

# Survey of Application of Virtual and Augmented Reality in Education

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**Abstract**—Virtual Reality and Augmented Reality is immersing with lots of prospective applications in a different area. With the advancement of hardware and software infrastructure, these technologies are more reachable and affordable now. The application of VR and AR in education is now a reality. Students face issues and complexity during their learning process. Sometimes, proper material can not be provided due to cost, and sometimes study material is an imaginary thing without actual existence. Therefore, the learning process can be cumbersome, and VR & AR can be a blessing to improve the learning process in this kind of scenario. This paper will review applications, technology, specific field of application of VR and AR in education.

**Keywords**—Virtual Reality, Augmented Reality, Education

## I. INTRODUCTION

Although Virtual Reality and Augmented Reality seem to be futuristic technology, both started in the late 18<sup>th</sup> and early 19<sup>th</sup> centuries. STEREOSCOPE, invented by Charles Wheatstone to allow the user to view a 3D image from a pair of images, can be considered the first VR attempt. [1] In 1968, Ivan Sutherland created a head-mounted display and named it Sword of Damocles that functioned similarly to AR technology and can be considered the pioneer. [2] VR- Virtual Reality is the immersion experience that replaces the real world, and AR – Augmented reality is the real-world experience with virtual objects super-imposed. With smartphones, memory storage, and related technologies, VR and AR have been rapidly developed and are now in reach. The educational application of these two technologies is also prominent. The learning process is challenged by many obstacles, like cost, lack of motivation, lack of support for standard tooling/lab, etc. VR & AR may come to the rescue to overcome some of those challenges. With VR, it's possible to set up a virtual lab where the physical lab is costly or unavailable. [3] On the other hand, introducing VR and AR can improve motivation for learning significantly. [4] Here in this paper, we will try to review some of the VR and AR solutions available or proposed, how those help in education with some specific focus on computer science education and technology and diversity of application in mind.

## II. RESEARCH METHOD

Systematic Mapping Studies in Software Engineering by Kai Petersen et al. [5] is followed in this study. To get most relevant papers from database based on popularity, relevance, customized program is also used to filter out from large search results. This mapping process is done in the following steps:

- Research question generation and review scope
- Generate search string for database search.
- Filter literature using inclusion and exclusion criteria

- Further, filter out more literature using a custom program based on the specific interest
- Full-text reading and removing irrelevant papers.
- Perform data extraction by systematic mapping.
- Systematic mapping results.

### A. Research Questions

The aim is to find available solutions of VR/AR for education, understand their effectiveness, the underlying technology to build those and see solutions specific to computer science.

To reach the goals mentioned above, the following RQ's have been generated:

- RQ1. What are available Virtual & Augmented reality solutions in education?
- RQ2. Which fields of education use VR and AR solutions?
- RQ3. What are the VR & AR solutions for computer science education?
- RQ4. How does Virtual & Augmented reality help in education?
- RQ5. Which platform VR & AR solutions deployed most?
- RQ6. Which game engine is used primarily for VR & AR solution development?

### B. Search

The searching process is done to get relevant papers to review and extract relevant data from those papers. In this study, IEEE Xplore is selected to perform a database search. This database is selected for its acceptance of reliability and relevance with our intended study.

#### 1) Search String

PICO (Population, Intervention, Comparison, Outcomes) suggested by Kitchenham and Charters [6] to generate a search string is used and formulated from research questions. After applying the steps, the final search string looks like following:

(“Virtual Reality” OR “Augmented Reality”)  
 AND  
 (“Solutions OR Software OR Games”)  
 AND  
 (“Education” OR “fields of education” OR “Computer  
 Science”)  
 AND  
 (“using” OR “applying” OR “helps” OR “benefit” OR  
 “improve”)  
 OR  
 “deployment platform”  
 OR  
 (“game engine” AND “used” OR “development”)

Fig. 1. Final Search String

## 2) Database Search

After the search string is finalized, a database search is performed. As previously mentioned, IEEE Xplore is selected for performing search operation. The main search strings need to be modified a little bit due to searching restrictions. Table 1 shows the number of results from database.

**Table 1**

Number of results

Database	Number of Search results
IEEE Xplore	5251

## 3) Inclusion & Exclusion Criteria

All the search results from databases might not be relevant to our scope, and they are many to be studied in a short period. So, some inclusion and exclusion criteria are generated to filter out the papers.

Inclusion Criteria are as follows:

- Published as conference papers or journals.
- Published after 2010.
- Related to VR or AR.
- Published in English.

Exclusion criteria are as follows:

- Published in magazines, books, or Gray literature.
- Published before 2010.
- Not related to VR or AR.
- Excluding duplicates
- Articles that do not have full-text access.

Table 2 represents the application of inclusion and exclusion criteria.

**Table 2**

Application of inclusion and exclusion criteria on database search result

Inclusion/Exclusion Criteria	IEEE Xplore
<b>Before applying</b>	<b>5251</b>
Including papers and journals	4823
Including papers published after 2010	2219
Excluding publication that doesn't have full-text access	2219
Exclude irreverent publications by reading the title and abstract up to 75 results	14
<b>Total</b>	<b>14</b>

After applying inclusion and exclusion criteria, 14 papers are initially selected. After that, a custom program is also used to filter out based on our interest from 2219 papers (after applying inclusion and exclusion criteria).

## 4) Custom filter by program:

After applying inclusion and exclusion criteria, it is cumbersome to read (at least title or abstract) 2219 papers. Initially, 14 articles were selected in the previous step by reading 75 top search results title/abstract. However, it is assumed that some relevant, exciting paper is missed. So, a custom filter program is developed that filters out documents based on some additional metrics and interests. The program used for further filtering is given below.

```

data = pd.read_csv("test_data.csv")
data = data.sort_values(by=['Reference Count', 'Publication Year'])
dataAbs = data[(data['Abstract'].str.contains('virtual reality', case=False)) ]
dataAbsCompu=
dataAbs[(dataAbs['Abstract'].str.contains('computer', case=False)) ]
dataAbsSoft=
dataAbs[(dataAbs['Abstract'].str.contains('Software Engineering', case=False)) ]
dataVirT=data[(data['Document Title'].str.contains('vir', case=False)) ]
dataVirT=dataVirT[(dataVirT['Document Title'].str.contains('education', case=False)) ]
dataVirT=dataVirT[(dataVirT['Document Title'].str.contains('computer', case=False)) ]
frames = [dataAbsSoft, dataAbsCompu, dataVirT]
final = (pd.concat(frames).drop_duplicates()
.sort_values(by=['Reference Count', 'Publication Year'], ascending=False)
dataOnlyEdu = final[(final['Document Title'].str.contains('education', case=False)) ]
  
```

After applying for this filter program, 29 papers were found, and five best papers were selected for the next step by reading the title and abstract.

### 5) Full-Text reading

Full-Text reading is done for 19 papers and additional irrelevant papers found during this process and removed from the data extraction process list. Finally, 17 papers were selected for the data extraction process.

### C. Data Extraction

After getting the final pool of literature, we use those for extracting data related to each RQ. The data extraction form used for this study is shown in Table 3.

**Table 3**

Data extraction form

Data Item	Value	RQ
Article Title	Name of the article	
Author name(s)	Set of names of the authors	
Available VR & AR Solutions in Education	Names Mentioned	RQ1
Fields of education using VR & AR solutions	Fields mentioned	RQ2
VR & AR solutions developed for Computer Science education	Application mentioned for CS education	RQ3
How VR & AR help?	VR & AR advantage or reasoning mentioned	RQ4
Deployment platform of VR/AR application	Platform mentioned	RQ5
Game engines mainly used to develop VR/AR application	Game engines name mentioned	RQ6

## III. RESULTS

During the survey, it was observed that the educational application of VR/AR is an emerging topic of research. Many applications and tools are available for this, and many projects are in a conceptual state. Below, results are presented for each RQ's generated before.

### A. Result (RQ1) – Available VR/AR solutions for education

This section presents the result of our first research question. RQ1 aims to find available VR & AR solutions in education. Table 4 shows our current findings.

**Table 4**

Available VR/AR solutions for education

VR/AR Solution	Purpose	Reference
Geo+	Geometry learning for primary schools	[7]
Goon AR	Storybook with AR experience	[7]

HistoryAR	Teaching history with AR	[7]
ABC Galaxy	English Alphabet tutoring game	[4]
Construct3D	Mathematics & Geometry learning	[8]
ARQuest	Computational Thinking Improvement	[9]
Fancy Fruits	Special Needs Education	[10]
Scenic Spheres	Geography Learning	[11]
Xerox	VR collaboration for training	[12]
mRLAB	Computer Architecture & Curriculum	[13]
“Virtual Electric Manual”- VEMA	Electric circuit theory learning	[14]
Treasure Hunt VR/CS Unplugged activity	Learning Theoretical Computer Science	[15]

### B. Result (RQ2) – Fields of education using VR/AR solutions

In this RQ, we aim to determine which fields of education use VR/AR solutions. And results seems it can be generally used in almost all kinds of education—table 5 shows education fields mentioned by different article references.

**Table 5**

Fields of education using VR/AR solutions

Field of Education	Reference
Chemistry	[7],[16]
Anatomy	[7]
Physics	[7],[8],[10],[16]
Math	[7],[8],[16]
Astronomy	[7]
Medicine	[7]
Landscape Architecture	[7],[12]
Engineering	[7],[16],[14]
History	[7]
Language Learning	[4],[12]
Computer Science	[9],[13],[15]
Geography	[11]
Real State Study Program	[17]
Cybersecurity	[16]
Aircraft Evacuation Training	[18]

### C. Result (RQ3) – VR/AR solutions for computer science education

This RQ aims to find out some VR/AR solutions for computer science education. During the survey, three solutions have been found in computer science. VisAir3D is a mixed reality solution that aims to teach software architecture, and currently, the solution is in a conceptual state. [19] Anna

Gardeli and Spyros Vosinakis worked on a solution called ARQuest that aims to improve computational thinking during the early stage of education. [9] mRLab is a work in progress solution in computer science using the mixed reality that aims to support learning computer architecture and organization through remote instrument lab. [13]

#### D. Result (RQ4) – How VR/AR help in education

This section will present how VR/AR solutions can help/improve the education experience based on surveys.

VR/AR solutions can be used to simulate environments that are risky or can not manage to prepare due to legal issues. So, this technology can be used for training purposes in those kinds of simulated environments. For example, Aeroplane evacuation drills. [18] VR/AR solution is also collaboration friendly, so it is possible to make virtual classrooms and perform collaborative lab tasks. [18] [14] Gamification of the lessons can improve motivation to learn. [20] As VR/AR is a controlled environment, it is also easy to evaluate the learner's performance. [20] [14] Another significant improvement in education can be made with VR/AR technology is by representing theoretical/conceptual study with metaphorical virtual objects. [15]

#### E. Result (RQ5) – VR/AR applications deployment platform

VR/AR solution is deployed to iOS, Android, Browser, Desktop platforms. From the survey, it can be seen that most of the applications deployed (iOS/Android) to mobile platforms.

#### F. Result (RQ6) – Game Engine used to develop VR/AR solutions

From the survey, it is found that almost all of the papers Unity as their development game engine. And other game engines mentioned are Vuforia, VirTools.

### IV. REVIEW OF THE EDUCATIONAL VR/AR APPLICATION

Due to lack of access and information, it was impossible to try out most of the applications mentioned in our reviewed papers. However, it was possible to test one emerging educational VR application named Futuclass.[21] This application is intended to provide science education with gamified experience. Chemistry lessons from Futuclass had been tested. It provides gamified experience to learn reaction balancing. The Player has to put the correct number of correct chemical elements on the reactor side and product side to balance the reaction. It provides pretty intuitive tutorials and an environment to get the intuition of the task to solve. It provides a good number of reactions to balance, and by playing it, the learner should get the idea of reaction balancing and increase the learning motivation. They also provide VR lessons before using the VR module and after using the VR module to test the skills.

Evaluating the student's performance while consuming the VR application is also possible by logging the time to solve each lesson.

Overall it is an excellent attempt to improve and inspire learning experience. Futuclass is still its early age, and it is expected to be much more improved over time.

### V. CONCLUSION

Delivering study content that is engaging, effective, and suitable to grasp for a wider audience is a significant challenge in education. In today's world, e-learning is gaining immense popularity, and still, some topics couldn't be adequately delivered without physical presence as those require special instruments. VR/AR applications can play a vital role in solving some of the challenges above. As seen from the survey, lots of research work is going on with these technologies for education. We can hope that VR/AR applications will be one of the essential parts of mainstream education soon.

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