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Systematic Examination of Educational Virtual Reality Studies: Google Cardboard

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This study aims to reveal the current situation viz. as of year 2024 in experimental educational studies conducted using Google Cardboard as a virtual reality tool. In the study, 36 articles published in journals indexed in Web of Science and Scopus databases and decided to be suitable for the research purpose were analyzed. The data were analyzed by content analysis method. According to the results obtained in the research, while the number of articles increased until 2020, it has been decreasing since this year reaching the year 2024. While the most preferred sample group was the undergraduate level, studies were carried out with the most participants between 11-30. While it is mostly used in STEM education, the number of in-school and out-of-school applications is close to each other. While survey/scale was the most preferred data collection tool, it was concluded that different media types were used in the studies. The advantages of the studies were summarized and analyzed in detail under 3 sub-themes: educational outcomes, affective outcomes and technical advantages. Whereas the most important educational outcome underlined in the articles is increases success (performance), the most important affective outcome is students develop positive attitudes. It is noteworthy that technical advantages are mentioned less frequently. On the other hand, it was concluded that some difficulties were encountered, such as eye strain and headaches.

Introduction

Rapid developments in technological developments increase the use and functions of virtual reality technology in all fields. Brey (2014) defines virtual reality as immersive and interactive three-dimensional environments created by a computer through multiple sensory channels. In a similar definition, it is considered as environments that allow users not only to be in virtual environments, but also to interact with the components within this environment in a way that evokes a sense of reality (Harvey et al., 2021). In virtual reality technology, users feel themselves as a part of this environment in an environment created in accordance with real life or in a digital environment that is completely a product of the imagination (Mustafa, 2022).

Virtual reality is a preferred technology in almost every sector with its advantages. It is used in different fields such as tourism (Tussyadiah et al., 2018), sports (Vignais et al., 2015), e-commerce (Bonetti et al., 2018). Virtual reality is a widely used technology in the education of these different disciplines. It is also used in the education of different disciplines such as

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medical education (Sahin & Erken, 2023), engineering and architecture education, military education (Mihelj et al., 2014), geological (Chin & Wang, 2024) and classroom management (Cardullo & Wang, 2022). More specifically, it can be said that virtual reality technology is used in almost every subject. Studies such as mathematics (Xu & Ke, 2016), sports education (Gómez-García, et al., 2018), science education (Palos-Sanchez et al., 2022) are examples of the use of virtual reality.

Virtual Reality technology has the potential to transform traditional educational methods (Rojas-Sanchez et al., 2023). Research results have revealed the advantages of using virtual reality in education. It allows interactive teaching of concepts that are impossible to experience in the real-world environment (Shin, 2017; Vesisenaho et al., 2019). It realizes easier and more permanent learning by appealing to multiple sensory organs at the same time (Kavanagh et al., 2017). In this way, it supports students with different learning styles (Lee et al., 2010). It also contributes to the development of students' spatial abilities (Cohen & Hegarty, 2014; Lee & Wong, 2014). Apart from these, virtual reality technology can also be utilized in the use of out-of-class environments for educational purposes in accordance with the reality. Students can explore museums (Othman et al., 2022) and natural environments (Chin & Wang, 2024) without leaving their classrooms or even their desks.

Even if the use of virtual reality in the classroom comes to the forefront with all these advantages, there are still significant disadvantages that need to be overcome. The most important of these is the financial burden that the hardware and software infrastructure required for virtual reality technology imposes on schools (Cook et al., 2019). Both virtual reality glasses and supporting equipment and virtual reality software can be costly expenses for educational institutions with limited budgets. In addition, the technical skills required by teachers to integrate this technology into the classroom also cause limitations in the use of virtual reality in the classroom. These difficulties direct educators to tools that can use virtual reality technology in a cost-effective and easy-to-use way. The most important of these tools is Google Cardboard. Google Cardboard is a low-cost virtual reality goggle made of cardboard material. Users experience virtual reality by placing their smartphones into Google Cardboard. Since the user's own phone is used, Google Cardboard can work independently of the operating system. Thus, many virtual reality applications from application markets such as Google Play Store and Apple App Store are accessible with Google Cardboard. Thus, a wide range of media applications such as Google Expeditions, virtual reality games, virtual tours, 360-degree videos, 3D models can be run seamlessly with Google Cardboard. With all these advantages, Google Cardboard is an important tool for using virtual reality technology in the classroom. With all these advantages, Google Cardboard can be considered an important virtual reality tool used in classroom settings. However, it is noteworthy that there is a lack of sufficient studies on Google Cardboard in the relevant literature. Only one study has been identified that systematically reviews research on Google Cardboard usage. In the systematic review conducted by Whang & Chan (2024), 35 experimental studies utilizing Google Cardboard were examined. This study, which makes significant contributions to the literature, analyzes the articles under the following headings: “educational levels of participants,” “target subjects,” “mobile applications,” “practical effects,” “advantages of using Google Cardboard in educational practice,” and “challenges of using Google Cardboard in educational practice.” The reviewed articles are discussed under the themes of “comparisons with previous literature reviews,” “pedagogical implications of integrating Google Cardboard in educational practice,” and “future research on using Google Cardboard for educational purposes.” In this review study, a different method has been adopted, approaching the articles from an inductive approach. The inductive approach allows deriving general principles or

theories from specific observations and is particularly important in exploratory research. It makes important contributions to the literature in terms of supporting theory development by revealing new concepts and relationships, capturing contextual details and contributing to the continuous development of academic knowledge. This study, which adopted an inductive approach, aimed to contribute to the literature. Thus, the aim is to contribute to the literature by revealing the current state, advantages, and challenges of experimental educational studies conducted using Google Cardboard. It is aimed to take a picture of the literature created by the accumulated strudies/relevant line of studies conducted with Google Cardboard. Thus, it is aimed to provide a perspective for future research using Google Cardboard. The results are expected to provide guidance for educators, researchers and policy makers. For this purpose, answers to the following research questions were sought:

(1) How are the general characteristics of Google Cardboard studies?
(2) What are the advantages identified in Google Cardboard studies?
(3) What are the challenges identified in Google Cardboard studies?

Method

Various methods are utilized in systematic review research. This study adopted a three-step methodology commonly used in previous systematic review studies in the fields of technology and education. Accordingly, the following three steps were followed in the study:

(1) Searching for articles in different databases using appropriate keywords,
(2) Reviewing the titles, abstracts, and full texts of the retrieved articles to determine which ones meet the inclusion and exclusion criteria for the study,
(3) Examining the selected articles to answer the research questions.

Article selection process

In review studies, different methods are used by researchers for article selection. Examples of these methods include selecting articles published in prominent journals in the field or choosing articles from journals indexed in certain databases. Singh et al. (2021) state in their review study that the most preferred databases are Web of Science and Scopus. While Scopus stands out with its extensive journal coverage, Web of Science is preferred by researchers for its selectivity (Singh et al., 2021). Considering these reasons, this study targeted articles published in journals indexed in Web of Science and Scopus databases. The PRISMA method was used to select the articles to be reviewed, following the identification, screening, and inclusion stages. Using the advanced search option, a specific query string was created to search for articles ((“Google Cardboard” OR “Cardboard”) AND (education OR class OR teach* OR learn*)). For the search filters, since Google Cardboard was launched in 2014, “2014-2024” was chosen as the publication year, “article” as the document type and “English” as the language. As a result of the latest search conducted on November 5, 2024, a total of 420 articles were listed across the two databases. These articles were reviewed according to the criteria outlined in Table 1.

Table 1. Inclusion and exclusion criteria.

Inclusion	Exclusion
Using Google Cardboard	Not using Google Cardboard
Articles	Conference proceedings, book chapters, and alike
Experimental research	Non-experimental research
Research for educational purposes	Non-educational research

In the initial screening, duplicate articles from the same study (28 articles) were removed by the researcher. Then, studies that did not align with the focus of the research were excluded according to the criteria in Table 1. At this stage, the abstracts of the articles were reviewed, and 304 articles that were not intended for educational purposes were excluded. The full texts of the remaining 88 articles were then examined, and an additional 52 articles were excluded as they were found to be non-experimental. Following the evaluation, 36 articles were determined to be suitable for the research purpose. The entire article selection process, conducted based on the PRISMA method, is visualized in Figure 1.

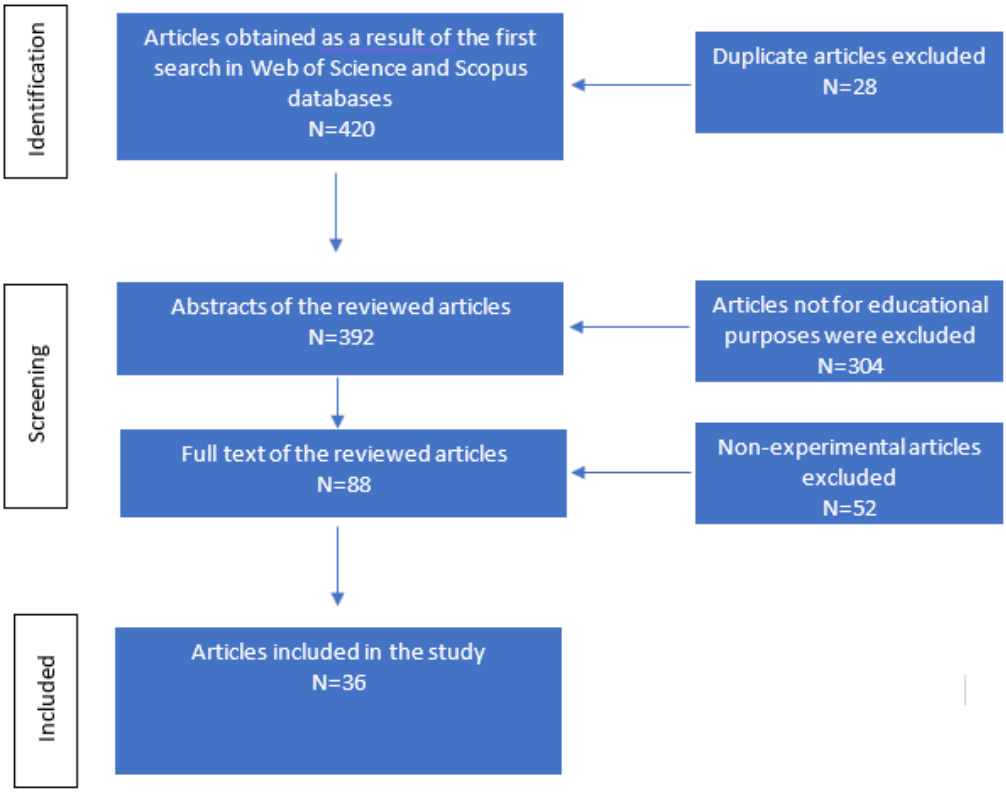

Figure 1. Article selection process.

Data Coding

The articles meeting the inclusion criteria were coded by the researcher. Microsoft Excel program was used for coding the data. Each article included in the study was assigned a unique identification number and systematically coded based on the research questions. The labels and descriptions used in the coding process are as follows. "Publication year" refers to the year in which the article was published in a journal. "Sample groups" represents the educational level of the sample group selected in the study. "Sample size" indicates the number of participants in the sample. "Conducted discipline" refers to the disciplines in which virtual reality applications were utilized to facilitate participants' learning. "Educational context" is a label used to determine whether the virtual reality application was implemented within or outside the school setting. "Data collection tool" denotes the instruments used for data collection in the study. "Media types" was employed to code the types of media utilized in the articles. "Advantages" was used to categorize the benefits reported in the findings of the studies. "Disadvantages" was applied to identify and code the challenges and limitations encountered in the studies. A second subject area expert was consulted to calculate the coding

reliability. For this, 6 randomly selected articles were coded separately by the researcher and the subject area expert. As a result of Cohen's kappa analysis, inter-rate reability was calculated as 0.94. Since it was understood that coding reliability was ensured, all of the remaining articles were coded by the researcher.

Analysis

The data were analyzed using the content analysis method. Content analysis is a method that involves organizing texts, categorizing them, comparing them, and deriving theoretical conclusions (Cohen et al., 2013). To enhance coding reliability, support was obtained from an independent subject matter expert, and the calculations confirmed that the coding process was reliable. The inductive approach proposed by Miles and Huberman (1994) was adopted in the analysis of the data. Thus, sub-categories were formed by combining codes, and themes (inductive categories) emerged from the grouping of sub-themes.

Findings

General Characteristics of Articles

When the distribution of articles using Google Cardboard over the years is analyzed, it is seen that the first experimental study was conducted in 2017 (Figure 2).

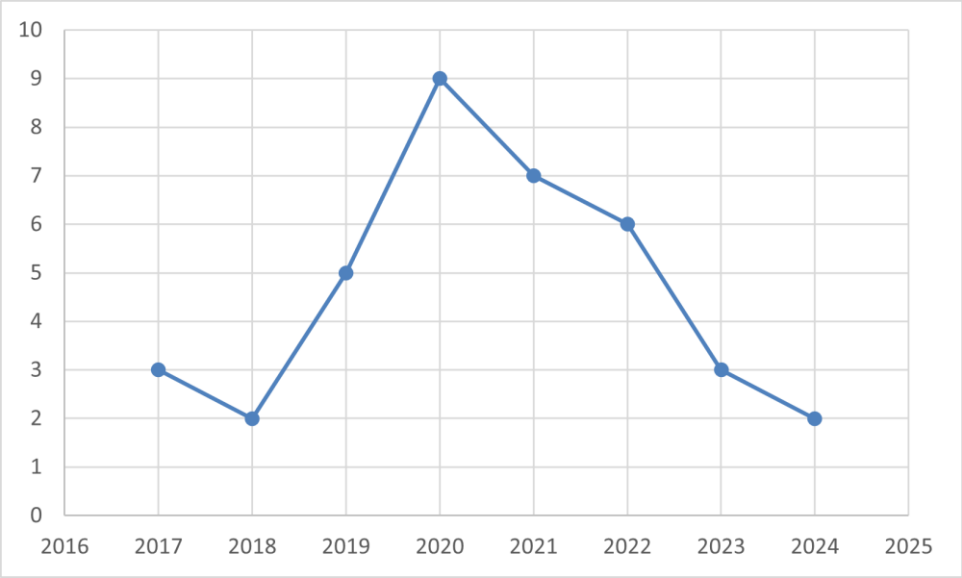

Figure 2. Number of articles by year.

It is noteworthy that there has been a significant increase in the number of studies until 2020. The increase over the years is noteworthy. After this year, there has been a steady decrease in the number of articles. The diversity in virtual reality technologies may be effective in this situation.

Table 2. Distribution of sample groups.

Sample Group	f	%
Undergraduate	21	52,5
Other	6	15
Middle school	5	12,5
High school	3	7,5
Primary school	2	5
Graduate	2	5
Preschool	1	2.5
Total	40	100

The distribution of the preferred sample groups in the articles using Google Cardboard is given in Table 2. When Table 2 is examined, it is seen that the most preferred sample group is undergraduate students (52.5%). However, this rate is quite low in the graduate group (5.0%). It is also seen that it is preferred in younger age groups such as middle school (12.5%) and high school (7.5%). As expected under these conditions, they were used at lower rates in the Primary School (5%) and Preschool (2.5%) groups. Different sample groups such as patients undergoing treatment, doctors, visitors were brought together under the heading Other (15.0%). This shows the applicability of the Google Cardboard application in different sample groups.

Table 3. Distribution of sample sizes.

Sample size	f	%
Between 11-30	8	22.2
Between 1-10	7	19.4
Between 31-50	7	19.4
Between 51-100	6	16.7
Between 101-300	6	16.7
Between 301-500	1	2.78
More than 500	1	2.78
Total	36	100

As a result of the analysis in terms of sample size, it is seen that different numbers of participants are included in the studies (Table 3). The most preferred sample size was 11-30 (22.2%), followed by 1-10 (19.4%) and 31-50 (19.4%). In a similar number of studies, sample sizes between 51-100 (16.7%) and 101-300 (16.7%) were preferred. There is a significant decrease in the number of studies when the sample size exceeds 300. Only one study (2.78%) each was conducted with sample sizes between 301-500 and more than 500.

Table 4. Conducted discipline.

Discipline	f	%
STEM	12	33.4
Language	8	22.2
Medicine	8	22.2
Special education	4	11.1
Others	4	11.1
Total	36	100

The data on which disciplines the research conducted using Google Cardbard is used in education (Table 4) are as follows: STEM (33.4%), Language (22.2%), Medicine (22.2%), Special education (11.1%) and others (11.1%).

Table 5. Educational context.

Educational context	f	%
Outside the school	21	56.84
In the school	16	43.2
Total	37	100

As a result of the analysis pertaining to the educational context where the studies were conducted, 56.8% of the studies were conducted outside the school (hospital, field trip, museum, or zoo) and 43.2% were conducted in the school (classroom or laboratory) (Table 5).

Table 6. Distribution of data collection tool.

Data collection tool	f	%
Survey / Scale	27	39.13
Interview	15	21.74
Observation	13	18.84
Other	8	11.59
Achievement test	6	8.7
Total	69	100

The most commonly used data collection tools in Google Cardboard studies are as follows (Table 6): survey/scale (19.13%), interview (21.74%), observation (18.84), other (11.59) and achievement test (8.70).

Table 7. Media types.

Media types	f	%
360º Video	12	33.33
3D Models	11	30.56
Panoramic Photos	7	19.44
Other (Simulation/Virtual Tour)	4	11.11
Unspecified	2	5.56
Total	36	100

The percentage distribution of media types used in Google Cardboard studies (Table 7) is as follows: 360º Video (33.33%), 3D Models (30.56%), Panoramic Photos (19.44%), Other (Simulation/Virtual Tour) (11.11%) and Unspecified (5.56%).

Advantages Identified in Articles

It is understood that the advantages obtained from the results of the research conducted using Google Cardboard are gathered in 3 subcategories: Educational outcomes, affective outcomes and technical advantages (Table 8). When the results of the content analysis are evaluated in general, it is understood that educational outcomes and affective outcomes are of great and equal importance in the results of the research conducted using Google Cardboard. However, technical advantages are also emphasized in the research results.

Table 8. Advantages of Google Cardboard

Inductive categories	Sub-categories	f	%
Educational outcomes	Increases success (performance)	14	16,87
	Facilitates understanding	7	8,43
	Provides fun learning	4	4,82
	Increases class participation	4	4,82
	Draws students' attention to the lesson	3	3,61
	Promotes cooperative learning	3	3,61
	Boosts creativity	1	1,20
Affective outcomes	Students develop positive attitudes	21	25,30
	Increases motivation	6	7,23
	Ensures student satisfaction	4	4,82
	Reduces anxiety	2	2,41
	Increases self-confidence	1	1,20
	Encourages students	1	1,20
	Increases communication between students	1	1,20
Technical advantages	Easy to use	6	7,23
	Low cost	5	6,02

Educational outcomes

When Table 8 is examined, the educational outputs obtained in Google Cardboard articles are as follows in order of importance: increases success (performance) (16.87%), facilitates understanding (8.43%), provides fun learning (4.82%), increases class participation (4.82%), draws students' attention to the lesson (3.61%), promotes cooperative learning (3.61%) and boosts creativity (1.20%).

Affective outcomes

The most important affective outcome obtained from Google Cardboard articles is that students developed positive attitudes (25.30%). It can be said that increasing students' motivation (7.23%) also has an important rate. Other affective outcomes are as follows: ensures student satisfaction (4.82%), reduces anxiety (2.41%), increases self-confidence (1.20%), encourages students (1.20%), and increases communication between students (1.20%).

Technical advantages

It is understood that the research conducted using Google Cardboard is centered around 2 important advantages: ease of use (7.23%) and affordability (6.02%). It can be said that these are the most common barriers to the use of virtual reality in educational institutions.

Challenges Identified in Articles

Although many advantages were mentioned in the articles using Google Cardboard, some difficulties were also emphasized (Table 9).

Table 9. Challenges of Google Cardboard

Challenges	f	%
Eye strain	3	50,00
Headache	1	16,67
Focus problem	1	16,67
Technical problems (Wi-fi)	1	16,67

The most common difficulty encountered in the articles was identified as eye strain (50.0%). This is followed by headache (16.67%), focus problem (16.67%), technical problems (16.67%) with the same rate.

Discussion

In terms of the number of articles, there was a steady increase between 2018 and 2020, while there was a decrease after 2020. This increase can be attributed to the widespread use of virtual reality technology and the discovery of new uses and purposes in the classroom. After the peak in 2020, the regular decrease in the number of studies may be due to the prominence of technologies such as augmented reality or artificial intelligence.

The most preferred sample group was undergraduate students. This finding is supported by Whang and Chan (2024), who stated that the majority of the sample group preferred in articles using Google Cardboard consisted of undergraduate students as a result of a similar study. It shows that the undergraduate group is generally used in more advanced education and research projects at the university level of virtual reality and similar digital tools. This may indicate a trend that technologies such as Google Cardboard are more preferred in educational and research settings at universities. It is seen that middle and high school students are the most preferred sample group after undergraduate students in Google Cardboard applications. This can be taken as an indication that such virtual experiences are also valuable for primary and secondary school students. This result is supported by Whang and Chan (2024). This is followed by primary school students, graduate students and preschool students. As can be understood, Google Cardboard is a tool that can be applied at almost any educational level. It is noteworthy that among these sample groups, the other category, which includes different audiences such as patients undergoing treatment, doctors and visitors, has a significant proportion.

The preference rates in terms of sample numbers in Google Cardboard articles are as follows respectively: 11-30, 1-10, 31-50, 51-100, 101-300, 301-500 and more than 500. The fact that only experimental articles were examined within the scope of the study may have an effect on this result. This may have an effect on the fact that the ratios, which are close to each other, especially when the number of participants is 300 and below, decrease significantly when the number of participants increases to 300 and above.

The order according to the disciplines in which the articles using Google Cardboard were applied is as follows: STEM, Language, Medicine, Special education, and others. Such a high percentage of STEM fields indicates that Google Cardboard is an effective tool for disciplines that require visualization and interactive learning, such as science, technology and engineering. Whang & Chan (2024), who reached a similar conclusion, stated that the most used discipline is STEM fields. This can be interpreted as virtual reality technology has a strong potential in the education of STEM fields. Virtual and augmented reality technologies facilitate learning by helping to make abstract concepts concrete. It is noteworthy that Google Cardboard is also preferred in language and medical disciplines. This suggests that virtual

reality is suitable both for creating cultural contexts in language learning and for simulation-based approaches in medical education. Whang and Chan (2024) emphasize in their research that Google Cardboard is a preferred tool for teaching different languages and various medical subjects (such as spinal anatomy, clinical simulation, anatomy and pathology, and patient education). The use in special education points to the potential of this technology to improve the learning experience for individuals with disabilities. In particular, customized virtual environments can adapt to the different needs of students. This result is supported by Whang and Chan (2024). In the Other category, it was observed that training on topics such as social media and communication skills were included.

As a result of the evaluation conducted by educational context, it was observed that although the number of articles conducted outside the school was higher, the difference was small. This situation can be interpreted as that virtual reality research conducted using Google Cardboard is successful in moving the education process out of school. No article was found in the literature on a similar variable.

The most preferred data collection tool in articles using Google Cardboard is survey/scale. This is followed by the following respectively: interview, observation, other, and achievement test. The fact that the use of survey/scale has the highest rate shows that in these studies, great importance is attached to quantifying the opinions and experiences of the participants in a quantitative way. The evaluation of technologies such as Google Cardboard in terms of user experience may have made survey and scale methods more attractive. Interview and observation methods stand out as qualitative data collection tools for a deeper understanding of the impact of the application on the user. The fact that the rate of achievement tests is at a lower level can be interpreted as an indication that the research emphasizes the importance of determining the opinions and attitudes of the participants before learning outcomes or academic achievement. Practices conducted outside the school and the involvement of participants other than students and teachers in the studies allowed the use of other data collection tools.

Although there is a diversity in terms of the type of media used in Google Cardboard articles, it is seen that close ratios are obtained. Accordingly, 360º Video, 3D Models, and Panoramic Photos are mostly used in the articles. These are followed by other (Simulation/Virtual Tour) and Unspecified. The fact that 360-degree videos represent the highest rate can be attributed to the fact that they allow users to have dynamic and interactive experiences in virtual reality environments. This method shows significant potential in education by allowing users to directly experience a specific area or process. The high preference for 3D models can be interpreted as pointing to the need to create more detailed learning materials in a visual and structural sense in education. Panoramic photographs are one of the most preferred cost-effective materials for experiencing an overall view of an environment or place as if you were there. The fact that they are easy to develop and low-cost is a factor in their preference. The rate of simulations may be due to the number of studies conducted in medical education.

One of the important findings of the research is the advantages obtained in Google Cardboard articles. It was understood that these advantages were gathered in 3 subcategories: Educational outcomes, affective outcomes and technical advantages According to the results obtained, the most important educational outcome of the applications with Google Cardboard is that it increases students' academic achievement (Ebadijalal & Yousofi, 2022; Lan & Tam, 2022). This can be considered as a result of the advantage of virtual reality technology in providing instruction by materializing it. However, the fact that one of the first variables

looked at in the studies was the academic achievement of the students played an important role in the emergence of this result. However, as a result of 4 studies, it was revealed that virtual reality supported education compared to traditional methods did not create a significant difference on students' achievement. As a similar result, in a significant number of studies, it was concluded that the use of Google Cardboard in the lesson helped to facilitate and understand the subjects (Omlor et. al, 2022; Tham et al., 2018). According to other results, Google Cardboard provides fun learning (Fokides & Kefallinou, 2020) and increases student engagement (Xie et al., 2021). Virtual reality technology enables students to have a fun learning experience. Thanks to the sense of reality it creates, students are transformed from passive recipients to active participants in the process. This results in increased student interest (Ebadijalal & Yousofi, 2022; Tham et al., 2018) and engagement. Finally, it was concluded that collaboration (Parmaxi et al., 2021) and creativity (Parsons et al., 2019) increased in studies using Google Cardboard.

As a result of the studies, the most important affective outcome shown by the participants is that they are positive towards the application (Ahmed & Hossain, 2020; Darabkh et al., 2018). This positive attitude may be towards both the application of virtual reality and the context applied with virtual reality. Both situations reveal Google Cardboard as an effective educational tool. Similarly, it is understood that it plays an important role in increasing the motivation of the participants (Nobrega & Rozenfeld, 2019). Google Cardboard, together with virtual reality software, allows interactive and visually rich content to be used easily. It is understood that this situation also positively affects students' satisfaction (Ou et al., 2021). When other findings obtained are examined, it is understood that important affective outcomes such as reducing participants' anxiety, increasing self-confidence, encouragement and increasing communication between students are included.

As a result of the research, it was understood that Google Cardboard articles were centered around only two technical advantages: easy to use and low cost. Schools with low budgets have difficulty in purchasing expensive hardware and software (Banerjee et al., 2023; Ou et al., 2021) and require technical knowledge and skills (Ahmed & Hossain, 2020; Xie et al., 2021). Google Cardboard plays an important role in overcoming these two obstacles with its advantages.

Some disadvantages have been mentioned in a small number of articles. The most important disadvantage is eye strain. Similarly, headaches and focusing problems were also mentioned. In studies conducted with Google Cardboard, users' own smartphones are used. The screen refresh rate of smartphones is low to run virtual reality software (Banerjee et al., 2023; Lan & Tam, 2022). This technical reason may be the reason behind the difficulties experienced. In addition, it was stated in 1 study that connection problems such as Wi-fi were encountered.

Conclusions and Future Research

Virtual reality technology provides important opportunities for education. In this study, it was aimed to determine the current situation, advantages and difficulties related to the articles made with Google Cardbord, an important application tool of virtual reality technology.

First of all, the characteristics of the analyzed articles were tried to be determined. It is noteworthy that the articles that started in 2017 started to decrease as of 2020. The preference for undergraduate level participants in most of the studies may lead to the preference of other sample groups in future studies. Although the articles show a heterogeneous distribution in

terms of sample numbers, it can be said that there is a need for research with large sample groups. Similarly, it is noteworthy that different options are preferred in terms of data collection tool, applied discipline and educational context. However, prospective studies can be conducted by using the least preferred ones.

Secondly, the research aims to reveal the advantages of using Google Cardboard. The results of the study revealed that the use of Google Cardboard provides significant advantages in the learning and teaching process. However, it should not be forgotten that the novelty effect may have a share in these advantages. Virtual reality technology may be a new and impressive technology for many sample groups. For this reason, it may be suggested that future studies should be planned or piloted in sufficient time to eliminate this novelty effect.

Along with the advantages, it is seen that there are some difficulties, albeit few. The novelty effect mentioned above may cause some challenges to be overlooked. For this reason, it is recommended to prefer qualitative studies in which in-depth research will be conducted to identify the challenges.

Limitations of the study

The articles analyzed in this study are limited to journals indexed in Web of Science and Scopus databases. It is also limited to studies with experimental and educational dimensions in article type.

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Declaration

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