Trends of Augmented Reality Applications and Research throughout the World: Meta-Analysis of Theses, Articles and Papers between 2001-2019 Years

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Abstract—Our aim in this research was to analyze studies in the area of Augmented Reality applications and research throughout the world using meta-analysis methods in order to determine trends in the area. For the purpose of the study, a total of 1008 pieces of research, published between 2001 and 2019 and selected by purposeful sampling method were analyzed. Trends of Augmented Reality applications and research throughout the world were examined under 13 criteria. These criteria were; index, year of publication, number of authors, country of research, area of research, method, education grade, sample group, sample number, data collection method, bibliography number, analysis techniques, purpose of research, and research trends. These data were interpreted based on percentage and frequency. In Augmented Reality, technologies are integrated in many fields such as education technology, engineering arts, visual arts education and special education.

Keywords—Augmented Reality Applications, Augmented Reality in Education, Meta-Analysis, Publication Classification.

1 Introduction

"Augmented Reality Applications" have become increasingly popular in recent years as a result of developing technologies. In 2008, in a Horizon report issued by New Media Consortium (NMC), Augmented Reality (AR) technology was foreseen to play an important role in conjunction with mobile devices after 2010 and wearable technologies after 2013.AR projects are supported within the context of the FATIH (Increasing Opportunities and Improving Technology Movement) project as mentioned in the TUBITAK (Scientific and Technological Research Council of Turkey) Human-Computer Interaction Call. Accordingly, the use of AR technology in the classroom will increase. AR applications will be standardized both in smart phones and tablet PCs. For example, we can what apartments are for sale or for rent using the camera on our mobile devices, and we can read comments about the food of a restaurant we plan to visit using an AR application [1]. A 2D gesture annotation provides a simple way to annotate the physical world in augmented reality for a range of applications such as remote collaboration. Such innovative applications will prove to be convenient with AR.

Augmented Reality has been defined by a number of different researchers. Augmented reality according to [2]. is a live and interactive environment that is formed by adding virtual objects to real images obtained by the camera. AR, according to another definition, is the whole range of technologies that allows the user to see the real world developed, enriched or augmented by adding information such as text, image, voice etc. [3], [4]. Augmented reality, according to [5], is a derivative of virtual reality. Consequently, they are environments in which reality is not reproduced, but rather supported.

When the historical development of AR is examined it can be seen to be a system that was developed to provide information about the flight which appeared on the front windscreen of World War IIaircraft in the form of the Airborne Interception Radar Gun sighting Project. Even though this system reflected the AR technologies as a whole, it was one of the first examples of the development procedures associated with such technology [6]. Paradigmatic changes have occurred in AR technologies with variations in terms of functionality in the form of wide and wearable technologies benefiting from the developed features of applications in connection with the appearance of Information and Communication Technologies. These technologies have started to be used in many different areas [7].

[8] AR is a new technology that is likely to have an impact in education. This claim is supported by the Horizon Reports from 2004 to 2010 which describe AR as a technology that brings the computer world to the human world [9]. AR is different from virtual reality technology because AR combines the real world with computer graphics, while virtual reality immerses the user in a computer-generated world.

It is possible to classify AR types into three categories: geographical positioning, objects positioned over reality, and interactive AR applications. When the most commonly used areas are examined, it is possible to say that military, medical and health, tourism and travel, marketing and sales, public services, games, social interaction,

industrial uses, education and culture are in the forefront of AR technology use [10]; [11].

If we mention the integration of AR to education in today's world, we consider the point of view that students are growing up in a multimedia world and integrating with the technology as part of the digital native or digital generation; it is possible to say that they may become disinterested with traditional approaches to learning because of the rich content available in the training-education environment, leading to a decrease in interest and motivation with regard to traditional lessons. In this regard it is estimated that AR applications will have a different role to play during the process of achieving desired behaviors in the teaching and learning process, involving the placing of different point of views on the subjects and helping to inculcate positive attitudes to lessons that will lead to an increase in interest and motivation [12], [13], [14], [15].

The relevant research is examined; in their study [16], aimed to examine the reviews released on augmented reality applications in education, merging the results obtained in the studies that are independent from each other, and providing a new viewpoint for the studies that will be conducted in the future. The meta-analysis method has been used in their study. 15 out of 171 reviews, whose effect size of the data may be calculated, and released between the years 2005 and 2015 have been included in the meta analytic effect size analysis. The reviews were intended to examine the efficiency of augmented reality applications in education and were selected after scanning the SCI and SSCI Indices. The names and the abstracts of the reviews were taken as bases in the classifying according to the target audience and subjects. It was determined as a conclusion in the study that the average effect size of the augmented reality applications in education was ES=0.677. It was determined that the applications performed by using the augmented reality technology in education had a positive effect on students, and that this effect was at medium level that could not be underestimated according to Thalheimer and Cook Classification. In their study [17], reviews the research that has been conducted on AR. The review describes the application of AR in a number of fields of learning including Medicine, Chemistry, Mathematics, Physics, Geography, Biology, Astronomy and History. The review of the results of the research shows that, overall, AR technologies have a positive potential and advantages that can be adapted in education. Otherwise in their study [18], reports a systematic review of literature on augmented reality in educational settings considering the factors mentioned before. In total, 32 studies published between 2003 and 2013 in 6 indexed journals were analyzed. A short summary of the main findings of this review are: The number of published studies about AR in education has progressively increased year by year specially during the last 4 years. Science and Humanities & Arts are the fields of education where AR has been applied the most. Health & welfare, Educational (teacher training) and Agriculture are the research fields that were the least explored fields [19]. AR has been mostly applied in higher education settings and compulsory levels of education for motivating students [20]. The main purpose of using AR has been for explaining a topic of interest as well as providing additional information. AR educational games and AR for lab experiments are also growing fields. The main advantages for AR are: learning gains, motivation, interac-

tion and collaboration. Limitations of AR are mainly: difficulties maintaining superimposed information, paying too much attention to virtual information and the consideration of AR as an intrusive technology. AR has been effective for: a better learning performance, learning motivation, student engagement and positive attitudes. reviews of studies that compare student learning in AR versus non-AR applications. The findings on the positive impact are: Increased content understanding, Learning spatial structures, language associations, long-term memory retention, Improved collaboration and motivation. The findings on the negative impact are: attention tunneling, Usability difficulties, ineffective classroom integration, learner differences. Reviews considered papers published in IEEE Xplore. Authors applied a meta-analysis and a qualitative analysis in the dimensions of display metaphors, content creation and evaluation techniques. Authors conclude that there are three main affordances of AR: real world annotation, contextual visualization and vision-haptic visualization. Also, authors state that the three affordances are supported by existing theories like: multimedia learning theory, experiential learning and animate vision theory.

1.1 Purpose of the research

The purpose of this research -Research on Augmented Reality and Applications throughout the world is to reveal research trends by classifying relevant publications.

2 Method

2.1 Research design

This research involves a meta-analysis study using content analysis. Meta-analysis is a method that aims to obtain access to common results by using statistical tools with the aim of synthesizing research results by combining the research on a specific issue, and trying to decrease the restrictions of the individual studies (Büyüköztürk et al., 2011).

2.2 Population sampling

The population of the research comprises databases, journals, congresses, symposia and conferences through the world in the area of Augmented Reality.

The research sample consists of databases incorporating Augmented Reality applications research between 2001 and 2016; Scopus, IEE XPLORE, IEEE Transactıons on Education, Science Direct, EBSCO, Computer & Graphics, Web of Science, Taylor & Francis, Proquest, Ulakbim (Turkish National Academic Network and Information Center) and Turkish Council of Higher Education Thesis Search (YÖK). It also includes articles in journals; Journal of Instructional Technologies & Teacher Education, Journal of European Education, Journal of Educational Technology & Society, Journal of Information Technology Education, International Journal of Engineering Science Invention (IJESI), Journal of Computational Science, Media Educa-

tion Research Journal (MERJ), Visualization in Engineering – a Springer Open Journal, International Journal of Technology Enhanced Learning, Journal of Software Engineering and Applications, Journal of Education and Science, Journal of Educational Sciences Gazi University, The Turkish Online Journal of Educational Technology (TOJET), Pegem Journal of Education & Instruction , Journal of Education Faculty Sakarya University (SUJEF), Journal of Science and Engineering Sciences Afyon Kocatepe University, Journal of Education Faculty Mersin University and papers delivered in congresses, symposia and conferences; 210 pieces of research in total in the International Conference on Technologies for Interactive Digital Storytelling and Entertainment (2003), the International Conference on Computer Graphics (2004), the International Conference on Engineering Education (2008), the EDEN Open Classroom Conference (2011), the Academic Information Congress (2013), the EduRe Virtual Conference (2014), the 9th International Computer & Instructional Technologies Symposium (ICITS, 2015), and the 17th International Conference on Electronic Commerce (ICEC, 2015).

2.3 Data collection

Initially databases, journals, congresses, symposia and conferences relating to AR applications and research between 2001 and 2019 within world were searched, followed by a similar world-wide search. The findings were examined and interpreted. The reason for choosing 2001 as the initial point was that the first publication on Augmented Reality appeared that year.

2.4 Data analysis

The data obtained as a result of the search is presented in tabular form. The reason why this approach is followed is because of the fact that both the study constituting imagery and allowing to have idea relating to the researches performed at first sight. The data were interpreted based on percentage and frequency with regard to the research. After general descriptions were identified below the tables, the similarities and differences seen in the research were analyzed in detail using meta-analysis.

2.5 The validity of the research

The data have been collected appropriately for meta-analysis purposes, and appropriate analysis methods have been used. The studies have been numbered to make sure that every study is represented once in the sample. The coding form that has been developed is applied in the same way to all meta-analysis studies.

2.6 The reliability of the research

Two expert opinions have been used to determine the reliability of the data. Studies were coded into moderator variables that fell into two categories; substantive and

methodological. There were eight substantive variables; index, year of publication, number of authors, country of research, area of research, purpose of research, education grade, bibliography number, and six methodological variables; method, sample group, sample number, data collection method, analysis techniques. The inter-coding consistency has been found to be sufficiently robust with a value of .81; and revised with a Kappa parameter. The Kappa value was found to be .81 in this study. According to Cohen (1988), this value is almost perfect, as it lies between .81 and 1.

3 Findings

In Table 1, the studies in the area of Augmented Reality applications research throughout the world were examined in databases, journals, congresses, symposia and conferences as the result "database" was identified as the most content containing source of publications. These databases are "Scopus" with 29,9% and 302 publication relating to the subject; "Science Direct" with 27,0 % and 273 publications; and "Web of Science" with 11,7 % and 118 publications. Since a large proportion of research publications on Augmented Reality applications research appear in the Scopus database, it was noted that this database has hosted 15000 journals and publications in area of Educational Technologies.

Table 1. Distribution of studies in the field of Augmented Reality Applications and Research by publication index

Publication Index	Classification	f	%
Scopus	Database	302	29,9
Science Direct	Database	273	27,0
Web of Science	Database	118	11,7
IEE Xplore	Database	92	9,1
Ebsco	Database	75	7,4
Taylor&Francis	Database	42	4,1
Proquest	Database	16	1,5
YÖK Tez Tarama	Database	11	1,0
Computational Science Journal	Journal	10	0,9
Ulakbim	Database	9	0,8
Educational technology (theory and practice)	Database	5	0,4
IEEE Transactions on Education	Journal	3	0,2
Computers & Graphics	Journal	2	0,1
Computers & Education	Journal	2	0,1
EduRe Journal	Journal	2	0,1
Journal of Educational Technology & Society	Journal	2	0,1
Journal of Information Technology Education	Journal	2	0,1
Journal of Instructional Technologies & Teacher Education	Journal	2	0,1
Journal of European Education	Journal	2	0,1
Journal of Software Engineering and Applications	Journal	2	0,1
Journal of Education and Training Researches	Journal	2	0,1
Int. J. Technology Enhanced Learning	Journal	2	0,1

International Conference on Computer Graphics	Journal	2	0,1
International Conference on Engineering Education	Journal	2	0,1
International Conference on Technologies for Interactive Digital Storytelling and Entertainment	Journal	2	0,1
International Journal of Engineering Science Invention	Journal	2	0,1
The International Journal of Virtual Reality	Journal	2	0,1
VieJournal	Journal	2	0,1
Media Education Research Journal	Journal	2	0,1
Architecture Planning Art and Design	Journal	2	0,1
Eğitim ve Bilim Dergisi	Journal	2	0,1
Gazi University Journal of Gazi Educational Science	Journal	2	0,1
Afyon Kocatepe University Journal of Science and Engineering	Journal	2	0,1
Mersin University Journal of Educational Science	Journal	2	0,1
Pegem Journal of Education and Training	Journal	2	0,1
Sakarya University Journal of Educational Science (SUJEF)	Journal	2	0,1
EDEN 2011 Open Classroom Conference	Conference	1	0,1
ICEC (International Conference on Electronic Commerce)	Conference	1	0,1
ICITS (Computer & Instructional Technologies Symposium)	Conference	1	0,1
Academic Information Congress	Congress	1	0,1
Total		**1008**	**100**

Database, journal, conference and congress sequences were followed in the distribution according to the publication of the works in the field of Augmented Reality Practices and Researches. Then the related publications were examined in terms of content in their respective groups (database, journal, conference and congress). According to this;

- When the data bases are examined; the existence of publications related to the use of augmented reality applications and research in the field of medicine, engineering and education has been observed. Simulations, surgical navigation, robotics applications, mobile applications are these studies.
- When the journals were examined, the existence of publications aimed at the use of augmented reality applications and researches in the field of engineering and education was observed. As well as publications in the dimensions of technology, applications, approaches and limitations on augmented reality. According to the related study in the journals, the use of the augmented reality applications in many different areas. Food chemistry, creative drama, law and policy, ballet training, online shopping, visual arts education are examples of different areas.
- When the conferences and congress were examined, it was determined that the tendency in recent years is to support creativity and permanent learning in schools with augmented reality practices. Many applications developed for pre-school and primary school institutions have been identified for this purpose. These are the concept teaching and material application with the augmented reality.

Table 2. Distribution of increased reality research and applications by publication year and country

Countries				**Publication Year**																	
	2019	***2018***	***2017***	***2016***	***2015***	***2014***	***2013***	***2012***	***2011***	***2010***	***2009***	***2008***	***2007***	***2006***	***2005***	***2004***	***2003***	***2002***	***2001***	***To-tal***	***%***
United States	62	44	27	19	6	1	2		1		1									163	16,3
Taiwan	43	33	29	9	3	2	3													122	12.2
Germany	38	26	30	3	2	2	1	1												103	10,3
Turkey	34	26	12	10	4	3	1	1	2	1	1									95	9,5
Spain	31	30	7	7	3	2	5	3		1										89	8,9
Malaysia	24	23	15	4	3	2														76	7,6
Canada	27	25	16	4	x2	1	1													71	7,1
Brazil	13	14	10	3	2	1				1										44	4,4
China	11	13	9	1						3		2							1	40	4,0
Japan	16	7	6		1		2		3											34	2,4
Australia	9	5	4	2	1			1		1										23	2,4
Britain	6	9	3	1		1		1			1		1							23	2,4
Korea	7	5	4		1		1				1			1			1			21	2,4
Singapore	6	5	2	1		2			1											17	1,7
Mexico	4	3	2	1		1				1										12	1,2
Italy	4	2	1				2			2										11	1,1
Norway	2	2	2			2		1												9	0,9
Thailand	2	1	1	1	1															6	0,6
Switzerland	1	1								1						1				4	0,4
Czech	2				2															4	0,4
France	1		1						1									1		4	0,4
Lithuania											1					1				2	0,2
Egypt											1		1							2	0,2
Portugal						1		1												2	0,2
Russia				1						1										2	0,2
Venezuela							1					1								2	0,2
New Z.					1			1												2	0,2
Greece					1				1											2	0,2
Slovenia					1					1										2	0,2
Slovakia							1		1											2	0,2
Serbia															1					1	0,1
Poland						1														1	0,1
Sweden							1													1	0,1
Hong Kong					1															1	0,1
India									1											1	0,1
Holland															1					1	0,1
Indonesia																	1			1	0,1
Denmark																	1			1	0,1
Bulgaria							1													1	0,1
Austria										1										1	0,1
Total	343	274	181	67	34	21	21	10	11	14	8	3	2	1	2	2	3	1	1	**999**	**100**
																		0,1	0,1	**100**	

It is clear from this that researchers from United States had the most publications on the aforementioned topic with 163 publications (16, 3%). Taiwan follows the United States with 122 publications (12, 2%). In this context the study done by the countries in the field of the augmented reality applications has been crossed according to years. Countries with a lot of research on augmented reality applications (United States, Taiwan, Germany, Turkey, Spain and Malaysia) may say that these surveys are usually done between 2011 and 2019. So, the work done in the last five years is frequent. According to the publication year of studies into AR applications research in the world and in Turkey, the year 2019 came first with 34 publications of the total. 2018 follows with 26 publications (Table 2). The results obtained here is that there has been an increase in the number of publications in terms of AR applications research. The main reason why issue is being considered is the integration of AR applications with regard to education. When these publications are examined, it can be seen that the main source of such research is Japan, and the subject is "Enrichment of Text Based Books with Virtual Animations by Using Augmented Reality". Since the country to which the 9 articles belonged could not be reached, 999 articles were evaluated.

Table 3. Distribution of studies in the field of Augmented Reality Applications and Research by author numbers

Author Numbers	F	%
2 authors	261	25,8
3 authors	178	17,6
1 author	162	16,5
4 authors	146	14,4
5 authors	139	13,7
6 or more authors	122	12,0
Total	**1008**	**100**

In terms of author numbers (Table 3) it can be seen that 261 publications had "2 authors" making up a proportion of 25, 8%. Another remarkable point is that single author studies are 16, 5%. In addition, the existence of 122 publications with 6 and more authors is remarkable.

Table 4. Distribution of studies in the field of Augmented Reality Applications and Research by research area

Research Area	f	%
Education Technologies	214	21,2
Engineering	169	16,7
Science	145	14,3
Mobile Apps	132	13,5
Robotic Applications	93	9,1
Anatomy	51	4,9
Surgical Navigation	37	3,5
Special Education	36	3,4
Mathematical Sciences	32	3,0

Tourism	15	1,5
Foreign Language Education	15	1,5
Distance Education	12	1,5
Military Aviation Education	4	0,4
Environmental Education	2	0,2
Natural Sciences	2	0,2
Military Marine Education	2	0,2
Food Chemistry	2	0,2
Construction	2	0,2
Museum Applications	2	0,2
Instructional Design	2	0,2
Architecture	2	0,2
Pedagogy	2	0,2
Psychology	2	0,2
Rehabilitation	2	0,2
Social Media	2	0,2
Creative Drama	2	0,2
Dentistry	2	0,2
Library Management Systems	2	0,2
History	2	0,2
Visual Arts Education	1	0,1
Visual Tracking Systems	1	0,1
Hospital Applications	1	0,1
Law and Policy	1	0,1
Human Sciences	1	0,1
Military Logistic Support	1	0,1
Media and Communication	1	0,1
Nuclear Engineering	1	0,1
Pre-School Education	1	0,1
Picture-Work	1	0,1
Marketing	1	0,1
Civil Defense	1	0,1
Driving Course	1	0,1
Underwater Life Education	1	0,1
Theater	1	0,1
Aged Care	1	0,1
Early Childhood Education	1	0,1
Ballet Training	1	0,1
Scientific Literacy	1	0,1
Online Shopping	1	0,1
Ethical and evolving technologies	1	0,1
Total	**1008**	**100**

According to the research areas of the studies in Augmented Reality Applications Research that were examined, Augmented Reality Technologies were spread out across various areas such as Educational Technologies, Engineering Science, Mobile Applications, and Visual Arts Education. Educational Technologies is the leading research area with 214 publications and 21,2% of the total (Table 4). Especially in

recent years, a decrease in the cost of development and improvement with regard to Information and Communication Technologies has provided integration of these technologies in the field of education. In this regard it was decided that integration of augmented reality applications and research as a part of developing and improving technology and development, works. "Engineering", "Science", "Mobile Applications" and "Medicine" followed education in terms of the increase in development and the improvement of AR technologies and provides support of the integration of AR with "Engineering". As undertaking scientific experiments can be expensive, dangerous and difficult in the laboratory, the need for simulation systems has become necessary. It is thought that the increase in publications in the area of Educational Technologies may be explained by the following reasons; in the context of Mobile Applications, smart phones are becoming part of our lives in that they contain several applications that makes human life simpler and which provide support for AR integration. Finally, the integration of AR into medicine is substantial. The increased popularity of integrated surgical operations is thought to be the reason of this. The integration of AR applications in different areas such as "Underwater Life Education", "Theater", "Elderly Care", "Ballet Training", "Scientific Literacy" and "Online Shopping" have also been encountered.

Augmented reality applications begin with the detection of weather, range, flight distances through screens mounted on cockpit of warplane aircraft. When the table is examined it is seen that there are applications where the military area is used for augmented reality. Military aviation education, military marine education, military logistic support, civil defense these applications.

Augmented reality applications are frequently used in the medical field. Surgical navigation practices are the best example. Examples of use of the augmented reality in the field of medicine are included in the relevant table. Anatomy, surgical navigation, rehabilitation, dentistry these applications.

Table 5. Distribution of studies in the field of Augmented Reality Applications and Research by method

Method	f	%
Design and development work	273	27,0
Experimental Model	215	24,2
Literary Review	109	10,6
Qualitative Research Methods	77	7,4
Data Collection	70	6,7
Quantitative Research Methods	66	6,2
Mixed Model	58	5,5
Meta-analysis	35	3,2
Pilot Studies	32	2,9
Scale Development Work	31	2,8
Case Study	30	2,7
Empirical Study	12	0,8
Total	**1008**	**100**

In terms of methods used, "Design and Development Studies" led with 273 publications (34.8%). The reason for this is the integration of the AR applications research, especially in the "Engineering" area and the introduction of improved AR systems in this regard. "Experimental Model" follows with 16.7%. Qualitative Research Methods are used more frequently than the Quantitative Research Methods. The existence of mixed models which contain both the qualitative and quantitative research methods have been observed in the studies. "Meta-analysis", "Pilot Work", "Scale Development Work" and "Empirical Work follow the Mixed Model approach.

Table 6. Distribution of studies in the field of Augmented Reality Applications and Research by educational level

Educational Level	f	%
University	320	50,7
Primary School	101	16,0
Middle School	65	10,3
High School	58	9,4
Pre-School	35	5,5
Special Education	23	3,6
Primary-Secondary Education	18	2,8
Informal Education	11	1,7
Total	**631**	**100**

Education level were clearly identified in 377 out of 631 publications in the research (Table 6). When the education level associated with the studies were examined, "University" led with 320 publications (50,7%). AR applications developed with regard to integrated surgical operations for medical students, efficient use of AR technologies in the classroom by candidate teachers, scenario-based learning etc. all featured. "Primary School" followed university with 101 publications (16,0%) including the use of tablet PC technologies in education with AR technologies for primary school students, environmental education and field trips with AR technologies, language skills development based on AR technologies, and educational multimedia content. Primary school is followed by Secondary School studies including Creative Lesson Education with AR, digital content production with AR, application of AR technologies in the natural sciences, etc. Also, the other remarkable point in the table was that "Informal Education" led to a substantial number of publications. An evaluation of informal science education with AR, ballet training with AR integrated expression and integration, use of AR applications on animal phobia etc. are included in the research studies linked to informal education. Primary school is followed by "High school", "Pre-school", "Special Education", and "both Primary and Secondary school" publications. Design development with a fast prototype based on AR technologies for deaf students, AR-supported video based story book design work in order to assess the facial clues of children on the Autism spectrum; magical toys developed with AR technologies for early childhood education in special education, colorful book design with Disney characters by using AR and 3D modelling etc. are remarkable examples of research relating to Preschool Education.

Table 7. Distribution of studies in the field of Augmented Reality Applications and Research by sample groups

Sample Groups	f	%
University Students	181	31,8
Primary School Students	128	22,5
Secondary School Students	110	19,3
High School Students	60	13,0
Index, database and magazines (content analysis sample groups)	52	9,1
Tourists	4	0,7
Consumers	4	0,7
Classroom Teachers	3	0,5
Patients	2	0,3
Special Education Students	2	0,3
Special Education Teachers	1	0,1
Pre-school teachers, students and parents	1	0,1
Pre-school teachers and students	1	0,1
Pre-school students	1	0,1
Pre-school students and parents	1	0,1
Secondary school teacher and students	1	0,1
Secondary school student and parents	1	0,1
High school teacher and students	1	0,1
Primary school teachers and students	1	0,1
Primary school student and parents	1	0,1
Primary and secondary school teachers and students	1	0,1
Instructors	1	0,1
Dentists	1	0,1
Nurses and technicians	1	0,1
Experts	1	0,1
Driver candidates	1	0,1
Women	1	0,1
Elderly humans	1	0,1
Total	**568**	**100**

The sampling groups in 568 of the 1008 publications in total were identified as seen in Table 7. Publications are mostly Design and Development studies. When the ranges in terms of the samples used in the studies in the Augmented Reality Applications Research area were examined, “University Students” were used in 181 publications (31,8%). “Primary School” students were used in 128 publications (22,5%) and follow University students in order of importance. “Secondary School” students and “High School” students are placed in the table. Another remarkable point in the table is the variety of sampling groups. The generality of AR Applications research was revealed by such diverse sampling groups as “Dentists”, “Nurse and Technicians”, “Drivers” and “Elderly People”. It appears that there is a common tendency when Table 7 and Table 8 are crossed. When the distribution of the augmented reality applications according to education levels is examined, it is seen that the results are favorable to the "universities"; the distributions of the augmented reality applications according to sample groups were examined, it was seen that the results were in favor of the "university students". New multimedia technologies are offering opportunities

for engaging learning experiences in higher education. One such immersive technology, rich with potential for enhancing the classroom, is augmented reality (AR); "the use of augmented reality (AR) in formal education could prove a key component in future learning environments that are rich populated with a blend of hardware and software applications".

Table 8. Distribution of studies in the field of Augmented Reality Applications and Research by sample numbers

Sample Numbers	f	%
1-29	157	25,8
30-59	126	22,2
60-89	85	19,3
90-119	63	14,0
160-200	62	7,3
200 and more	40	7,0
120-159	35	4,4
Total	568	100

When the sampling numbers in the AR Applications Research area were examined, it can be seen that the most commonly found numbers ranged between "1 and 29". This issue was related to the intense use of "Experimental Models" when the range was examined according to the methods of the studies in the Augmented Reality Applications Research area.

Table 9. Distribution of studies in the field of Augmented Reality Applications and Research by data collection tools

Data Collection Tools	f		%
Survey	154		27,1
Interview	123		21,6
Pretest-posttest	81		14,7
Survey-Interview	52		9,1
Observation	48		8,4
Achievement test	34		5,9
Document analysis	31		5,4
Focus group interview	24		4,2
Scale	21		3,6
Total	**568**		**100**

In terms of data collection tools, it can be seen that the most common approach was revealed to be "Survey", "Interview" and "Pretest and Posttest" follows "Scale" (Table 9). The frequency of the experimental model in especially publications was considered, it increased the use of pretest-posttest data collection tools. The reason for the frequent use of scales in the published research is because it is assumed that it allows the calculation of total variance over the total points of an item. In addition, another remarkable point is that "Observation", "Interview" and "Document analysis" are data collection methods that are associated with Qualitative studies and have all

been included in the research. "Success Test" and "Focus Group" are the other data collection tools.

Table 10. Distribution of studies in the field of Augmented Reality Applications and Research by data bibliographic numbers

Bibliographic Numbers	**f**	**%**
26-50	351	34,8
1-25	287	28,4
51-75	175	17,3
76-100	143	14,1
100 and more	52	5,1
Total	**1008**	**100**

The range in terms of the number of references in the Augmented Reality Applications Research area was examined. It was revealed that the most common was "26-50" in 351 publications (41%). Also, the existence of "1-25" references is also remarkable. In addition, "100 and more" references were encountered in 52 publications (Table 10).

Table 11. Distribution of studies in the field of Augmented Reality Applications and Research by analysis technique

Analysis Technique	**f**	**%**
Average-Standard Deviation	81	14,2
Descriptive Analysis	77	12,0
T-test	56	9,8
Frequencies/Percentages	45	7,9
Content Analysis	35	6,1
Nonparametric Tests	35	6,1
Others (Post hoc tests, Kappa coefficient etc.)	34	5,9
ANOVA	32	5,6
MANOVA	25	4,4
ANCOVA	24	4,4
AFA and DFA	24	4,4
Pearson Correlation	23	4,3
Cronbach alpha	22	4,3
Qualitative Data Analysis	22	4,3
Factor Analysis	11	2,1
MANCOVA	11	2,1
Predictive Analysis	11	2,1
Total	**568**	**100**

The analysis techniques involving the use of "Average/Standard Deviation" in the AR applications research area were examined (Table 11). This analytical technique was used in 81 publications (14,2%). "Descriptive Analysis" followed Average/Standard Deviation. "t-test", "Frequency-percentage-scale" and "Content Analysis" followed descriptive analysis. Literature compilation studies were predicted to increase the use of content analysis frequency. According to the table use case of

"Nonparametric Tests", the analysis indicated that Mann-Whitney U, Kruskal-Wallis, Wilcoxon and chi squared tests were performed as part of nonparametric testing. Other analysis techniques were used in 34 publications (5,9%). Post hoc tests, Kappa coefficient, content validity rate, content validity index, Kolmogorov-Smirnov Test, Kurtosis Test and Cohen's d are among the other analysis techniques used. Other analysis techniques are "ANOVA, "MANOVA" and "ANCOVA". It is considered that scale development and scale adaptation studies increased the use of EFA and CFA in this regard.

Table 12. Distribution of studies in the field of Augmented Reality Applications and Research by purpose of research

Purpose of Research	f	%
Design, development and evaluation of AR applications in education	78	7,7
Mobile applications with AR technology	77	7,6
Use of 3D objects with AR /3D Modeling	77	7,6
Surgery with AR / use of simulation systems in integrated medicine	69	6,8
AR Applications in higher education	68	6,7
Science teaching with AR technology (cooperative-interrogation and scenario-based learning)	60	5,9
Games based learning / mobile educational games with augmented reality technologies	58	5,7
New trends in engineering and architecture with AR technologies	55	5,4
Development of simulation systems with AR technologies	55	5,4
Use of AR technologies in tourism / protection of cultural and touristic heritage	50	4,9
Literature search in AR system and applications	43	4,2
Robotic applications with AR / Human computer interaction	41	4,0
Development of navigation systems with AR applications	39	3,8
Use of AR technologies in teaching mathematics and geometry	38	3,7
Use of AR technologies in history teaching	37	3,6
Creating multimedia content with AR	31	3,0
AR technologies-based language teaching	30	2,7
Use of AR technologies in medical applications	22	2,1
Transfer of virtual objects to real situations with AR applications	21	2,0
Integration of AR technologies into special education (free AR application for deaf and disabled autistic students)	20	1,9
Civil defense/logistical support with AR technologies	9	0,8
Aerospace education with AR technologies	7	0,6
Museum application with AR technologies	5	0,4
Treatment of psychological disorders with AR technologies	4	0,3
Use of AR technologies in dentistry	3	0,2
Anatomy training with AR technologies	3	0,2
Field and case studies in the field of AR systems and applications	3	0,2
Creative drama education with AR technologies	1	0,1
Ballet training with AR technologies	1	0,1
Theater education with AR technologies	1	0,1
Elderly care	1	0,1
Food separation techniques	1	0,1
AR scale development studies	1	0,1
Total	**1008**	**100**

According to Table 12, when the range of aims of the studies in the AR applications research area was examined, it was seen that there is a large variety when it comes to structure. It was revealed that 78 publications making up 7,7% of the total dealt with "Design, development and evaluation of AR applications in Education". "AR technologies with mobile applications" followed. It is clear from Table 5 that there is a wide variety of structures according to research areas of the studies in the area of AR applications research and that AR applications are wide ranging, ranging from Educational Technologies to Engineering Sciences and from Mobile Applications to Visual Arts Education. The results are compared with Table 5; this finding supports the variety of research aims and revealed in the analysis in fields as diverse as science, medical applications, aviation training, civil defense, logistics support, psychological disorder treatment, theatre education and elderly care.

Table 13. Distribution of studies in the field of Augmented Reality Applications and Research by research trends

Research Trends	f	%
Academic achievement	142	34,2
Attitude	132	32,8
Teacher candidates' opinions	78	7,2
Technology acceptance	62	6,3
Motivation	52	5,0
Student experiences	45	4,3
Student behavior	33	3,1
Teacher opinions	24	2,2
Teacher perceptions	21	1,9
Opinions of teaching staff	13	1,1
Parental Opinions	11	0,9
Patient Opinions	5	0,3
Consistency measurement of behavior	4	0,2
Diffusion	4	0,2
Success, attitude	4	0,2
Learning achievements, real world opinions, attitude	1	0,1
Total	**631**	**100**

According to Table 13, when the range of research tendencies in the AR applications research area were examined, the emphasis on "academic success" has frequently attracted attention. "Attitude", "Opinions of Candidate Teachers", "Technological Acceptance" and "Motivation" followed academic success. The remaining research tendencies showed some variation; the variety of the research tendencies as revealed in the analysis were "student behaviors", "academician views", "dissemination", "learning success" and "harmony behaviors".

4 Conclusion

The trends in terms of AR applications research throughout the world were examined using13 criteria: index, year of publication, number of authors, country of research, area of research, method, education grade, sample group, sample number, data collection method, bibliography number, analysis techniques, purpose of research and research trends. The most important result of research is that almost all areas, from Education Technologies to Engineering Science, Mobile Applications to Visual Arts Education, are included. When the literature is examined, this result is supported by many studies. The educational levels of augmented reality applications are examined; there is a variety of structures from pre-school to university. Apart from these educational levels, augmented reality practices are also used in areas such as special education early childhood education. Rapid development and changes in information technologies, increase in usage of mobile devices, decrease in cost are thought to be factors affecting this result. In addition to this, in this study, different from other studies; the "research trends" criterion was mentioned. The purpose of adding this criterion is to indicate the trends in the area and this structure is important for researchers. Researchers who see deficiencies in the area they will be able to make efforts to eliminate these deficiencies.

5 Recommendations

The method related to "design and development work" appears in a significant part of the research. At this point the studies involving research and development (R&D), and those projects that support researchers in terms of providing them with more information about these methods could be provided to reveal the need for an upgrade of the importance of “qualitative” and “mixed” methods for the studies to be executed by trends. Samples could be selected randomly and objectively with particular attention being paid to the form of sample selection. The reliability of the research can be supported by using more samples. The statistical methods that have been used could be varied for the purposes of analyzing the data. For this purpose, the scope of courses in scientific research methods at a graduate level should be enriched.

6 Statements on Open Data, Ethics and Conflict of Interest

No empirical data were collected from individuals or groups during the development of this conceptual paper. As a result, data cannot be accessed and there were no ethical issues related to the selection and treatment of subjects associated with this paper. The authors had no conflicts of interest during the development and publication of the study.

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