The Applications of Virtual Reality in Education in Scientific Research in the Arab World: A Review of the Published Literature

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Abstract

The study aims to provide a review of the published educational research related to the applications of Virtual Reality (VR) technologies in education in the Arab world that were published from 2012 till the first half of 2022. The research studies were collected from English and Arabic language sources. These sources include selected reputational journals and databases. The criteria for the selected research papers include having a topic related to the use of VR technologies in education, being published in refereed journals, and being published between 2012 and 2022. The selected research papers were categorized based on the education area, research design, sample, used technology, and focus. For the study, a total of 85 papers were selected. The findings indicated that most of the selected research studies examined different aspects in specific education areas including physical education and sports science, science and math, instructional technology, special education, and engineering and architecture. The great majority of the selected research studies used different types of experimental research designs. The most commonly used instruments to collect data in the examined studies were tests and evaluation forms. Furthermore, the participants in the examined studies were either university students or school students. The number of participants in most of the studies was less than 100 participants. Most of the examined studies employed desktop VR. The focuses of the studies varied but the great majority of the studies focused on the effect of VR on developing psychomotor and cognitive skills. A series of suggestions were made in light of the findings.

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Study Background

"VR is a powerful tool in supporting and facilitating learning and teaching processes" (Kamińska, et al, 2019, p.321). The world of technology is evolving day after day. The potential of the integration of new technology in education is promising, especially with changing characteristics of nowadays learners who can be described as "Students immersed in technology". VR technologies are one of the new evolving technologies that have the potential in enhancing the quality of education.

There are several definitions of VR, Novak-Marcincin, (2007) reported a definition of VR as "the illusion of participation in a synthetic environment rather than external observation of such an environment. VR relies on three-dimensional, stereoscopic head-tracker displays, hand/body tracking, and binaural sound. VR is an immersive, multi-sensory experience" (p.1949). In addition, VR can be defined as " a technology which allows a user to interact with a computer-simulated environment, whether that environment is a simulation of the real world or an imaginary world." (Mandal, 2013, p. 304). In another definition of VR, Singh, et al, (2020) defined it as "developing simulated expertise which is somewhat similar to the real-time situation"(p.661). The past, present, and future can all be known about, felt, and touched by VR. It acts as the means through which we can create and shape our special reality. Making a video game or going on a virtual tour of the globe could be involved. Additionally, it might include traveling via our ideal home or to a planet beyond our solar system. We can safely test out VR events and encounter the most horrific situations by being cautious and maintaining a learning mentality. Virtual reality (VR) is lifelike and dynamic, giving users a sensation of presence in a made-up environment.

The development of VR technologies has passed through several stages. The first idea of VR appeared in the 1960s through the invention of the Sensorama Machine which represents "a multi-sensory simulator in which prerecorded film in color and stereo, was augmented by binaural sound, scent, wind and vibration experiences" (Mandal, 2013, p.304). However, in the 1990s, VR technologies become much more popular and

the phrase "virtual reality" itself sprang to fame (Mandal, 2013). Nowadays, several commercial VR technologies are available and they are taking a crucial place in different sectors such as the military, entertainment, health, construction, and education.

The VR technologies vary in the used devices and characteristics. For instance, the simplest form of VR involves the user using desktop computers to view a virtual environment through their monitors and that doesn't require using any special devices. Other forms of VR technologies involve using particular devices like a Head-Mounted Display (HMD), cameras for computer vision, wands, and wired gloves. In addition, one form of VR technology is the Automatic Virtual Environment (AVE) e.g., CAVE.

The key characteristics of VR technologies that distinguish them from the available media e.g., video and television are immersion, presence, interactivity, and the geometric setting (Mandal, 2013; Boas, 2013; Mütterlein, 2018). Immersion describes the amount to which computer displays may provide a participant's senses with an inclusive, comprehensive, surrounding, and vivid illusion of reality (Jain, et al, 2016). The immersion levels can be classified into three levels that include: non-immersive systems, semi-immersive systems, and immersive systems (Mandal, 2013). An example of a non-immersive system is Desktop VR and an example of a semi-immersive system is Fish Tank VR. Presence is related to "the levels of the illusion of being in the virtual world (the place illusion component of presence), and the extent to which people respond as if events in the virtual world were really happening" (Slater, 2018; p.432). The user of VR technology is usually an active participant, where interactivity refers to the conversation or interaction between the user and the VR technology. There are several possible interactions between the users and VR technology. VR is distinguished by its geometric setting, where the setting in VR technology is three-dimensions.

The advantages of the applications of VR in education are well documented in the literature. There are several reported advantages of the use of VR in teaching students, these benefits include, but are not limited to, enhancing students' performance (Bashabsheh, Alzoubi, & Ali, 2019), improving students' motivation (Ho, Sun, & Tsai, 2019), providing access to limited resources (Do, et al, 2013), facilitate distance education (Mystakidis, Berki, & Valtanen, 2021) allow the student to be an active participant in the educational process, concentrating on diverse learning styles, facilitate experiential-based learning (Al-Allaq, Jaksic, Al-Amili, & Mahmood, 2021), facilitate collaboration among students, and provide authentic learning environment (Wang, Thompson, Uz-Bilgin, & Klopfer, 2021).

Worldwide, there is increasing interest in distance education that was triggered by the domination of the Covid -19 pandemic. VR can be used to replace real-life learning as well as enhance such a learning experience. Reviewing the literature showed increased use of VR for educational purposes during and after the appearance of the Covid-19 pandemic (Siddiqui, & Aslanian, 2020; Raja & Lakshmi, 2022; Shen, Xu, Sotiriadis, & Wang, 2022).

Taking into account the usefulness of VR technologies and the increasing interest of educators to integrate such technologies into their educational practice, reviewing previous scientific research would provide an important resource to inform policy and practice about VR technology integration in education. In addition, reviewing previous scientific research regarding VR technologies integration in education in the Arab world would indicate the extent of integration of VR technologies in the educational system based on different conditions such as the educational area, type of technology, way of integration, way of investigation, and type and number of participants.

The current study aimed to present a study of the published educational research related to the applications of VR technologies in education in the Arab world in the last decade based on the educational area, research design, sample, used technology, and focus.

Reviewing the literature showed that several studies were conducted to provide a survey of published research regarding the applications of VR technologies to support teaching and learning in different parts of the world. These studies used different criteria for sorting studies that examined the use of VR in education. The following sections provide presentations of some of the previous research studies that represent a review of the literature regarding the use of VR technologies in education based on selected criteria.

The applications of VR technologies in education based on education areas

Several studies examined the applications of VR technologies in education based on education areas. For instance, Kamińska, et al, (2019) provided a detailed review of the educational areas in which VR technologies can be used. These education areas include medical education, space technology and mathematics, general education, engineering education, and special needs education. Kamińska, et al, (2019) provided a summary of the benefits of the applications of VR in each of these education areas. In engineering education, the benefits of VR include providing engineering students with virtual-world industrial situations that would prepare them for the real one, allowing students to make timely economic in-design decisions, saving time and cost in the design process, and facilitating students' learning of the design process. In the medical area, the benefits of

VR include providing medical students with real-life situations that would improve their medical competencies and provide students with hands-on medical experience. In complex educational topics, the benefits of VR include providing students the opportunity to virtually travel in space and simplifying the complexity of some math topics in geometry. In general education, the benefits of VR include providing an economical, user-friendly educational tool, allowing students to visit hard-to-reach locations in real life e.g., underwater. In special needs education, the benefits of VR include enhancing special children's behavioral, communication, and social competencies.

In a study that examined the distribution of research papers that examined the applications of VR in education based on the academic fields, Luo, et al (2021) found the majority of the 149 reviewed research papers, that examined the applications of VR technologies in education, were conducted in three fields that include basic science (e.g., biology physics, chemistry, geology, and other similar fields.), social science (e.g., liberal arts, history, sociology, education, culture, and other similar fields.), and health and medicine (e.g., anatomy, health science, medical training, mental health, safety education, and other similar fields.) However, the researchers reported less common use of VR technologies in mathematics education and interdisciplinary programs.

In another study, Kavanagh, et al, (2017) examined the application domains of 99 research studies. They found that about one-third of the studies (35%) were conducted in the health sector including general medical topics, surgical education, and physical education. Twenty-eight studies (28%) were conducted for general education that presented VR applications that can be used in any educational setting e.g., a virtual campus using Second Life to facilitate online education. About one-fifth of the studies (19%) were conducted in the engineering field. Mainly, the VR applications in these studies were designed and developed to accomplish educational objectives in aviation, architecture, and robotics. A total of 16 studies were conducted in science fields. A limited number of studies presented VR applications in safety, history, psychology, wildlife education, military, environmental studies, teacher training, transportation, communication, general art, terrorism, art, music, English, and interior design subjects. In another study, Radianti, et al, (2020) examined the domains of higher education in which immersive VR technologies are used. They found that out of the 42 examined studies, 10 research studies were in the engineering field, 10 research studies were in computer science, and 3 research studies were in astronomy.

The review studies showed variation in the education areas in the research studies that examined the integration of VR technology in education. Such variations show that VR can be useful in a variety of subject areas.

The distribution of studies that investigated the applications of VR in education based on the research design and sample

The research studies that examined the distribution of the literature regarding VR in education based on the research design showed that these studies used various research designs. These research designs include descriptive and analytical studies that provide the developmental stages and uses of the VR technologies in education, experimental studies that involve studying the effect of using VR technologies on specific variable(s), quantitative studies that do not have treatment or control groups such as survey study, qualitative studies that include narrative research, phenomenology, grounded theory, ethnography, and case study, the mixed study that includes quantitative and qualitative design, and review study that used a systematic evaluation of the literature.

In their review of studies that investigated the application of VR technologies in education, Luo, et al, (2021) found that a little less than half of the research papers (45%) were experimental studies, and about one-third of the studies (32%) used qualitative research design include case reports and action research. A low percentage of the research papers (13%) used quantitative research, while a few research studies (10%) were survey studies. In another study, Radianti, et al, (2020) examined published research that investigates the uses of immersive VR in higher education. They reviewed 38 relevant articles. They found that the research studies that document the development and use of VR technologies for educational purposes were the most common ones (68%). Furthermore, they found that experimental studies were the second most popular research method among the examined research papers with a percentage of 47. Only 16 research studies were survey studies. The analyzed research studies did not frequently use the qualitative method, only 13% of research papers were qualitative studies.

Furthermore, Durukan, Artun, and Temur (2020) examined the types of research methods in the papers that examined the applications of VR technologies in science education. They found that out of the 30 research studies, half of them (50%) were experimental studies, and about a quarter (27%) of the examined studies were classified as descriptive in terms of introducing possible results and existing chances associated with the use of VR technologies in education. In addition, a small percentage (13%) of the examined studies were development studies, and only a few studies (10%) were classified as reviews.

The studies that investigated the distribution of the literature regarding VR in education according to the participants showed that these studies had collected data from different sources. These sources include different types of students, teachers, and previous studies (Luo, et al, 2021). Durukan, Artun, and Temur (2020) examined the distribution of sample or data sources of the reviewed studies that investigate the applications of VR technologies in science education. They found that out of the 30 research studies, 27% of them collected data from undergraduate students who were in different majors. Also, 9.3% of the studies collected data from the literature. Furthermore, there was one study (3%) that collected data from elementary school students, one study (3%) that collected data from graduate students, and one study (3%) that collected data from faculty members (%3).

The review studies showed variation in the used research designs and samples in the studies that investigated the integration of VR technology in education. However, experimental research designs were the most common designs in the examined research. In addition, school and university students were the main sources of data in these studies.

The distribution of studies that investigated the applications of VR in education based on the types of the used VR technology

There are several types of VR technologies that can be used in education. One way to classify these technologies is based on the used equipment for the VR. The commonly used types of equipment for VR include computers/smartphones, Head-Mounted Displays (HMDs), projectors, and input devices. The most popular systems of HMDs include HTC Vive Pro, Oculus Quest, Samsung Gear VR, and Google Cardboard (Kamińska, et al, 2019). Projectors can be used to create a cave automatic virtual environment. In this environment, projectors were used to create a stereoscopic image that would cover the walls of a room. Examples of input devices include movement recognition devices such as wired gloves, wands, and computer vision (Boas, 2013).

Another way to categorize VR technologies is based on the level of immersion. In this context, VR technologies can be categorized into three types: Desktop VR, Fish Tank VR, and immersive systems (Shubhangi & Jugele, 2917). Desktop VR is considered a non-immersive system in which the users view the virtual environment by using a high-resolution screen (Boas, 2013); a good example of such a type of VR is the Second Life application. Fish Tank VR is considered a semi-immersive system, Fish Tank VR can be defined as a "stereo image of a three dimensional (3D) scene viewed on a monitor using a perspective projection coupled to the head position of the observer" (Ware, Arthur, & Booth, 1993, p.37), a good example of such type of VR is the flight simulators applications. Immersive VR systems are considered the final edition of VR systems, where the user uses HMD to let him/her be entirely immersed in a computer-generated world. The HMD would provide immersive VR users with a stereoscopic view of the scene accordingly to their place and orientation (Shubhangi & Jugele, 2017). Auditory, kinesthetic, and sensual interfaces may enhance immersive VR systems. (Shubhangi & Jugele, 2017).

The research studies that examined the distribution of the literature regarding VR in education based on the types of used VR technologies showed that these studies used various VR technologies. For instance, Radianti, et al, (2020) examined the types of immersive VR technologies used in higher education. The researchers reviewed 38 research papers. They found that high-end HMDs were the most popular type of used immersive VR technology. Examples of these technologies include Oculus Rift and HTC Vive. The results showed that 76% of examined research studies had employed these types of technologies. The second popular set of technologies was low-budget mobile VR technologies such as smartphones and Google Cardboard. These technologies accounted for 20% of the examined studies. Enhanced VR technologies were used in 2% of the studies.

In another study, Luo, et al, (2021) examined the types used VR technologies based on the used equipment in the literature in the last decade. They found that the most popular type of VR technology was the computer which was used in 35% of the studies. The second popular type of VR technology was the HMD with a use percentage of 24% of the studies. Projectors followed in their popularity in the examined studies with percentages of 22. In addition, Luo, et al, (2021) classified the examined studies based on the level of immersion. The classification had three categories: Immersive, non-immersion, and combined. The great majority of the studies (74%) used non-immersions technologies. A little less than a quarter of the studies (23.6%) used immersive VR technologies. Only 3 research studies used combined immersive and non-immersion VR technologies.

The findings regarding the distribution of research studies that examined the use of VR technologies in education based on the types of used VR technology show that previous research studies examined the use of diverse kinds of VR technologies. The review shows that basic and enhanced types of technologies were used for educational purposes.

The distribution of studies that investigated the applications of VR in education based on the main focus of the studies

The main focus of the research study is directly related to its aim, where it is related to the examined topic in the research in terms of the examined variables and situations. A limited number of studies have reported results of reviewing the focuses of VR studies

Durukan, Artun, and Temur (2020) examined the variables and situations in the research papers that looked into the use of VR technologies in science education. They found that out of the 30 research studies, 20% of studies examined participants' attitudes towards the VR technologies to assist instruction, and 13% of the studies investigated the effect of the use of VR technologies to assist instruction on participants' acceptance of technology, 10% of the studies looked at the effect of utilizing VR technologies to assist instruction on participants' spatial skills, 10% of the studies examined the effect of the use of VR technologies to assist instruction on participants' self-efficacy, 6.6% of the studies examined the effect of the use of VR technologies to assist instruction on participants' retention. Furthermore, 6.6% of the studies examined the participants' perceptions of some of the characteristics of VR technology in terms i.e., of immersion and presence experiences in educational VR environments. Finally, the researchers found that one study examined each of the following variables: science process skills, conceptual understanding, the usability of VR technology, instruction practice, psychosomatic and adverse effects, and creativity in the education supplemented by VR. There was diversity in the examined variables and situations in the studies that dealt with the applications of VR in educational practice.

Research aim and questions

Given that the scientific research in this area is still being developed in the Arab world, the current study aimed to provide a review of the published educational research related to the applications of VR in education in the Arab world in the 11 years based on the educational area, research design, sample, used technology, and focus to give a deeper knowledge of the scientific research associated with this technology and to identify the educational research gap in this field. The current study has the following research questions:

- What are the subject areas of research papers that examined the applications of VR technologies in education in the Arab world?

- What are the used research designs of research papers that examined the applications of VR technologies in education in the Arab world?

- Who are the participant groups in the research papers that examined the applications of VR technologies in education in the Arab world?

- What are the types of used technologies in the research papers that examined the applications of VR technologies in education in the Arab world?

- What are the focuses of the research papers that examined the applications of VR technologies in education in the Arab world?

Method and procedures

Method of collection and selection of studies

First of all, some literature that focuses on how to conduct a systematic study of published literature was reviewed (e.g., Beelmann, 2006). The search for related studies was conducted on selected resources using a variety of the following search terms: "virtual reality ", "virtual reality in education", "virtual reality in teaching", " virtual reality in instruction", "virtual reality in learning", "avatar", "virtual reality applications", "virtual reality   Arab World" and " virtual reality Names of countries in the Arab world" and their translation on the Arabic language were identified as the terms that were used to search for the research papers that related to the applications of VR in education in the Arab world.

The Arab League is made up of the 22 Arab nations that make up the Arab globe. The criteria for inclusion of research papers include being relevant to the topic of applications of VR technologies in education, conducted in the Arab educational system, and published in peer-reviewed journals. The period between 2012 and 2022 was determined as the time criteria for the selection of published research, this study started in August 2022. The selected research papers were checked for duplication. The selection of papers for the current study took place over several rounds to make sure that only research papers that satisfy the requirements of educational research were included in the current study.

The following sources were considered for the search of research studies: First, a selected group of journals in English and Arabic language specialized in educational technology and distance teaching. Second, a selected set of common academic databases that published research in English and Arabic language.

For the initial search, five publications published in the Arabic language and four journals published in the English language, respectively, were chosen. Table 1 shows the results of the search for research related to the applications of VR technologies in education in the Arab world in a group of selected journals.

Table 1: the results of the search for research related to the applications of VR technologies in education in the Arab world in a group of selected journals.

Journal name	Related results	Date
British Journal of Educational Technology	0	2022-07
The Internet and Higher Education	0	2022-07
Education and Information Technologies	4	
International Journal of Technology and Design Education	0	2022-07
Journal of the Islamic University of Educational and Psychological Studies - Palestine	1	2022-07
Educational journal - Kuwait	1	2022-07
Journal of Studies in Educational Sciences - Jordan	0	2022-07
Journal of Educational Sciences – King Khalid University- Saudi Arabia	0	2022-07
Journal of Educational and Psychological Research - Iraq	0	2022-07

For the search, four well-known databases in the English language and four well-known databases in the Arabic language were chosen. Table 2 shows the results of the search for research related to the use of VR technologies in education in the Arab world in a group of the selected academic database.

Table 2: the results of the search for studies related to the use of VR technologies in education in the Arab world in a group of the selected academic database.

Database name	Related results	Date
Elsevier Science Direct	1	2022-08
JSTOR for education titles	0	2022-08
Education Resource Information Center (ERIC)	2	2022-08
Springer Science+Business Media	3	2022-08
Candles of the Arab Educational Information Network (Shamaa)	14	2022-08
Dar Al Mandumah - AraBase	52	2022-08
search.emarefa.net	3	2022-08
Iraqi scientific academic journals	4	2022-08

The search process resulted in the selection of 85 research studies. The great majority of these studies were founded on Arabic resources. The following sections present descriptions of the selected studies based on the different criteria.

Data analysis

The analysis of the result started with a general categorization of the founded research studies based on the published dates, education stage, geographical locations, and language of the study. The educational types took several options that include pre-school, K-12, special education, higher education, vocational training, and distance education (eg., Massive Open Online Course (MOOC)), the geographical locations involve all the Arab countries including 22 countries, and the language was either Arabic or English language. After the general categorization of the founded research papers, these papers were categorized based on the education area, research design, sample in terms of type and number, used technologies, and focus to answer the research questions.

Results and discussion

The results of the search showed that there are a total of 85 research studies related to the applications of VR technologies in education in the Arab world between 2012 and 2022 found in the selected resources. Table 3 shows the basic information about the research that was found in terms of year of publication, education type, geographical location, and language of the study.

Table 3: General description of the founded research studies **(N = 85).**

Variable	Options	Frequency	Percentage
Published dates	2012	3	3.5
	2013	3	3.5
	2014	2	2.4
	2015	6	7
	2016	5	5.8
	2017	6	7
	2018	8	9.4
	2019	16	18.8
	2020	18	21
	2021	16	18.8
	2022	2	2.4
Education type	Pre-School	3	3.5
	K-12	29	34
	Higher Education	44	52
	Special Education	5	5.9
	Vocational Training	1	1.2
	Distance education (MOOC)	1	1.2
	N/A	2	2.4
Geographical locations	Saudi Arabia	19	22
	Egypt	47	55
	Iraq	4	4.7
	Palestine	1	1.2
	Jordan	3	3.5
	UAE	2	2.4
	Kuwait	3	3.5
	Sudan	1	1.2
	Oman	1	1.2
	Qatar	2	2.4
	Morocco	1	1.2
	Other	1	1.2
Language of the study	English	15	17.6
	Arabic	70	82

The results showed that more than two third of the studies (*n=60, 71%)* were published after 2018. Such results indicate the recent attention to the applications of VR technologies in education in the Arab world. More than half of the studies were in higher education (*n=44, 52%)* and K-12 (*n=29, 34%).* The results align with the findings of Durukan, Artun, and Temur's (2020) study who found that applications of VR technologies are more frequent in higher education institutions compared to schools. The implementation of VR technologies in education needs financial requirements, universities are usually more capable financially compared to schools and pre-school institutions and that might explain the widespread use of VR technologies in higher education compared to other types of educational institutions. More than half of the research studied (*n=47, 55%)* was published in Egypt, and about one-fifth of the studies (*n=19, 22%).* were published in Saudi Arabia. The findings are aligned with classifications of Arab countries based on their research profile that show that Egypt and Saudi Arabia have the highest ranks in research (SCImago, 2022). In addition, searching studies that are either in Arabic or English language might limit results. For instance, there are many researchers in the Arab countries, especially in North Africa who publish their research in the French language. Only one research study had participants from two countries: Saudi Arabia and Jordan (Theeb & Bakri, 2015). The great majority of the studies (*n=70, 82%)* were in the Arabic language.

- **First research question: What are the subject areas of research papers that examined the applications of VR technologies in education in the Arab world?**

The selected research studies were analyzed based on the education area in which the VR technologies were used. Table 4 shows the frequencies and percentages for each educational area among the reviewed studies.

Table 4: Distribution of research papers related to applications of VR technologies in the Arab world based on the educational area (**N = 85**).

Education area	Frequency	Percentage
Physical education and sports science	25	29
Science and Math	9	10
Instructional technology	7	8.2
Special education	6	7
Engineering and Architecture	5	5.9
Medicine and Nursing	3	3.5
Vocational training	1	1.2
IT	2	2.4
History	3	3.5
Design/Fashion	2	2.4
Geography	1	1.2
Philosophy	1	1.2
Economy	1	1.2
Art/ Applied Arts	4	4.7
Tourism	1	1.2
Social science	1	1.2
Language	3	3.5
Primary education	2	2.4
Teacher-Education	1	1.2
Others	7	8.2

Of the 85 papers analyzed, 25 (29%) were applied to physical education and sports science educational areas. Applications in Science and Math were also common, occurring in 9 (10%) of the 85 papers. A total of 7(8.2) of the 85 papers were conducted in the instructional technology area for study. Interestingly, 6 of the papers were conducted in the special education area examining the use of VR technologies to teach students with special needs e.g., Autistic children (Mustafa, 2019; Muhammad, Badr, & Juma, 2020; Al-Ajmi, 2020), deaf and hard of hearing children (Al-Salem, 2017), children with learning disabilities (Fayed, Shaker, & Abdel-Halim, 2017), and children with cerebral palsy and a mild mental disability (Al-Tayeb & Abdul-Hamid, 2020). Of the 85 papers analyzed, 7 (8.2%) did not belong to any education area. Some of these papers examined the perceptions of teachers and students from different subjects, about employing VR technologies in the educational process (Mohammed, et al., 2015; Al-Enezi, 2021). Others examined the ways of use and the design standards of VR technologies for educational purposes (Khalifa, 2012; Raoof, 2012; Al-Siddi, 2016; Ahmed, 2017). In addition, one study examined the design of VR in academic literacy course (Alblehai, 2022). A low percentage of the studies were conducted in engineering and architecture areas (n=5, 5.9%), and Art/ Applied Arts (n=4, 4.7%). Only one research study was conducted in the vocational training field (Al-Helo, 2019), Geography (El-Sherbiny, 2013), Philosophy (Ramadan, 2016), Economy (Al-Sharqawi, 2019), Tourism (Samarkandi & Ymani, 2021), social science (Al-Riyami & Al-Najjar, 2020), and teacher-education (Al-Saai, 2019).

The findings did not align with previous studies such as the study of Luo, et al, (2021) who found the majority of the 149 reviewed research papers that examine VR in education, in the field of basic science, and the study of Radianti, et al, (2020) who found that most of VR studies were conducted in an engineering field and computer science.

- **Second research question: What are the used research designs of research papers that examined the applications of VR technologies in education in the Arab world?**

The selected research studies were analyzed based on the research design. Table 5 shows the frequencies and percentages for each research design among the reviewed studies.

Table 5: Distribution of research papers related to the applications of VR technologies in education in the Arab world based on the research design (N = 85).

Research designs	Frequency	Percentage
Quasi-experimental control group design	42	49.4
Pre-experimental research design	13	15.3
Descriptive/analytical design	18	21.2
Review design	5	5.9
Case study	3	3.5
One group, Pre-, post-, and follow-up experimental design	2	2.4
Focus group design	1	1.2
Quasi-experimental multi groups design	1	1.2

The findings indicated that the great majority of the papers analyzed (68%) employed different forms of experimental designs. The second popular research design (n=18, 21.2%) was Descriptive / analytical design. Only 5 research studies represent review studies and only 3 studies were case studies. The qualitative design was not common among the examined studies, one study employed a focus group design. The findings regarding the popularity of experimental research design in VR studies align with findings of other studies that found experimental studies were the most common type of research studies that examined the application of VR technologies in education (Durukan, Artun, & Temur, 2020; Luo, et al, 2021). However, the findings regarding the short in qualitative studies did align with the findings of similar research studies e.g, Luo, et al, (2021).

The popularity of the experimental research design was reflected in the used instrument to collect data in the research papers that examined the use of VR technologies in education. Tests and evaluation forms were the most common instruments in the analyzed studies, where 73(85%) studies used test instrument, evaluation form, or both instruments. Several research studies used more than one instrument. Some studies used unconventional instruments to collect data such as screen captures (Daghestani, Al-Nuaim, & Ragab, 2012) training completion time, and the number of errors in the final products (Abidi, Al-Ahmari, Ahmad, Ameen, & Alkhalefah, 2019). Table 6 shows the distribution of the research based on the used instrument.

Table 6: Distribution of research papers related to applications of VR technologies in education in the Arab world based on the used instrument (N = 85).

Used instrument	Frequency	Percentage
Test	42	49%
Evaluation form	31	36%
Questionnaire	27	32%
Review criteria	12	14%
Interviews	5	6%
Others	3	3.5%

- **Third research question: Who are the participant groups in the research papers that examined the applications of VR technologies in education in the Arab world?**

Thirty-two studies (38%) were carried out with university students from various departments, and twenty-one studies (25%) were conducted with school students from various levels. A small percentage (n=9, 10.5%) of the studies collected data from the school teacher and faculty members. Five studies, which were conducted in special education, collected data from students with special needs, special education educators, or parents of students with special needs. Seven studies (8.2%) collected data from unlisted sources that include school supervisors (Al-Shamrani, 2020) principals of kindergarten (Muhammad, 2015), educational experts (Al-Barbrai, 2013), students in MOOC, and online learners (El-Kabtane, El-Adnani, Sadgal, & Mourdi, 2020; Alblehai, 2022) university's coordinators (Alenezi, & Shahi, 2015) and designers (Mohamed & Sicklinger, 2022). Also, 15 studies (17.6%) collected data from the literature utilizing descriptive or survey research to look at a particular study topic that was connected. Several studies had more than one group of participants. The findings related to the popularity of VR research studies that collect data from university students are similar to the findings of another research study (Durukan, Artun, & Temur, 2020). Table 7 shows the distribution of sample or participant groups of the reviewed studies.

Table 7: Distribution of research papers related to applications of VR technologies in education in the Arab world based on the sample type (N = 85).

Sample type	Frequency	Percentage
University students	32	38
School students	21	25
School teachers	3	3.5
Faculty members	6	7
Students with special needs	2	2.4
Special education educators	2	2.4
Parents of students with special needs	1	1.2
Pre-school students	2	2.4
Others	7	8.2
N/A	15	17.6

The number of participants in the reviewed studies showed that a great part of the studies focused on one class or small group of participants. For instance, more than half of the studies (n=59, 63%) had one hundred or fewer participants. Only two studies had more than 200 participants (Al-Salem, 2017; Al-Gamal, 2020). Table 8 shows the distribution of the number of participants in the reviewed studies.

Table 8: Distribution of research papers related to applications of VR technologies in education in the Arab world based on the number of participants (N = 85).

Number of participants	Frequency	Percentage
50 and less	38	38
51-100	21	25
101-150	2	2.4
151-200	1	1.2
Above 200	2	2.4
N/A	17	20

- **Fourth research question: What are the types of used technologies in the research papers that examined the applications of VR technologies in education in the Arab world?**

Regarding the used VR technology in the examined studies, the results showed that the computer is still the most popular VR technology (44, 51.7%) despite the recent development of more sophisticated VR technologies e.g., the development of HMD. The popularity of desktop VR demonstrates the continued allure of desktop-based simulations, games, and virtual worlds by educators. However, HMDs were used in about a quarter of the studies (n=21, 24.7%). Only two studies employed AVE technology (Al-Saai, 2019; Halabi, 2020). The findings indicated that the VR technologies that relied on the computer are the most popular in the Arab world. Expected needed efforts from educators and high cost might explain the shortage in studies that implement advanced equipment such as AVEs. The findings related to the popularity of VR research studies that examined the use of desktop VR aligned with the findings of previous research studies (Luo, et al, 2021), while the findings contradicted the findings of other research studies (Radianti, et al, 2020))

However, several research studies did not explicitly include/state the used VR technologies. For instance, some studies examined participants' perceptions of VR technologies in general and others provided a review of the use of VR technologies.   Table 8 shows the distribution of the type of used technology in the reviewed studies.

Table 9: Distribution of research papers related to applications of VR technologies in education in the Arab world based on the type of used technology (N = 85).

Type of used technologies	Frequency	Percentage
Head-Mounted Displays(HMD)	21	24.7
Desktop virtual reality	44	51.7
Automatic Virtual Environment (AVE)	2	2.4
Not specified	22	25.8

- **Fifth research question: What are the focuses of the research papers that examined the applications of VR technologies in education in the Arab world?**

Regarding the focus of the examined studies, the results showed that about one-third of the studies (n=30, 35%) examined the effect of VR technologies on the development of psychomotor skills in various subjects. For

instance, several studies examined the effect of using VR technologies on the development of psychomotor skills in different sports such as tennis (Al-Gamal, 2020; Ali & Makki, 2020), Judo (Ahmad, 2020; Saber, 2019), ballet (Rabeh, 2020;), rhythmic exercise (Abdel-Hamid, 2020), long jump (Al-Azzazi, Shuaib, & Hassan, 2021) badminton (Al-Ajmi, 2021) weightlifting (Othman, 2020); basketball (Aboelata, 2018; Mehran, 2021; Drwish & Jalal, 2021; Al-Namer, 2021), Volleyball (Al-Desouki, Al-Sayed, Hussein, Ahmed, Muhammad, 2015; Muhammad, Sayed, & Faraj, 2020; Shaheen, 2021) soccer (Turki, 2020; Hassan, Mohammad, Al-Jellaba, & Abd-aslam, 2021; Ismaeel, Shehata, & Abd-Salam, 2021), handball (Shehateh, Alkt, Qasim, Eid, 2020) and fencing (Ganem, 2018)). In addition, there were studies examined the effect of using VR technologies on the development of phlebotomy skills nursing field (William, Vidal, & John, 2016), Oud instrument skills in the music field (Shaker, 2018), group play skills, and travel skills for students with special needs in special education field (Muhammad, Badr, & Juma, 2020; Al-Ajmi, 2020) maintenance skills of educational devices (Gasm, 2016).

Furthermore, the results showed that less than one-third of the studies (n=27, 31.7%) examined the effect of using VR technologies on the development of cognitive skills in various subjects. These skills are related to visual thinking skills (Al-Hanan, 2015; Al-Riyami & Al-Najar, 2020; Ismail & Ismail, 2021; Al-Tayeb & Abdul-Hamid, 2020) acquiring different concepts (Farjoun, 2013; Zork, 2018; Abdul-Maqsoud & Al-Baqmi, 2017; Desouki, 2018; El-Sherbiny, 2013), imagination skills (Atifi, & Al-Malij, 2015; Maarouf, Suleiman, & Mrwad, 2016) math manipulative (Daghestani, Al-Nuaim, & Ragab, 2012) ICT skills (Abdul-Jawad, Attar, Ismaeel, 2018; Jabra, Khalil, Ibrahim, & Ismail, 2019;) teaching skills (Zagloul, 2019), fashion design skills (Al-Juaid & Salem, 2021) creative thinking skill (Ramadan, 2016; Seveen, Khalil, & Ahmed, 2018;) writing Skills (Al-Harbi, 2017), decision-making skills (Al-Sharqawi, 2019) VR design skills (Al-Barbrai, 2013), heart anatomy skills (Alfalah, et al., 2019) and instructional technology skills (Ahmad, 2021).

The uses of VR technologies in the affective domains were not popular, only 5 studies (6%) examined the effect of VR technologies on the development of affective skills that related to love of learning skills (Akl, Abu-Odeh, Al-Alam, Al-Omrani, 2020), achievement motivation (Al-Saud, 2019) aesthetic values (Zork, 2018) competition anxiety (Theeb & Bakri, 2015), and involvement in the learning (Al-Farani & Bashmakh, 2020). Table10 shows the distribution of the reviewed studies based on their focuses. Some research studies had multiple focuses.

Table 10: Distribution of research papers related to applications of VR technologies in education in the Arab world based on the focus of the studies (N = 85).

Focuses on the studies	Frequency	Percentage
Effect of VR on developing psychomotor skills	30	35
Effect of VR on developing cognitive skills	27	31.7
Effect of VR on developing affective skills	5	6
Effect of VR on the teaching process	10	11.8
Description of the use of VR in education (use, requirement, design, advantages, and obstacles)	16	18.8
Perspective toward VR	6	4.7

Ten (11.8%) research studies focused on the teaching process using VR technologies in various fields. These fields include architecture and engineering (Saffo, Mannona, & Al-shek, 2014; Al-Allaq, Jaksic, Al-Amili, & Mahmood, 2021; Elfeki, & Elfeki, 2021; Halabi, 2020) teacher education (Al-Saai, 2019) computer programming (Samarkandi & Ymani, 2021) vocational Training (Al-Helo, 2019) multiple designs (Mohamed & Sicklinger, 2022) on-line teaching (Al-Barbrai, 2013) assembly training (Abidi, Al-Ahmari, Ahmad, Ameen, & Alkhalefah, 2019).

About one-fifth of the examined studies (*n=16, 18.8%*) were devoted to describing the use of VR technologies in education in terms of the potential advantages and obstacles (Al-Enezi, 2021; Al-Aqali, 2018; Khalifa, 2012) ways of use and requirements to use (Muhammad, 2015; Al-Salem, 2017; Radwan, 2019; Al-Shamrani, 2020; Fayed, Shaker, Abdel-Halim, 2017; Othman, Atallah, & Masoud, 2017; Aziz, 2014; Othman, Al-Alfi, Amin, & Saleh, 2019; Alenezi, & Shahi, 2015) design standards (Al-Siddi, 2016; Ahmed, 2017; Raoof, 2012; Alblehai, 2022).

A small percentage of the examined studies (*n=4, 4.7%*) investigated different stakeholders' perspectives on the use of VR in the educational process. Examples of these stakeholders include students (Al-Saud, 2019), teachers (Alfalah, 2018; Alneyadi, 2019), and university faculty members (Alhudaithy, 2019).

The findings related to the popularity of the research studies that examine the effect of the use of VR technologies on a specific set of skills indicate that these studies are low-scale studies that focus on a specific topic and the use of VR technologies is still at the trial level. The findings did not align with the findings of

similar research studies that found that the participants' attitudes were the most common focus of the examined studies (Durukan, Artun, & Temur, 2020).

Conclusion and recommendations

The current study reviewed the research on the application of VR in education in the Arab world between the years 2012 and 2022. Based on the review results of 85 chosen papers, the five research questions regarding the education area, research design, participants, used technology, and focus were answered. The results indicated that the majority of analyzed research studies examined different aspects in five education areas that include physical education and sports science, science and math, instructional technology, special education, and engineering and Architecture. The great majority of the selected research studies used different types of experimental research designs. The most commonly used instruments to collect data in the examined studies were tests and evaluation forms. Furthermore, the participants in the examined studies were either university students or school students with less than 100 participants. Most of the examined studies employed desktop VR. The focuses of the studies varied but the great majority of the studies focused on the effect of VR on developing cognitive and psychomotor skills.

Considering the review's findings, several practical implications can be offered for stakeholders in the educational field. A thorough evaluation of learning domains and tasks should serve as the foundation for any choice to utilize VR technology. VR is suited in a wide range of educational areas but it is suited the most in physical education, science, math, instructional technology, special education, engineering, and architecture. The VR technology is suitable to develop students' psychomotor and cognitive skills. The capacity of VR to support remote learning was another fairly popular application in the field of education. Although the type of participants in the examined studies revealed that very few papers found in our analysis examined the applications of VR in facilitating distance education.

Although VR is frequently referred to as an immersive technology, the great majority of the examined VR interventions used desktop VR rather than using fully immersive learning experiences using more sophisticated HMD or AVE. educators should be encouraged to employ such immersive VR technologies.

Considering the review's findings, several recommendations can be offered for future research agendas in the Arab world. With 52% of implementations made for use in higher education, the institutions for which the educational applications were intended were likewise disproportionately skewed. Therefore, more research should be done on K-12 education, special education, and vocational training in the Arab world. To increase the rigor and usefulness of future research, more varied study designs and methodologies should be used rather than focusing on experimental designs. Future research can explore best practices regarding the applications of VR technology in education and the specific design aspects of VR technology in terms of pedagogy and technology. In addition, to increase the interpretability and generalisability of the research results, more participants from disciplines rather than from specific classes or subjects should be employed in future studies. Finally, meta-analysis studies should be conducted to systematically assess the results of previous experimental research that employed VR technology in education.

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