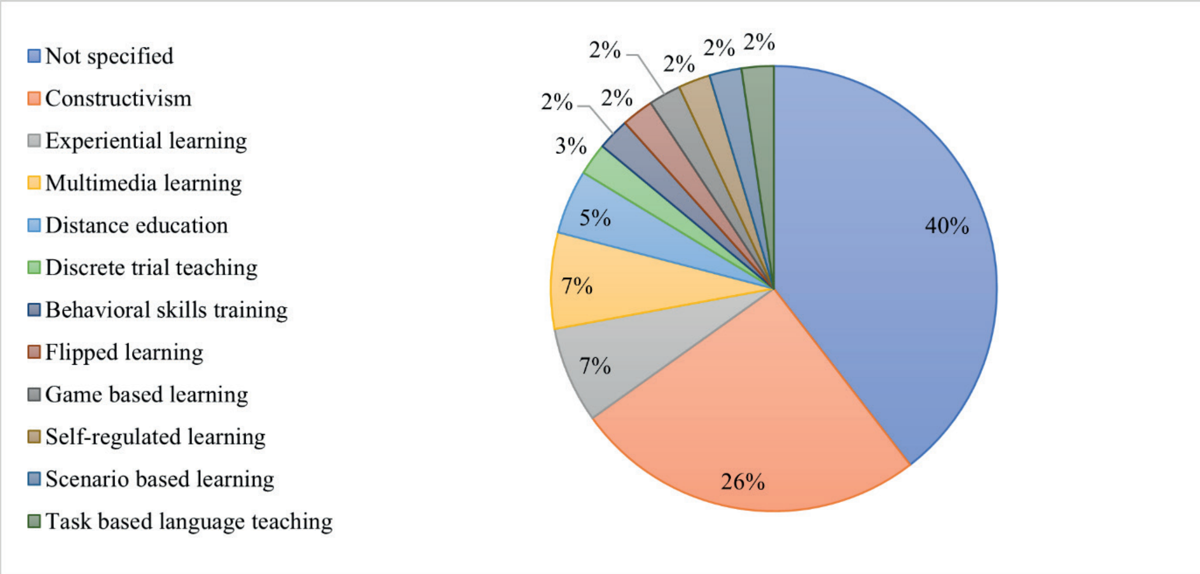


Figure 11. Distribution of VR research according to learning theory

Figure 12 illustrates the distribution of design elements incorporated into VR applications within the research. Notably, the most prevalent design elements observed include realistic experience (n=33), passive observation (n=32), moving around (n=28), and interaction with the virtual environment (n=24). Following these, feedback was present in 14 studies, while informing within the virtual environment and enabling meaningful choices were apparent in 12 and 11 studies, respectively. Conversely, less frequently used design elements encompassed assembling objects (n=4), screen sharing (n=4), knowledge testing (n=11), virtual rewards (n=3), interaction with other users (n=2), and user-generated content (n=1).

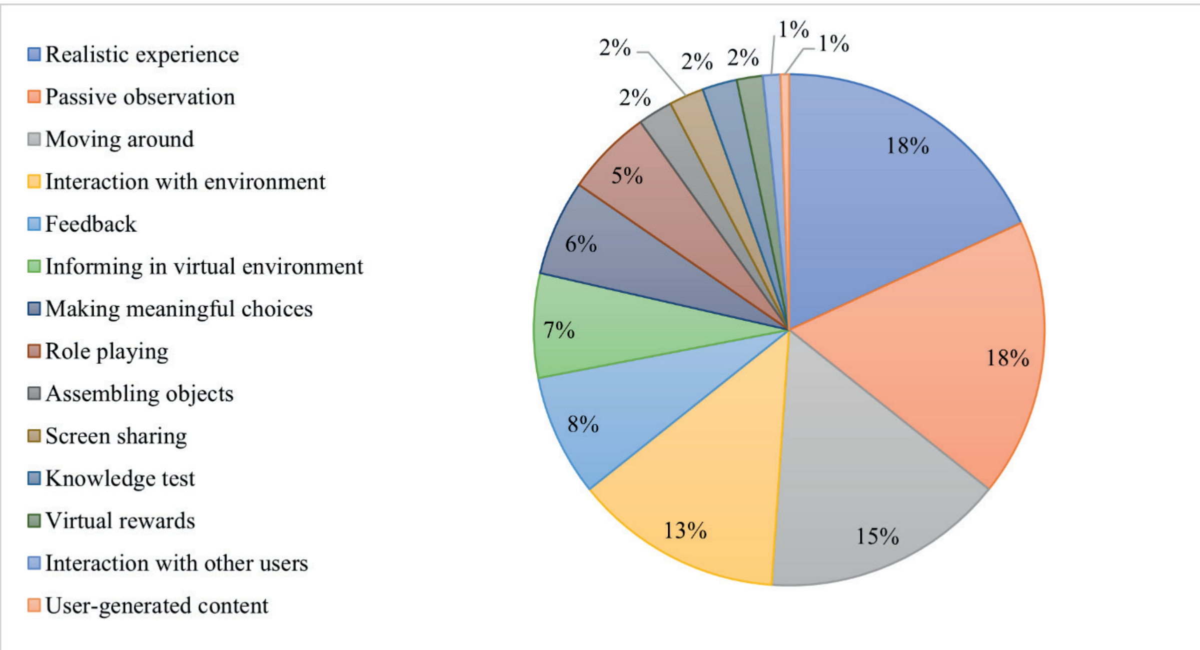


Figure 12. Distribution of VR research by design element

Figure 13, depicted as a bubble chart, illustrates the relationship between the departmental affiliation and research designs employed in the studies. Notably, within the instructional/educational technology department, prevalent research designs encompass qualitative research (n=7), experimental research (n=6), and design and development research (n=3). Science education, educational science, primary school teaching, physical education, and sports teaching departments predominantly employed experimental and qualitative research methodologies. Conversely, the special education department, by its nature, primarily utilized single-subject research (n=1) alongside experimental and qualitative research. Studies within mathematics education were predominantly conducted using design and development and qualitative research. Conversely, departments such as graphic education, English language teaching, Turkish teaching, and management information systems relied solely on experimental research. Notably, in social sciences teaching studies, qualitative research emerged as the preferred methodology. A noteworthy observation is the substantial preference for design and development research observed primarily within the instructional/educational technology department.

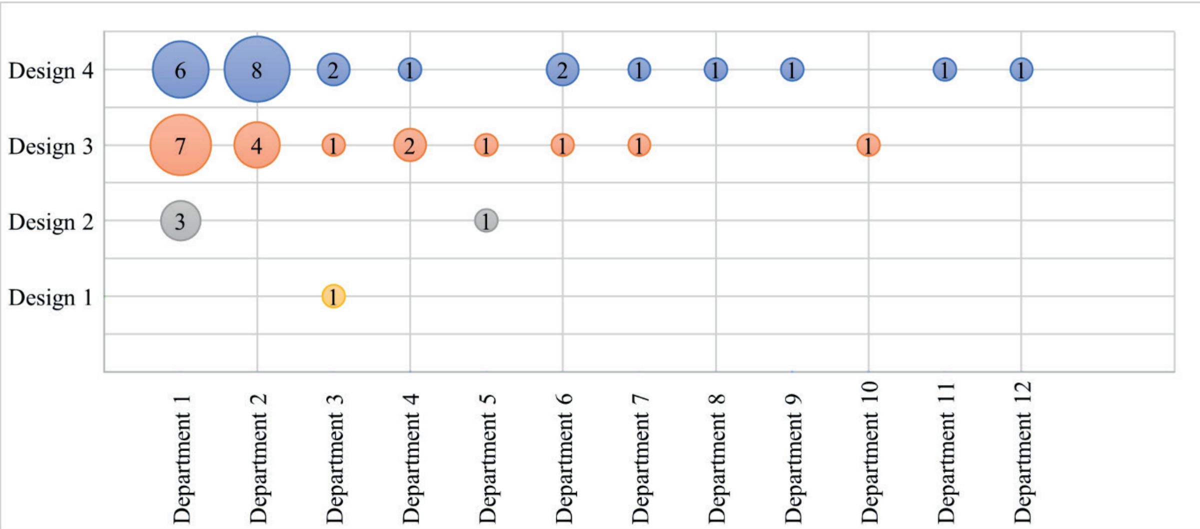


Figure 13. Research design relationship with the department where VR research is conducted

Figure 14 delineates the relationship between the departmental focus in VR studies and the intended learning domains. Notably, studies within the instructional/educational technology department encompassed a wide spectrum, targeting multiple domains such as behavioral impacts, learning a language, declarative knowledge, procedural knowledge, soft skills, and problem-solving. However, within science education, the emphasis primarily lay on declarative knowledge despite its applied nature. Special education studies were directed towards soft skills, procedural knowledge, and declarative knowledge. Meanwhile, research conducted in educational science and primary school teaching departments predominantly centered around the problem-solving domain. In the mathematics education department, studies aimed at problem-solving and behavioral impacts. Notably, studies in physical education and sports teaching primarily concentrated on procedural knowledge. Conversely, departments including graphic education, social sciences teaching, and management information systems primarily targeted the declarative knowledge domain. Lastly, studies within the English language teaching and Turkish teaching departments inherently focused on the domain of learning a language.

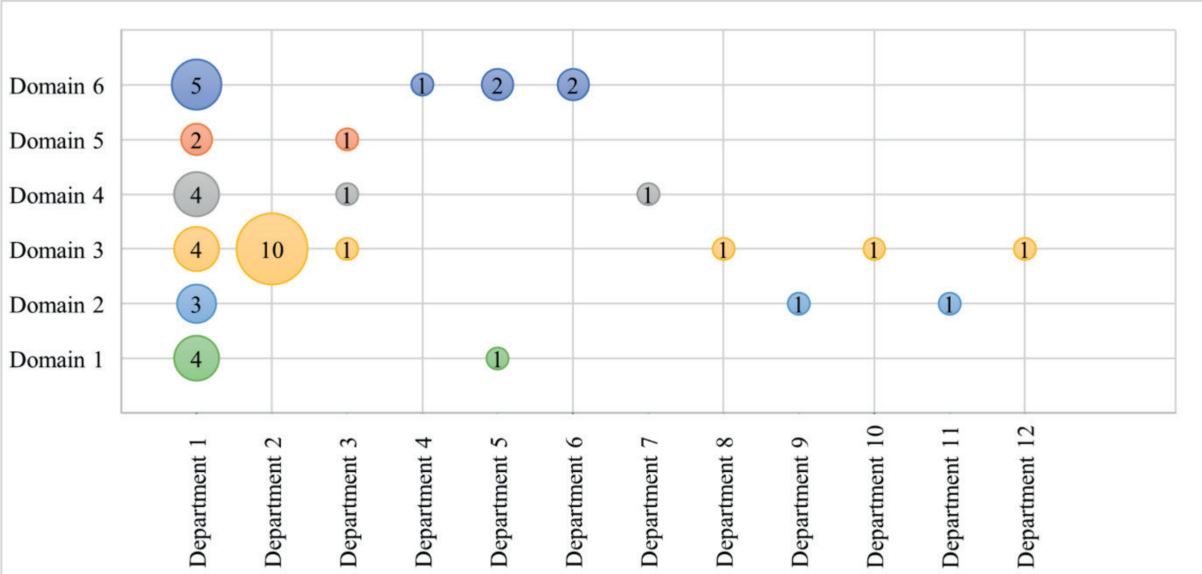


Figure 14. The relationship between the field of VR research and the learning domain

Figure 15, represented as a bubble chart, outlines the relationship between departments and the underlying learning theories in research. Notably, studies within the fields of graphic education, English language teaching, social science teaching, and Turkish teaching lack a specified theoretical basis. In the management information systems department, the sole study is grounded in experiential learning theory. Meanwhile, the study within the Physical education and sports teaching department is based on constructivism. Primary school teaching research primarily leans towards constructivism and self-regulated learning, while mathematics education emphasizes constructivism and game-based learning theories. Within the educational science department, research aligns with experiential learning and distance education theories. In the special education department, the focus is on discrete trial teaching theories. In science education, although constructivism, distance education, and flipped learning were observed in some studies, three studies lacked a specified theory. While most studies in the instructional/educational technology department do not specify a theoretical basis, a few are based on constructivism, experiential learning, multimedia learning, behavioral skills training, game-based learning, and task-based language teaching theories.

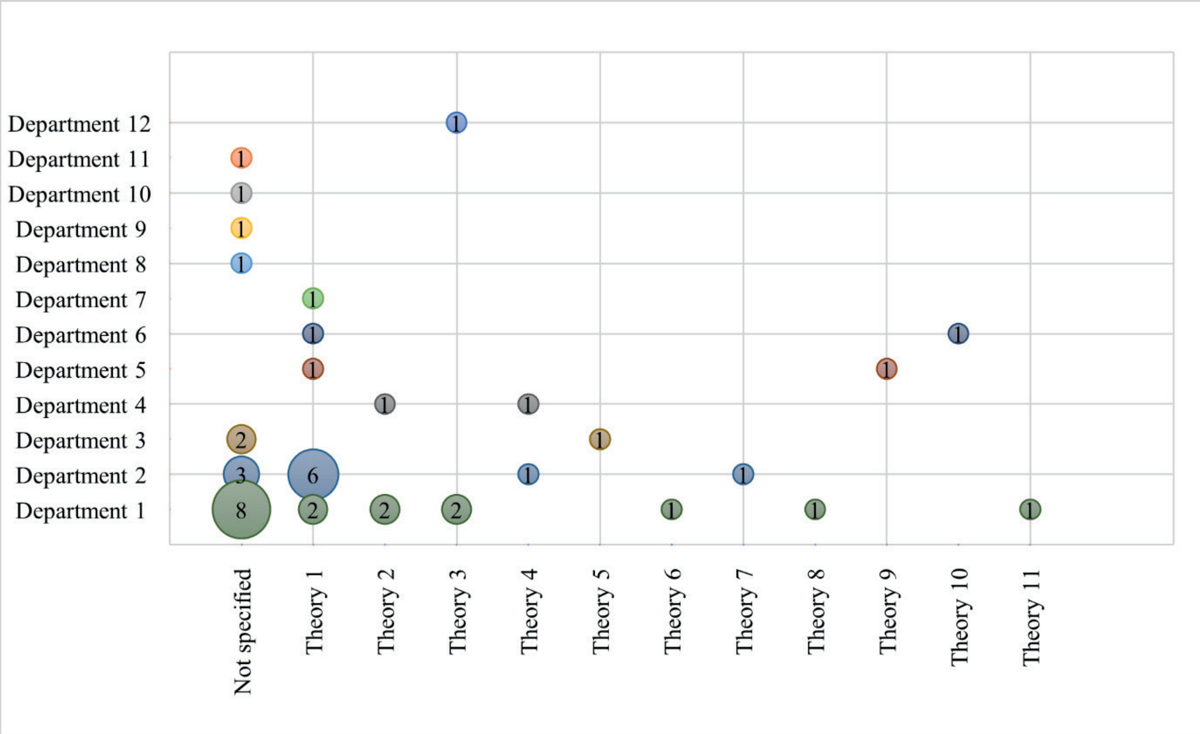


Figure 15. Relationship between the department where VR research is carried out and learning-teaching theory

Figure 16, depicted as a bubble chart, illustrates the relationship between design elements and the type of VR employed in research. Notably, common design elements observed in both immersive and nonimmersive VR applications encompass realistic experience, passive observation, movement within the environment, interaction with the environment, interaction with other users, and screen sharing. However, immersive VR applications include additional prevalent design elements such as role-playing (n=10), informing within the virtual environment (n=12), feedback (n=14), and making meaningful choices (n=11). Conversely, less frequently used design elements within immersive VR applications encompass user-generated content (n=1), knowledge testing (n=4), and virtual rewards (n=3).

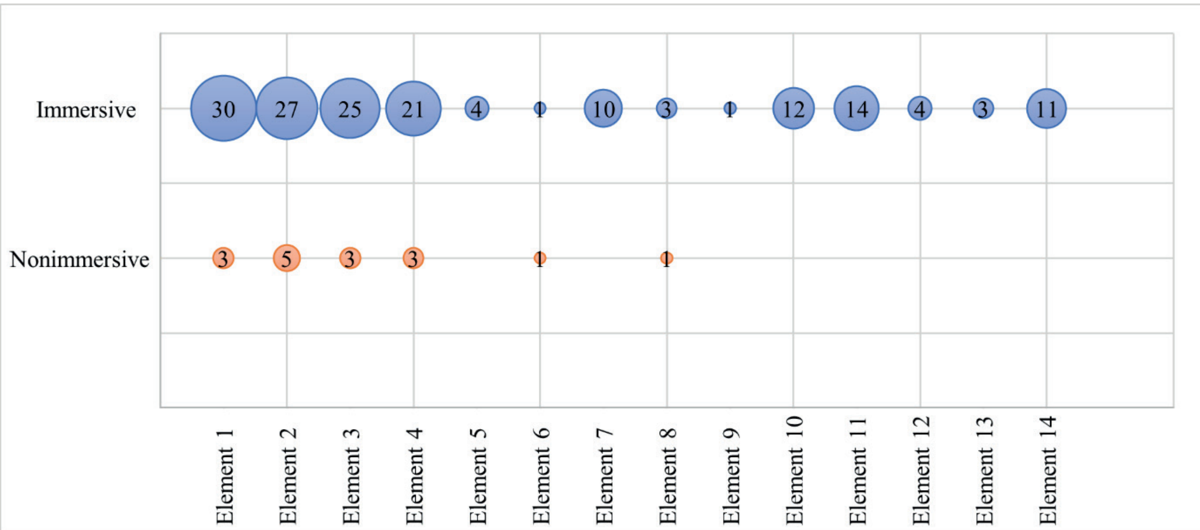


Figure 16. Relationship between design element and VR type in VR research

Figure 17, displayed as a bubble chart, illustrates the relationship between design elements and learning domains. Notably, in research focused on the problem-solving domain, prevalent design elements include interaction with the environment (n=10), movement within the environment (n=8), feedback mechanisms (n=8), and enabling meaningful choices (n=8). Conversely, elements such as interaction with other users (n=1), user-generated content (n=1), and knowledge testing (n=1) are less frequently utilized within this domain. For studies targeting soft skills, knowledge testing and virtual rewards elements have not been used, while other design elements have limited application, appearing once or twice.

In research addressing procedural knowledge, the frequently employed design elements encompass realistic experiences (n=6), movement within the environment (n=5), interaction with the environment (n=5), and information presentation within the virtual setting (n=5). Notably, interaction with other users has not been utilized within this domain. For studies focusing on declarative knowledge, commonly utilized design elements include passive observation, realistic experiences, and interaction with the environment. Conversely, elements such as assembling objects, interaction with other users, role-playing, user-generated content, virtual rewards, and meaningful choices have not been encountered within this domain.

In VR applications aimed at learning a language, prevalent elements involve movement within the environment, realistic experiences, passive observation, interaction with the environment, knowledge testing, role-playing, information presentation within the virtual setting, and meaningful choices. Lastly, VR applications directed at behavioral impacts commonly incorporate realistic experiences, movement within the environment, and interaction with other users, whereas elements like knowledge testing and virtual rewards are absent within this domain.

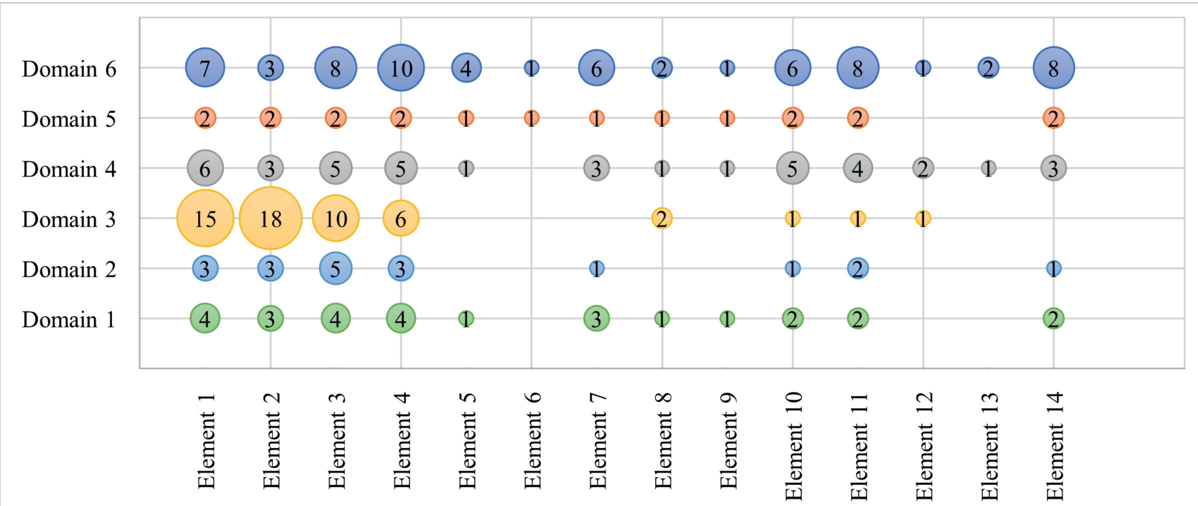


Figure 17. Relationship between the design element and the learning space in VR research

DISCUSSION AND RECOMMENDATIONS

The fields of instructional/educational technology and science education emerged as the most active departments conducting VR research, potentially owing to their inclination toward immersive learning environments. However, despite this inclination, VR applications have proven effective across various domains, showcasing positive impacts on learning outcomes (Bailenson et al., 2008; Dogan & Sahin, 2023; Koivisto et al., 2018; Merchant et al., 2014). A significant challenge in adopting VR lies in the technical complexity inherent in its implementation, as highlighted by Maples-Keller et al. (2017). Nonetheless, Dogan and Sahin (2023) demonstrated that this obstacle could be overcome by developing user-friendly interfaces in VR environment design. Such advancements could democratize the utilization of VR applications, enabling educational research across all academic departments.

The progression of VR research has shown a steady increase since 2011, particularly surging from 2018 onward. This trend aligns with findings from Radianti et al. (2020) and Suh and Prophet (2018). Moreover, the Gartner hype cycle indicated that VR transitioned into the slope of enlightenment phase in 2016, signifying widespread acknowledgment of its benefits. Consequently, the increased frequency of VR becoming a focal point in educational research post-2018 appears consistent with the growing recognition of VR's potential benefits.

Upon methodological scrutiny of VR research, it's evident that experimental research stands as the most frequently employed method, focusing notably on examining VR's impact on various facets of the learning process. The substantial use of qualitative research aligns with prior findings by Suh and Prophet (2018). However, it's noteworthy that design and development research are markedly underutilized. This contrasts with the prevalence of design-oriented studies in VR literature, as highlighted by Radianti et al. (2020). Incorporating design-oriented research is crucial, considering that VR applications necessitate thorough design and development stages. The absence of such studies within research frameworks limits guidance for future endeavors, urging a shift towards emphasizing design-oriented research in VR applications. Upon exploring the correlation between research design and department, a notable observation emerged: the prevalent preference for design and development research within the department of instructional/educational technology. This inclination can be attributed to the comprehensive training instructional technologists undergo, specifically in the design and development of instructional design and materials. Hence, leveraging the expertise of professionals in this department becomes imperative when undertaking research involving VR applications.

An overwhelming majority (91%) of VR application participants comprise K12 and higher education students. Nonetheless, the evolving landscape of education systems from closed to open systems includes numerous new stakeholders (Anderson et al., 2001). Encouraging the involvement of stakeholders like parents, teachers, community leaders, and non-governmental organizations can significantly enhance the system's success (Khadija, 2022). Hence, it's imperative to expand participant groups in VR research to encompass managers, policymakers, teachers, experts, and others involved in educational realms. Our findings emphasize the predominant use of test, scale, and interview tools, indicating a focus on variables like achievement, affective skills, and opinions. This prevalence aligns with the frequent use of experimental and qualitative research methodologies. Correspondingly, the preference for data analysis methods appears connected to research design, with parametric tests and content analysis being predominantly employed. These trends corroborate with prior SLR results (Radianti et al., 2020).

The research indicates a significant preference for immersive VR, constituting almost 90% of VR research endeavors, prominently utilizing technologies such as HMD and HMD with joystick. These findings align consistently with prior studies (Radianti et al., 2020; Suh and Prophet, 2018), reinforcing the convergence of our research outcomes with existing SLR trends.

The outcomes predominantly highlight efforts aimed at enhancing declarative knowledge through VR applications. Declarative knowledge forms the fundamental basis for verbal knowledge and intellectual skills. Additionally, problem-solving and procedural knowledge emerge as other frequently targeted domains in VR research. This tendency aligns logically with VR's potential for practical application. Notably, Radianti et al. (2020) observed a similar trend, albeit ranking procedural knowledge as the foremost domain. Examining the association between these learning areas and the departments conducting research revealed that instructional/educational technology studies encompassed research across all domains. This phenomenon can be attributed to the interdisciplinary nature of instructional technology. Conversely, although science education primarily focuses on applied aspects, its studies predominantly aim at declarative knowledge. Consequently, it's advisable for this field to explore studies on procedural knowledge and problem-solving.

Our study unveils a significant trend wherein nearly half of the VR studies lack a clear theoretical foundation, with Constructivism being the most frequently cited learning theory. This finding is expected, given the strong compatibility between VR utilization and the constructivist paradigm. Mikropoulos and Natsis (2011) highlighted a similar trend in their review of VR in education, observing that few studies were grounded in theoretical or pedagogical frameworks, with most aligning with constructivism. Similarly, Radianti et al. (2020) reported that 68% of studies didn't reference any theoretical foundations. Notably, no mention of learning-teaching theories was observed in studies within the departments of graphic education, English language teaching, social science teaching, and Turkish teaching, suggesting a need for theoretical foundation training across disciplines, particularly in these areas.

Examining the design elements of VR applications, we note the frequent usage of elements like realistic experience, passive observation, moving around, and interaction with the environment. This observation echoes findings by Radianti et al. (2020) and aligns with Suh and Prophet's (2018) mention of intense applications involving immersion, presence, and interactivity. However, when we investigate the relationship between design elements and VR type, we find that while many studies claim an immersive experience, elements such as assembling objects, screen sharing, virtual rewards, interaction with other users, and user-generated content are scarcely incorporated. This discrepancy underscores the need for a deeper exploration into the concept of immersion.

Upon analyzing the design elements in VR applications and their correlation with the learning domains targeted for development, several distinct associations emerge. Elements such as interaction with the environment, moving around, feedback, and making meaningful choices are prominently featured in applications aimed at enhancing problem-solving skills. Given that problem-solving inherently involves interactivity, feedback mechanisms, and decision-making, this alignment is quite logical. Interestingly, elements like knowledge testing and virtual rewards are consistently absent in applications focusing on soft skills. This absence might be attributed to the emphasis on communication and collaboration in this domain. Notably, applications aiming to enhance procedural knowledge frequently employ elements such as realism, interactivity, and information dissemination within the virtual environment. These elements seem tailored to simulate realistic experiences that aid in procedural knowledge acquisition.

Declarative knowledge applications often prioritize passive observation, presenting users with immersive oral presentations resembling traditional learning environments. Conversely, applications geared towards learning a language frequently incorporate the moving around element, encouraging users to navigate the virtual environment to learn object names. In the domain of behavioral impacts, realistic experience, moving around, and interaction with other users emerge as preferred elements. This domain, focused on inducing behavioral change, notably highlights interaction with others, a feature standing out for the first time in this area. Previous studies by Wohlgenannt et al. (2019) also indicated a preference for exploration elements in declarative knowledge, instruction elements in procedural knowledge, and realistic environments for problem-solving and collaboration skills. Our research thus contributes additional insights to the existing literature, suggesting the need for further investigations into the specific design elements that significantly contribute to the development of distinct learning domains.

LIMITATIONS

Our study specifically focused on VR applications within educational processes, overlooking the broader spectrum of VR's extensive applications. VR's reach extends across diverse domains, spanning health, engineering, social sciences, and advertising, where VR applications might have attained varying levels of maturity. Consequently, our research outcomes are confined solely to the educational domain, limiting insights into advancements and trends present in other sectors leveraging VR technology.

Additionally, our SLR primarily encompassed postgraduate thesis studies conducted in a Eurasian country (Table 6), aiming for an extensive scope by examining VR studies without temporal restrictions. However, this review's limitations are evident in its exclusion of publications like articles and papers, which might offer deeper insights and diverse perspectives on VR applications beyond the confines of theses.

Table 6. Studies included in SLR

	Author	Title
1	Abdusselam (2022)	The effect of augmented and virtual reality technologies on using light microscope in science teaching
2	Akbiyik (2020)	Effectiveness of virtual reality technology on teaching communication initiating and maintenance skills to students with autism spectrum disorder
3	Akman (2019)	The investigation of the effects of a virtual reality application developed for fractions in the mathematics lessons of elementary school considering some different variables
4	Albayrak (2015)	The impact of Kinect usable 3d virtual reality applications on young learners' vocabulary development in foreign languages vocabulary learning

5	Arici (2013)	A study on 3D-virtual reality in science education programs: "Solar system and beyond: Space puzzle" unit sample
6	Bilen (2023)	The effect of virtual reality based virtual museum design application on student achievement in science education
7	Bilgin (2018)	The evaluation of different technology supported learning environments for data sub-learning field in secondary mathematics curriculum
8	Bozdemir (2022)	The effect of immersive virtual reality use on listening skill in foreign language education
9	Ceken (2023)	Examination of multimedia learning principles in augmented reality and virtual reality learning environments
10	Coruh (2011)	Assessment of the effectiveness of virtual reality applications in art history course as a learning model (An example of Erciyes University architecture & fine arts faculties)
11	Dagdalan (2019)	The effects of virtual reality supported science education on students' cognitive levels, meta cognitive awareness and attitudes toward virtual reality
12	Dalak (2022)	Mathematics teachers' self-regulated learning behaviors in an immersive virtual environment
13	Demir (2018)	Investigation of students' views on the use of virtual reality in algorithm teaching in the context of learning styles
14	Denizalp (2022)	Investigation of the effects of a virtual reality application developed for area measurement and geometric objects in mathematics lessons considering some different variables
15	Dogan (2021)	Design and development of virtual reality environments in Pharmacy education
16	Dogdu (2023)	An implementation intended to flipped classroom model supported by virtual reality: Example of solar and beyond unit
17	Durukan (2018)	Investigating the effects of virtual reality enriched learning environment on pre-service science teachers
18	Gokoglu (2019)	The impact of virtual reality based learning environment on the development of behavioral skills towards fire safety
19	Gul (2016)	Exploring the use of 3D virtual worlds for psychoeducational groups: A multiple case study
20	Guler (2021)	Mobile based virtual reality application development study for visuospatial skills of dyslexic individuals
21	Gunduz (2022)	The effect of virtual reality assisted task-based language teaching approach on graduate students
22	Kalkan (2020)	Examining the efficiency of virtual reality technology in basic technical skills training: Table tennis case study
23	Karadayi (2022)	A case study on implementing experiential learning supported with virtual reality technology in teacher education
24	Kocbug (2018)	The effectiveness of virtual reality tools on vocabulary learning and retention
25	Kurt (2022)	The effect of virtually reality practice on mathematic success of students with learning disabilities
26	Kurtca (2021)	Effectiveness of virtual reality technology in teaching pedestrian skills to children with intellectual disabilities
27	Mete (2021)	Design and development research: "Hezarfen VR" educational virtual reality game
28	Metin (2023)	The use of virtual reality applications in social studies teaching: seben rock houses and fossil forest examples
29	Ozer (2023)	A case study on the use of virtual reality application in primary school science course
30	Ozonur (2013)	The design of second life applications as virtual world and examining the effects of these applications on the learning of the students attending internetbased distance education in terms of different variables
31	Sagdic (2019)	A comparison of discrete trial teaching and virtual reality glasses teaching effectiveness in teaching facial expressions to students with autism spectrum disorder
32	Saricam (2019)	Investigation of the effect of virtual reality applications on teaching circulatory system concepts in science lesson
33	Sarioglu (2019)	The effect of using virtual reality in 6th grade science course the cell topic on students' academic achievements and attitudes towards the course
34	Tacgin (2017)	Development and evaluation of a virtual reality simulation to teach surgical sets used in the operating room

35	Tarhan (2020)	The effect of virtual reality tools on vocabulary learning in teaching Turkish as a foreign language and its efficiency in retention
36	Tay (2020)	Evaluation of the effects of the virtual campus tour application designed according to panoramic based virtual reality
37	Tepe (2019)	Investigating the effects of virtual reality environments developed for head-mounted display on learning and presence
38	Topuz (2018)	The comparison of virtual reality and desktop three-dimensional materials in anatomy teaching in terms of academic performance and cognitive load
39	Tugtekin (2019)	Effect of reducing extraneous processing principles on cognitive load and achievement in augmented reality and virtual reality environments in multimedia learning
40	Urhan (2019)	Investigation of the effect of virtual reality applications for science education
41	Unal (2022)	Virtual museum implementation on biology issues: Its reflection to science teachers
42	Yesiltas (2019)	The effect of guide materials based on animation and virtual reality on some learning products; example of circulatory system
43	Yilmaz (2023)	Examination of technology-supported laboratory applications in terms of different variables

Our research primarily emphasizes the interrelation between design elements, learning domains, learning-teaching theories, and research designs within VR studies. Consequently, aspects like the advantages and disadvantages of integrating VR in educational settings were deliberately omitted from our study's scope. Essentially, our research is confined to exploring and analyzing the specific elements inherent to VR applications within educational contexts.

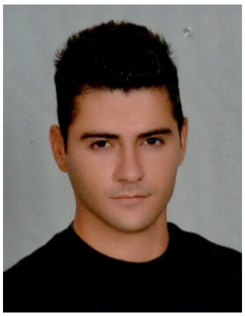
CONCLUSION

The aim of this research is to delineate the prevailing trends in VR applications within educational contexts and to explore the interconnectedness among learning-teaching theories, learning domains, design elements, VR types, and the departments conducting such research. The findings indicate a notable concentration of VR research within technology-related departments. The predominant approach in this domain involves experimental examinations of diverse variables within VR learning environments, yet there's a scarcity of design-oriented studies. Considering the current characterization of VR research as the 'Wild West' with a lack of established guidelines (Birckhead et al., 2019), there's a pressing need for research that elucidates the design and development processes comprehensively. Furthermore, a striking revelation is the absence of a solid theoretical framework in the majority of studies. Given the pivotal role of learning-teaching theories in guiding these processes, their absence might impede the broader integration of VR in educational settings. In exploring design elements, the prominence of realistic experience, passive observation, moving around, and interaction with the environment is evident. Recognizing the potential impact of diverse elements in enhancing realism, it's apparent that aligning specific elements with distinct learning domains can elevate the immersive quality of VR experiences.

BIODATA and CONTACT ADDRESSES of AUTHORS

Dr. Ezgi DOGAN is an Assistant Professor of Department of Measurement and Evaluation at Education Faculty, Van Yuzuncu Yil University. Dr. Dogan gained her Ph.D. in Computer Education and Instructional Technology at July, 2021. Her academic interest areas are virtual environments, social media, digital games in education and educational statistics. She has various journal articles published in international indexes, international book chapters and other national and international articles, papers submitted to international meetings.

Ezgi DOGAN
Department of Measurement and Evaluation, Faculty of Education
Address: Van Yuzuncu Yil University, 65080, Van, Turkiye
Phone: +90 5458570885,
E-mail: ezgidogan@yyu.edu.tr



Dr. Ferhan SAHIN is an Assistant Professor of Department of Special Education at Education Faculty, Agri Ibrahim Cecen University. Dr. Sahin gained his Ph.D. in Computer Education and Instructional Technology at July, 2021. His academic interest areas are technology acceptance, online education, teacher education, special education and digital games. He has various journal articles published in international indexes, international book chapters and other national and international articles, papers submitted to international meetings.

Ferhan SAHIN
Department of Special Education, Faculty of Education
Address: Agri Ibrahim Cecen University, 04100, Agri, Turkiye
Phone: +90 5453181118,
E-mail: fsahin@agri.edu.tr

REFERENCES

Abdusselam, Z. (2022). *The effect of augmented and virtual reality technologies on using light microscope in science teaching* [Unpublished doctoral dissertation]. Hacettepe University.

Akbiyik, M. (2020). *Effectiveness of virtual reality technology on teaching communication initiating and maintenance skills to students with autism spectrum disorder* [Unpublished master's thesis]. Bolu Abant IzzetBaysal University.

Akman, E. (2019). *The investigation of the effects of a virtual reality application developed for fractions in the mathematics lessons of elementary school considering some different variables* [Unpublished doctoral dissertation]. Amasya University.

Albayrak, M. (2015). *The impact of Kinect usable 3d virtual reality applications on young learners' vocabulary development in foreign languages vocabulary learning* [Unpublished master's thesis]. Fatih University.

Alhalabi, W. (2016). Virtual reality systems enhance students' achievements in engineering education. *Behaviour & Information Technology, 35*(11), 919-925. https://doi.org/10.1080/0144929X.2016.1212931

Anderson, L., Briggs, A. R., & Burton, N. (2001). *Managing finance, resources and stakeholders in education*. Sage.

Appleton, K. (1997). Analysis and description of students' learning during science classes using a constructivistbased model. *Journal of Research in Science Teaching, 34*, 303-318. https://doi.org/10.1002/(SICI)1098-2736(199703)34:3<303::AID-TEA6>3.0.CO;2-W

Arici, V. A. (2013). *A study on 3D-virtual reality in science education programs: "Solar system and beyond: Space puzzle" unit sample* [Unpublished master's thesis]. Adnan Menderes University.

Bailenson, J. N., Yee, N., Blascovich, J., Beall, A. C., Lundblad, N., & Jin, M. (2008). The use of immersive virtual reality in the learning sciences: Digital transformations of teachers, students, and social context. *The Journal of the Learning Sciences, 17*(1), 102-141. https://doi.org/10.1080/10508400701793141

Bilen, S. (2023). *The effect of virtual reality based virtual museum design application on student achievement in science education* [Unpublished master's thesis]. Necmettin Erbakan University.

Bilgin, E. A. (2018). *The evaluation of different technology supported learning environments for data sub-learning field in secondary mathematics curriculum* [Unpublished doctoral dissertation]. Ataturk University.

Birckhead, B., Khalil, C., Liu, X., Conovitz, S., Rizzo, A., Danovitch, I., ... ve Spiegel, B. (2019). Recommendations for methodology of virtual reality clinical trials in health care by an international working group: iterative study. *JMIR Mental Health, 6*(1), e11973. https://doi.org/10.2196/11973

Blyth, C. (2018). Immersive technologies and language learning. *Foreign Language Annals, 51*(1), 225-232. https://doi.org/10.1111/flan.12327

Boell, S.K., & Cecez-Kecmanovic, D. (2015). On being 'systematic' in literature reviews. In: Willcocks, L.P., Sauer, C., Lacity, M.C. (Eds.), *Formulating research methods for* information *systems* (pp. 48-78). Palgrave Macmillan. https://doi.org/10.1057/9781137509888_3

Bozdemir, Y. (2022). *The effect of immersive virtual reality use on listening skill in foreign language education* [Unpublished master's thesis]. Inonu University.

Bruner, J. S. (2009). *The process of education* (2nd ed.). Harvard University Press,

Bygate, M. (2016). Sources, developments and directions of task-based language teaching. *The Language Learning Journal, 44*(4), 381–400. https://doi.org/10.1080/09571736.2015.1039566

Ceken, B. (2023). *Examination of multimedia learning principles in augmented reality and virtual reality learning environments* [Unpublished doctoral dissertation]. Bogazici University.

Chavez, B., & Bayona, S. (2018). Virtual reality in the learning process. In A. Rocha, H. Adeli, L. Reis, & S. Costanzo (Eds.), *Trends and advances in information systems and technologies. WorldCIST'18* (pp. 1345–1356). Springer. https://doi.org/10.1007/978-3-319-77712-2_129

Chen, C. J. (2007). Formative research on the instructional design process of virtual reality-based learning environments. *Proceedings Ascilite Singapore*, 149-156.

Coruh, L. (2011). *Assessment of the effectiveness of virtual reality applications in art history course as a learning model (An example of Erciyes University architecture & fine arts faculties)* [Unpublished doctoral dissertation]. Gazi University.

Dagdalan, G. (2019). *The effects of virtual reality supported science education on students' cognitive levels, meta cognitive awareness, and attitudes toward virtual reality* [Unpublished master's thesis]. Ordu University.

Dalak, H. (2022). *Mathematics teachers' self-regulated learning behaviors in an immersive virtual environment* [Unpublished master's thesis]. Bogazici University.

Dalgarno, B., & Lee, M. J. W. (2010). What are the learning affordances of 3-D virtual environments? *British Journal of Educational Technology, 41*(1), 10–32. https://doi.org/10.1111/j.1467-8535.2009.01038.x

Demir, D. (2018). *Investigation of students' views on the use of virtual reality in algorithm teaching in the context of learning styles* [Unpublished master's thesis]. Canakkale Onsekiz Mart University.

Denizalp, N. (2022). *Investigation of the effects of a virtual reality application developed for area measurement and geometric objects in mathematics lessons considering some different variables* [Unpublished master's thesis]. Recep Tayyip Erdogan University.

Dogan, E. (2021). *Design and development of virtual reality environments in Pharmacy education* [Unpublished doctoral dissertation]. Anadolu University.

Dogan, E., & Sahin, Y. L. (2023). Virtual reality environment in pharmacy education: A cyclical study on instructional design principles. *Journal of Computer Assisted Learning*, 1–19. https://doi.org/10.1111/jcal.12878

Dogdu, N. (2023). *An implementation intended to flipped classroom model supported by virtual reality: Example of solar and beyond unit* [Unpublished master's thesis]. Van Yuzuncu Yil University.

Duffy, T. M., & Cunningham, D. J. (1996). Constructivism: Implications for the design and delivery of instruction. In D. H. Johassen (Ed.), *Handbook of research for educational communications and technology* (pp.170-198). Macmillan.

Durukan, A. (2018). *Investigating the effects of virtual reality enriched learning environment on pre-service science teachers* [Unpublished master's thesis]. Van Yuzuncu Yil University.

Fink, A. (2005). *Conducting research literature reviews: From the internet to paper* (2nd ed.). Sage Publications.

Gagne, R. M. (1972). Domains of learning. *Interchange* 3, 1–8. https://doi.org/10.1007/BF02145939

Gokoglu, S. (2019). *The impact of virtual reality based learning environment on the development of behavioral skills towards fire safety* [Unpublished doctoral dissertation]. Trabzon University.

Gul, A. (2016). *Exploring the use of 3D virtual worlds for psychoeducational groups: A multiple case study* [Unpublished doctoral dissertation]. Orta Dogu Teknik University.

Guler, M. C. (2021). *Mobile based virtual reality application development study for visuospatial skills of dyslexic individuals* [Unpublished master's thesis]. Ege University.

Gunduz, A. (2022). *The effect of virtual reality assisted task-based language teaching approach on graduate students* [Unpublished doctoral dissertation]. Ataturk University.

Hawkins, D. G. (1995). Virtual reality and passive simulators: the future of fun. In F. Biocca ve M. R. Levy (Eds.), *Communication in the age of virtual reality* (pp. 159-189). Lawrence Erlbaum.

Hedberg, J., & Alexander, S. (1994). Virtual reality in education: defining researchable issues. *Educational Media International, 31*(4), 214–220. https://doi.org/10.1080/0952398940310402

Himle, M. B., & Miltenberger, R. G. (2004). Preventing unintentional firearm injury in children: The need for behavioral skills training. *Education and Treatment of Children, 27*, 161-177.

Holmberg, B. (2005). *The evolution, principles and practices of distance education*. BIS-Verlag der.

Johnson, D. W., & Johnson, R. T. (1996). Cooperation and the use of technology. In D. H. Jonassen (Ed.), *Handbook of research for educational communications and technology* (pp. 777-803). Macmillan.

Jonassen, D. (1999). Designing constructivist learning environments. In M. Reigeluth (Ed.), *Instructional-design theories and models: A new paradigm of instructional theor*y (pp. 215-241). Lawrence Erlbaum Associates.

Jonassen, D. H. (1992). Evaluating constructivist learning. In T. M. Duffy ve D. H. Jonassen (Eds.), *Constructivism and the technology of instruction* (pp. 137-148). Erlbaum Associates.

Kalkan, N. (2020). *Examining the efficiency of virtual reality technology in basic technical skills training: Table tennis case study* [Unpublished doctoral dissertation]. Manisa Celal Bayar University.

Karadayi, Z. (2022). *A case study on implementing experiential learning supported with virtual reality technology in teacher education* [Unpublished doctoral dissertation]. Canakkale Onsekiz Mart University.

Khadija, H. (2022). Stakeholders in education. *Annals of the University of Oradea, Economic Science Series, 31*(1), 425-435.

Kocbug, R. (2018). *The effectiveness of virtual reality tools on vocabulary learning and retention* [Unpublished master's thesis]. Istanbul University.

Kochin, D., Ustinovichius, L., Sliesoraitiene, V. (2005). Implicit Learning System for Teaching the Art of Acute Cardiac Infarction Diagnosis. In S. Miksch, J. Hunter, E. T. Keravnou (Eds.), *Artificial Intelligence in Medicine, Lecture Notes in Computer Science.* Springer. https://doi.org/10.1007/11527770_52

Koivisto, J. M., Haavisto, E., Niemi, H., Haho, P., Nylund, S., & Multisilta, J. (2018). Design principles for simulation games for learning clinical reasoning: A design-based research approach. *Nurse Education Today, 60*, 114–120. https://doi.org/10.1016/j.nedt.2017.10.002

Kolb, D.A. (1984). *Experiential learning: Experience as the source of learning and development*. Prentice-Hall Inc.

Kurt, A. (2022). *The effect of virtually reality practice on mathematic success of students with learning disabilities* [Unpublished doctoral dissertation]. Burdur Mehmet Akif Ersoy University.

Kurtca, V. E. (2021). *Effectiveness of virtual reality technology in teaching pedestrian skills to children with intellectual disabilities* [Unpublished doctoral dissertation]. Trakya University.

Lave, J. (1991). Situating learning in communities of practice. In L.B., Resnick, L.B., Levine J.M., Teasley, S.D. (Eds.), *Perspectives on socially shared cognition* (pp. 63-82). American Psychological Association.

Makransky, G., & Petersen, G. B. (2021). The cognitive affective model of immersive learning (CAMIL): A theoretical research-based model of learning in immersive virtual reality. *Educational Psychology Review, 33*, 937–958. https://doi.org/10.1007/s10648-020-09586-2

Mayer, R.E. (2009), *Multimedia learning* (2nd ed.). Cambridge University Press. https://doi.org/10.1017/CBO9780511811678

Merchant, Z., Goetz, E. T., Cifuentes, L., Keeney-Kennicutt, W., & Davis, T. J. (2014). Effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education: A meta-analysis. *Computers & Education, 70*, 29–40. http://dx.doi.org/10.1016/j.compedu.2013.07.033

Mete, S. E. (2021). *Design and development research: "Hezarfen VR" educational virtual reality game* [Unpublished doctoral dissertation]. Bahcesehir University.

Metin, E. (2023). *The use of virtual reality applications in social studies teaching: Seben rock houses and fossil forest examples* [Unpublished master's thesis]. Bolu Abant Izzet Baysal University.

Mikropoulos, T. A. & Natsis, A. (2011). Educational virtual environments: a ten-year review of empirical research (1999–2009). *Computers & Education, 56*, 769–780. https://doi.org/10.1016/j.compedu.2010.10.020

Mulders, M., Buchner, J., & Kerres, M. (2020). A framework for the use of immersive virtual reality in learning environments. *International Journal of Emerging Technologies in Learning, 15*(24), 208–224. https://doi.org/10.3991/ijet.v15i24.16615%0d

Okoli, C., & Schabram, K. (2010). A guide to conducting a systematic literature review of information systems research, *Sprouts: Working Papers on Information Systems 10*(26), 1-49.

Ozer, F. (2023). *A case study on the use of virtual reality application in primary school science course* [Unpublished doctoral dissertation]. Istanbul University.

Ozonur, M. (2013). *The design of second life applications as virtual world and examining the effects of these applications on the learning of the students attending internetbased distance education in terms of different variables* [Unpublished doctoral dissertation]. Mersin University.

Petticrew, M., & Roberts, H. (2006). *Systematic reviews in the social sciences: A practical guide*. Blackwell Pub.

Prensky, M. (2003). Digital game-based learning. *Computers in Entertainment (CIE), 1*(1), 21-21. https://doi.org/10.1145/950566.950596

Radianti, J., Majchrzak, T. A., Fromm, J., & Wohlgenannt, I. (2020). A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. *Computers & Education, 147*, 103778. https://doi.org/10.1016/j.compedu.2019.103778

Sagdic, A. S. (2019). *A comparison of discrete trial teaching and virtual reality glasses teaching effectiveness in teaching facial expressions to students with autism spectrum disorder* [Unpublished master's thesis]. Biruni University.

Sams, A., & Bergmann, J. (2013). Flip your students' learning. *Educational leadership, 70*(6), 16-20.

Saricam, S. (2019). *Investigation of the effect of virtual reality applications on teaching circulatory system concepts in science lesson* [Unpublished master's thesis]. Marmara University.

Sarioglu, S. (2019). *The effect of using virtual reality in 6th grade science course the cell topic on students' academic achievements and attitudes towards the course* [Unpublished master's thesis]. Gazi University.

Schraw, G. (2010). Measuring self-regulation in computer-based learning environments. *Educational Psychologist, 45*(4), 258-266. https://doi.org/10.1080/00461520.2010.515936

Suh, A., & Prophet, J. (2018). The state of immersive technology research: A literature analysis. *Computers in Human Behavior, 86*, 77–90. https://doi.org/10.1016/j.chb.2018.04.019

Tacgin, Z. (2017). *Development and evaluation of a virtual reality simulation to teach surgical sets used in the operating room* [Unpublished doctoral dissertation]. Marmara University.

Tarbox, R. S., & Najdowski, A. C. (2008). Discrete trial training as a teaching paradigm. In J. K. Luiselli, D. C. Russo, W. P. Christian, S. M. Wilcyznski (Eds). *Effective practices for children with autism* (pp.181-194). Oxford University Press.

Tarhan, Z. (2020). *The effect of virtual reality tools on vocabulary learning in teaching Turkish as a foreign language and its efficiency in retention* [Unpublished master's thesis]. Istanbul University.

Tay, V. (2020). *Evaluation of the effects of the virtual campus tour application designed according to panoramic based virtual reality* [Unpublished master's thesis]. Ankara University.

Tepe, T. (2019). *Investigating the effects of virtual reality environments developed for head-mounted display on learning and presence* [Unpublished doctoral dissertation]. Hacettepe University.

Topuz, Y. (2018). *The comparison of virtual reality and desktop three-dimensional materials in anatomy teaching in terms of academic performance and cognitive load* [Unpublished master's thesis]. Marmara University.

Tugtekin, U. (2019). *Effect of reducing extraneous processing principles on cognitive load and achievement in augmented reality and virtual reality environments in multimedia learning* [Unpublished doctoral dissertation]. Anadolu University.

Unal, H. (2022). *Virtual museum implementation on biology issues: Its reflection to science teachers* [Unpublished master's thesis]. Erciyes University.

Urhan, O. (2019). *Investigation of the effect of virtual reality applications for science education* [Unpublished master's thesis]. Dokuz Eylul University.

Veznedaroglu, H. M. (2005). *Senaryo temelli* ogrenmenin ogretmen *adaylarinin* ogretmenlik *meslegine yonelik tutum ve* oz *yeterlik algisina etkisi* [Unpublished master's thesis] Ankara University.

Webster, J., & Watson, R. T. (2002). Analyzing the past to prepare for the future: Writing a literature review. *MIS Quarterly, 26*(2), 13-23.

Wohlgenannt, I., Fromm, J., Stieglitz, S., Radianti, J., & Majchrzak, T. A. (2019). Virtual reality in higher education: Preliminary results from a design-science-research project. In A. Siarheyeva, C. Barry, M. Lang, H. Linger, & C. Schneider (Eds.), *Information systems development: Information systems beyond 2020* (ISD2019 proceedings). ISEN Yncrea Mediterranee.

Wojciechowski, R., & Cellary, W. (2013). Evaluation of learners' attitude toward learning in ARIES augmented reality environments. *Computers & Education, 68*, 570e585. https://doi.org/10.1016/j.compedu.2013.02.014

Yesiltas, H. M. (2019). *The effect of guide materials based on animation and virtual reality on some learning products; example of circulatory system* [Unpublished master's thesis]. Ordu University.

Yilmaz, S. (2023). *Examination of technology-supported laboratory applications in terms of different variables* [Unpublished master's thesis]. Yildiz Teknik University.

Youngblut, C. (1998). *Educational uses of virtual reality technology* (Report No. IDA Document D-2128). Institute for Defence Analyses. https://apps.dtic.mil/sti/pdfs/ADA339438.pdf