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A Meta-Analytic and Thematic Comparative Analysis of the Integration of Augmented Reality Applications into Education

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Abstract

The aim of this study is to determine the efficiency of Augmented Reality Applications (ARAs) in the learning environment. In this regard, both quantitative (meta analytic) and qualitative (thematic) dimensions are used in the study. In terms of meta-analysis, the data of 12 studies from different databases of national and international arenas in which the effect size of ARAs on academic success was determined were analyzed through CMA and MetaWin programs. Data on thematic dimension were obtained from the teacher candidates at Kilis 7 Aralık University, Faculty of Muallim Rıfat, Department of Science Teaching chosen by a maximum variation sampling method through a semi-structured interview form. The views from the interview were resolved in accordance with the content analysis method and the action research design through Maxqda 11 program. Meta-analytic results showed that the effect of ARAs on academic success was found to be as ES= +0.360 which is a small level. On the other hand, thematic assessment shows that ARAs has a positive effect on social, cognitive and emotional improvement and it makes the learning environment more realistic. In line with the relating results, well-designed ARAs can be proposed to be used in a more common and systematic way in order to create fruitful environments that increase academic success.

Keywords

Augmented reality applications
Learning environment
Meta-analysis
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Introduction

Developments in information technologies provide us with easier lives by taking place more and more, day by day in various areas of our lives. In addition to technological developments, the increase in demand for mobile applications as a result of the widespread use of computers, tablet computers and mobile devices there has also been an increase in both the number and enrichment of the applications being developed. One of the reflections of this situation in the educational field is the "augmented reality" that has become more popular in recent years. Augmented reality is an up-to-date technology that uncovers coded rich multimedia content by adding a digital layer on the objects created by a camera. In brief, it provides the simultaneous interaction of real and digital objects. (Abdüsselam & Karal, 2012; Azuma, 1997; Billinghurst, 2002; Çınar & Akgün, 2015; Uluyol & Eryılmaz, 2014). Thanks to this technology, one can see, hear, or even touch and smell much more than the others who do not

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use the related technology. Also, this technology has begun to come out of laboratories and enter into the industrial and consumer market (Van Krevelen & Poelman, 2010).

As one of the most striking technological developments, augmented reality stated by Azuma (1997), includes the scenes that have three features. On these scenes, *i)* the real and the virtual take place together; *ii)* the images are real-time and interactive; *iii)* and scenes are perceived in three dimensions. The tools of augmented reality have been used in advertisements, marketing, engineering, architecture, construction, amusement, health care and the military field up to day. (Azuma, 1997; Barfield, 2015; Hansen, Wieferich, Ritter, Rieder, & Petigen, 2010; Feiner, 2002; Karatay, 2015; Küçük, Kapakin, & Göktaş, 2015; Sayımer & Küçüksaraç, 2015; Uğur & Ceylan, 2014; Koşan, 2014). However; with the increase in utilization of mobile devices, (desktop and laptop computers, portable devices, smart phones, etc.) the use of augmented reality in the educational field has also started (Billinghurst, 2002; Johnson, Smith, Levine, & Hywood, 2010; Uluyol & Eryılmaz, 2014).

Upon analysis of the studies in literature, in many studies it is reported that the use of AR applications with digital content and utilizing technology at its utmost in the educational field has positively affected the learning process (Kaufmann, 2004; Lee, 2012). ARAs provide many benefits such as the reduction of costs in learning environments, directing the educational studies, facilitating the learning process, providing a new learning environment different from traditional ones, developing social interactions and supporting the research-oriented learning environment (Kerawalla, Luckin, Seljeflot, & Woolard, 2006; Küçük, Yılmaz, & Göktaş, 2014; Özarslan, 2011; Singhal, Bagga, Goyal, & Saxena, 2012; Wojciechowski & Cellary, 2013). AR applications have especially been stated as providing more efficient learning environments for students with low success rates (Cai, Wang, & Chiang, 2014). Additionally, in Abdüsselam and Karal (2012), it is observed that in traditional class environments, students have shorter periods of attention while the use of an augmented reality environment increases this period of attention thanks to the device's being highly technological, materializing abstract concepts for the students and for providing easier comprehension.

Augmented reality environments became widespread in 2000s and the MagicBook project was created, which was regarded as the first application in formal education institutions. This project includes book, building and structure pictures provided for the use of the students. When the marker on the related page is detected, three-dimensional virtual objects designed by the designer can be seen on this marker via the student's tool. In this way, the students have the opportunity of seeing the cases thanks to the modeled shapes, in a real environment that they could not perceive via sense organs. Thus, it is aimed to draw the attention of the students by creating a difference in the books (Billinghurst, 2002). It is found that the use of educational magical toys during pre-school education increases effectiveness, cooperation and interaction among the students (Yılmaz, 2016).

In the literature, it is seen that ARAs have found areas of use in classes such as astronomy, chemistry, biology, mathematics, geometry, and physics. Accordingly, students can examine the solar system, earth and sun with the help of 3-dimensional objects created in astronomy classes; they can understand the movements of molecules and atoms visually in chemistry and science classes and in biology classes, they can observe the human body and organs in 3 dimensions as if they were real. In the same manner, the use of a three dimensional view of the shapes in mathematics and geometry classes enables them to be more understandable, and in physics classes this enables the kinematical features to be foreseen depending on the user reaction, in virtual environments prepared dynamically out of laboratory (Lee, 2012). In terms of astronomy, current augmented reality applications have been developed in order to teach subjects such as rotation/cycle, solstice/equinox, seasonal change of temperature and light in sun and earth relation more effectively (Shelton & Hedley, 2002).

In our country, starting from 2005, the attention to augmented reality has increased in the engineering, architecture and communication fields and after 2012, various studies have been conducted in the educational field. In physics, the MagAR device and software have been produced to analyze magnetic fields. In this study, by designing an augmented reality environment through transferring the virtual objects to real situations for the purpose of teaching "magnetism", it is reported that the use of this environment positively affect the students' success. Moreover, it was also suggested to develop augmented reality environments for other subjects hard to understand and visualize (Abdüsselam, 2014; Abdüsselam & Karal, 2012). In one of the studies conducted across the country, ARGE3D software is developed for geometric shapes in the geometry field. An interactive 3D geometry book has been developed and used as an experimental study. As a result, the ARGE 3D geometry book has become effective for teaching challenging geometry subjects (İbili & Şahin, 2013). Moreover, by targeting the "At the fair" unit in the 6th grade English class curriculum, a hybrid class book has been designed supported by texts, visuals and augmented reality to view the content in an enriched visual and auditory way (Çınar & Akgün, 2015). It is reported that the applications concerned reacted in a positive way.

In the study by Huang, Chen, and Chou (2016), including research on ecological productiveness in a botanic garden, with the participation of 21 secondary school students, a learning environment was created by requesting the experiment groups to reflect ARAs in the learning environment while the control group was requested to note down what they observe. According to the results of this study, it was observed that the use of technological applications (ARAs) in educational environments have provided not only more learning about the environment but also increased their readiness and positive cognitive development. In line with all of these studies, it is considered that ARAs technologies will become one of the most important components in the future of formal education systems thanks to its main features such as materializing abstract information, accurate construction of information that is hard to understand, developing cognitive thinking skills, providing learning by doing and meaningful learning, increasing the readiness of the students towards affective and technological practices and increasing the success levels when compared to the traditional methods (Dunleavy, Dede, & Mitchell, 2009; Freitas & Campos, 2008). So as to determine the positive effects of ARs on learning, studies regarding AR are reviewed through meta-analysis with a view to obtain more comprehensive research results. In addition, a thematic aspect is also added to the paper in order to get remarkable research results.

The Aim and Importance of the Research

It can be seen that ARA (Augmented Reality Application), consisting of a device converting a booklet including pointer, information on pointer to the digital data and a screen showing the digital data as 3B or 2B, and offering to student an opportunity to learn by living and doing by offering possibility to examine objects in these aspects, is carrying out more effective and permanent learning as a result of international literature review (Chen & Tsai, 2012; Dunleavy et al., 2009; Walczak, Wojciechowski, & Cellary, 2006; Wojciechowski & Cellary, 2013; Yen, Tsai, & Wu, 2013). Even in comparative studies performed among traditional class applications with ARAs, it is revealed that ARA increases learning by a considerable level (Freitas & Campos, 2008; Kerawalla et al., 2006). Thusly, it is revealed in national (Akçayır, Akçayır, Pektaş, & Ocak, 2016; Aktamış & Arıcı, 2013; İbili, 2013; Korucu, Gençtürk, & Sezer, 2016; Küçük, 2015; Ersoy, Duman, & Öncü, 2016) and international studies (Chen & Tsai, 2012; Freitas & Campos, 2008; Hsiao, Chen, & Huang, 2012; Ibanez, Serio, Villaran, & Kloos, 2014; Kerawalla et al., 2006; Sommerauer & Müller 2014), that augmented reality technology helps to teach more deeply by providing sights of objects from different aspects in subjects which are difficult to learn by drawing the interest and attention of students in comparison with the traditional class environment and increases their success. For this reason, using augmented reality technologies in science teaching is considered as important in terms of education and as studies conducted with two dimension (meta-analytic and thematic) are not encountered much in literature it is decided to conduct the present study. It is considered that obtaining results will bring in extensive and overall opinion; two dimensional studies will draw attention in literature and encourage researchers to carry out studies by using such multiple methods. In this context, the main purpose of the study is to discover the effects of using ARAs on the teaching environment. In line with this basis it is aimed to:

1. Determine the effect size of ARAs on academic success.
2. Determine overall opinions of teacher candidates related to the integration of ARAs applied in science lessons with education.
3. Determine the effectiveness of ARAs' contributions to the teaching environment in social, cognitive and effective dimensions.
4. Actualize the sub-purposes in forms of determining negative aspects to be encountered in the learning environment related to ARAs.

Method

In this study, quantitative and qualitative methods are used together in order to determine the effectiveness of ARAs on the learning environment. The study includes a methodological process of a combination of both quantitative and qualitative methods. For the quantitative dimension of the study, meta-analysis methods providing the determination of the effect size of ARAs on academic success was utilized. Meta-analysis is defined as a statistical technique used for the compounding of findings of studies which had been conducted before and related to similar subjects in order to attain a general conclusion (Glass, 1976; Patrick & Diehr, 1994). Thus in a meta-analytic review considered as the analysis of analyses, the purpose is to reach a common and combined effect size (Borenstein, Hedges, & Rothstein, 2007).With this purpose, scanning is carried out with Turkish and English keywords in forms of "arttırılmış gerçeklik ve eğitim", "augmented reality and education" in search engines of Council of Higher Education Dissertation Centre, Google Scholar, Ebscohost, ScienceDirect and Web of Science. As a result of this search, it was found that 12 studies were available in which especially pretest-protest are applied among 19 thesis and 384 articles. When these studies are chosen, inclusion criteria are considered in forms of examining academic success; the sample size belongs to the experiment and control group to provide the calculation of effect size (n), arithmetic average (x) and includes data to calculate the value of standard deviation (sd). In this context, population is formed by scientific studies performed in national and international fields in matters of ARAs. The study sample is formed by studies chosen according to inclusion criteria from theses and articles regarding ARAs. In the study, any sample method is not applied because all of the relevant sources regarding ARAs are tried to be reached. By carrying out analysis of meta-analytic data with CMA and MetaWin programs, the effect size is created according to the level classification of Cohen (1992). Analysis is interpreted by random effect model (REM) and the confidence level of the study is calculated by formulation [consensus / (consensus + dissensus) x 100] of confidence calculation among evaluations (Miles & Huberman, 1994) and the result is found to be 100%.

The qualitative (thematic) dimension is added to the study as a subsidiary and complementary element for meta-analytic dimension. Data obtained concerning thematic aspects were solved in compliance with content analysis. Content analysis offers a more understandable product to the reader by combining similar ones among data collected for study under themes and codes (Yıldırım & Şimşek, 2008). The pattern of study is defined as action research. Action research is an approach which includes the collection and analysis of systematic data related to understanding and solving a problem already occurring or an occurrence of problems related to an application process (Yıldırım & Şimşek, 2008). In this context, in the 2015-2016 educational year, teacher candidates in the department of Science Teaching of Muallim Rıfat Faculty of Education of Kilis 7 Aralık University are preferred. 44 people taking 3rd class "Science Teaching Laboratory Application 2" lesson (37 women, 7 men) and 49 people taking 4th class "Astronomy" lessons in the same department (43 women, 6 men) among teacher candidates are preferred as a study group. This step is carried out using the Single Group Test Model which constitutes the application of an independent and the measurement of the effect on the dependent variable (Karasar, 2012). The subjects of "teaching elements" at 3rd class and "introducing planets" at the 4th class are taught with ARA. Each application lasts 3 weeks. In this study, opinions regarding the effectiveness of ARA are applied after a three-week application. For this, opinions of 27 students (3x9=27) are applied in each class class at the level of good-middle-weak according to maximum diversity among 3rd and 4th class teaching candidates determined in a single group test model. Opinions regarding augmented reality are gathered in a semi-structured interview form applied as a protest. On the other hand, pretest is not used because teacher candidates are meeting with ARA for the first time.

When qualitative findings are offered, direct quotes are made in text from opinions by coding teacher candidates in the form of S4-056 (4th class-last three digits of student number). Opinions obtained in semi-structured interview form were analyzed by means of the Maxqda 11 program. It ensures that themes and codes provide integrity with consistency and meaningfulness between each other for consistency in finding pursuant to transactions conducted for providing legitimacy and reliability of qualitative dimension of study. Data obtained for reliability of study are directly offered without applying any interpretation. Besides, when making data analysis, consistence values (Cohen Kappa) are calculated in order to find consistence between data coders. It is defined in the form of "consistence at good level" if the ranges of adaptive values are in the range of .61-.80 and "consistence at very good level" if they are in the range of .81-1.00 (Viera & Garrett, 2005). In the current study, the adaptive value interval is between .720 and .881 and it is found as adaptation at "good/very good level" (Appendix-1).

Findings and Comments

In this section, findings obtained within the framework of meta-analytic and thematic dimensions in detailed examination performed regarding effectiveness of ARAs in the learning environment, are interpreted separately. In this context, meta-analysis data of 12 studies obtained in scans performed regarding ARAs can be seen in Table 1.

Table 1. Homogeneous Distribution Values in Effect Models Concerning Academic Success Score of the Studies included in Meta-Analysis, Average Effect Size and Confidence Intervals

Model Type	n	Z	p	Q	df	ES	SE	95% Confidence Interval	
								Lower Limit	Upper Limit
FEM	12	3.355	0.001	89.196	11	0.219	0.065	0.091	0.347
REM	12	1.861	0.063	15.065	11	0.360	0.193	-0.019	0.739

General effect size value is seen as +0.360 in Table 1. Q statistical value shows that distribution of effect size of studies is in quite a heterogeneous structure (Q=89.160, df=11,). In other words, change of effect size in analysis are bigger than expected than a change that occurred due to sample error. For this reason, calculations are made according to REM (Borenstein, Hedges, Higgins & Rothstein, 2009; Dersimonian & Laird, 1986; Lipsey & Wilson, 2001). According to Cohen (1992), this value takes part on a small level. On the other hand, a relevant confidence interval is reflected in Figure 1 by looking at confidence of meta-analysis size of study with Normal Quantile Plot.

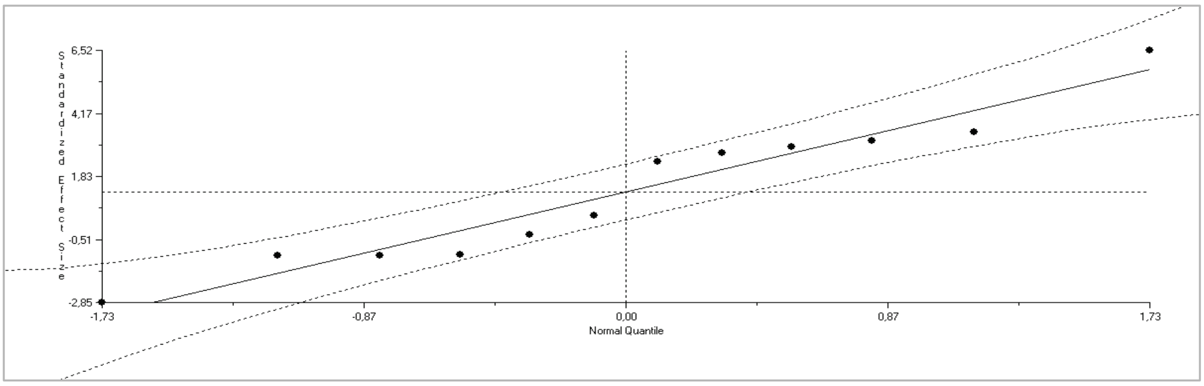

Figure 1. Normal Quantile Plot

It is indicated that the distribution stated by points in Figure 1 is between lines and it is in a confidence interval so that there is a relation among studies in terms of statistics. In addition, in meta-analysis studies, including only published studies (which have significant difference) in the analysis causes publication bias. With the intent of abolishing this idea, it is necessary to analyze this idea until the effect size produces zero (Rosenthal, 1979). The number calculated by the MetaWin program is fail safe number (N_{FS}). The value of N_{FS} calculated considering the effect of ARAs on academic success is 72.6. When a certain number of studies are involved in the analysis the effect of ARAs on academic success as a result of meta-analysis, this number decreases to 0.001. In this context, 12 more studies are included in the analysis, it is obvious that the number of 72 for studies is a high number for accessibility and owing to that it can be said that the achieved analysis results are reliable.

As complementary to the meta-analytic dimension of the study and conducting thematic analysis additionally, candidate teachers of the Department Science Teaching, Muallim Rıfat Faculty of Education, Kilis 7 Aralık University are asked about teaching "Spatial Bodies" subject with ARAs. At this point, opinions obtained through interview forms are presented as models by being coded under different themes.

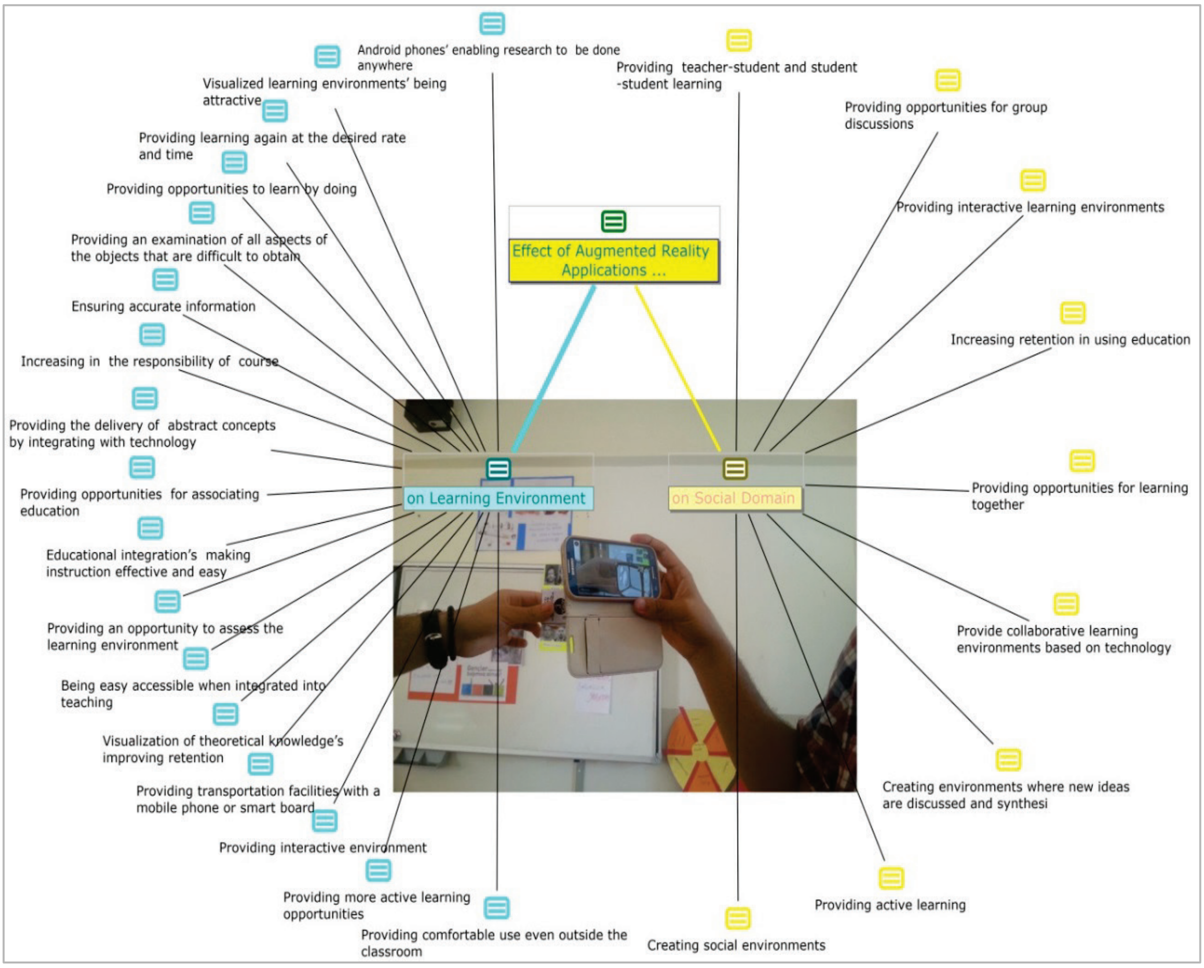

Figure 2. The effect of ARAs on Learning Environment and Social Domain

In figure 2, codes regarding learning environment and social dimension themes of ARAs are evaluated in two categories. The visual embedded inside the model is one of the photographs taken during application and reflects the ease of application usage and reality dimension. When the figure is examined in detail, such codes are mentioned as follows: “Being easily accessible when integrated into teaching”, “Visualized learning environments being attractive", "Providing an examination of all aspects of the objects that are difficult to obtain", “Visualization of theoretical knowledge’s improving retention" are mentioned and these codes are formed by taking source into account these quoted sentences: "*4D applications have contributions such as offering environments of permanence, joyful lessons, living that moment, feeling, easy-reachable, learning by doing and living* (C4-054)"; "*… provides environments based on visuality so more understandable, clear and net situations are formed* (C4-037)"; "*we catch a chance to see in practical what we know theoretical in daily life…* (C4-011)" and "*…it is absolutely more reliable. In experiments performed in the real environment, there are no worrisome factors in applications such as explosion, poisoning and burning* (C4-045)".

In model 2, it is seen that the effect of ARAs on social dimensions with codes in the form of "Providing opportunities for learning together", "Providing teacher-student and student-student learning", "Presenting interactive learning environment". These codes are formed based on directly quoted sentences of "*4D applications provide to establish an collaboration with everybody by creating social environments* (C4-041)"; "*teaching a lesson with these applications were integrated, is important in terms of developing collaborative learning between teacher-student and student-student* (C3-007)".

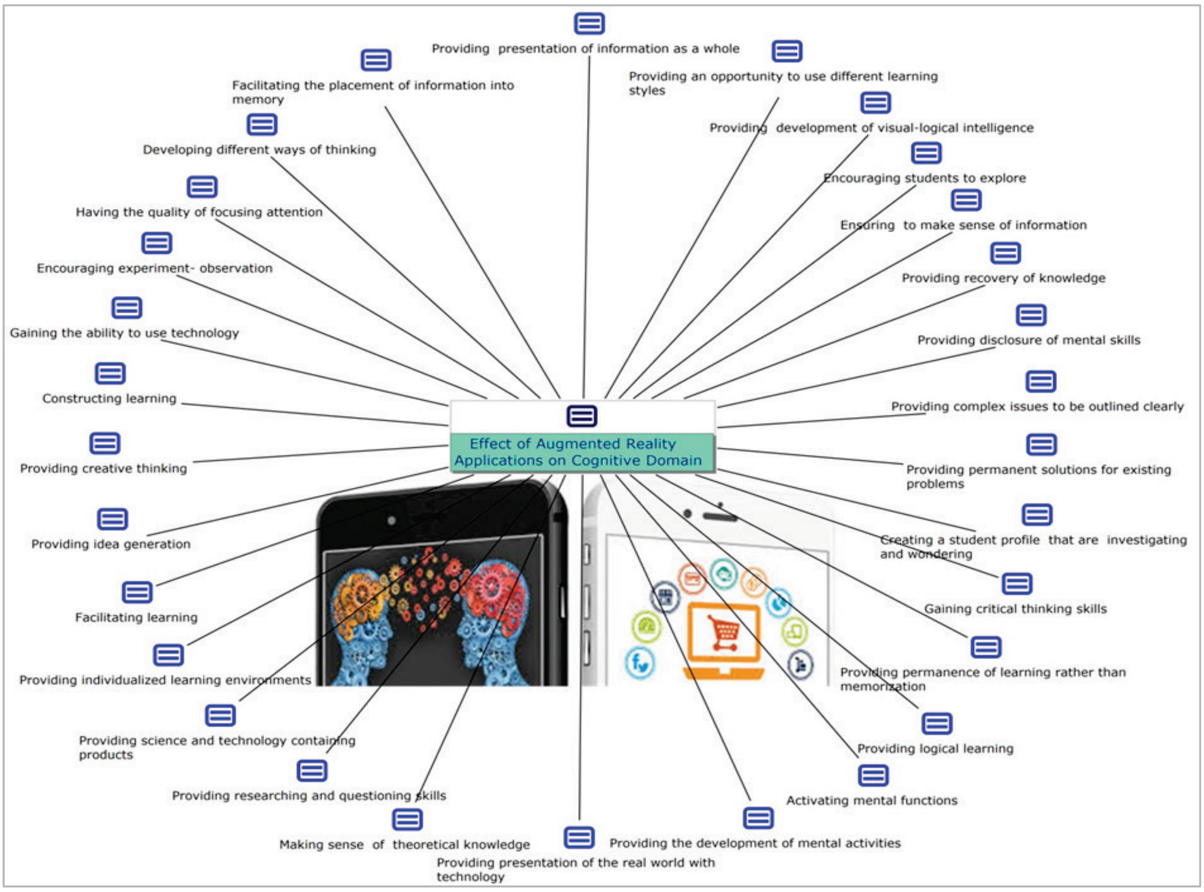

Figure 3. The effect of ARAs on the Cognitive Domain

Effectiveness of ARAs on the cognitive dimension is specified with the following themes: "Providing the development of mental activities", "Providing science and technology containing products", " Enabling creative thinking", Providing presentation of information as a whole" and " Providing complex issues to be outlined clearly". And some of the quotes which are thought to be a resource for these themes according to the students' opinions: "*...I believe students will make lots of contributions in cognitive, affective and social aspects... I think students will tend towards questioning research more.* (C3-002)"; "As it is going to be at a further point than the examinations that the students perform in its integration with education, it allows mental skills of the students to be developed, it lets the students stretch their imagination and it enables various mental activities to be experienced densely…(C3-008)"; "*With the integration of technology within education, the student gets close to the science and technology as if he/she were in the environment displayed. It delivers different scientific products* (C4-052)".

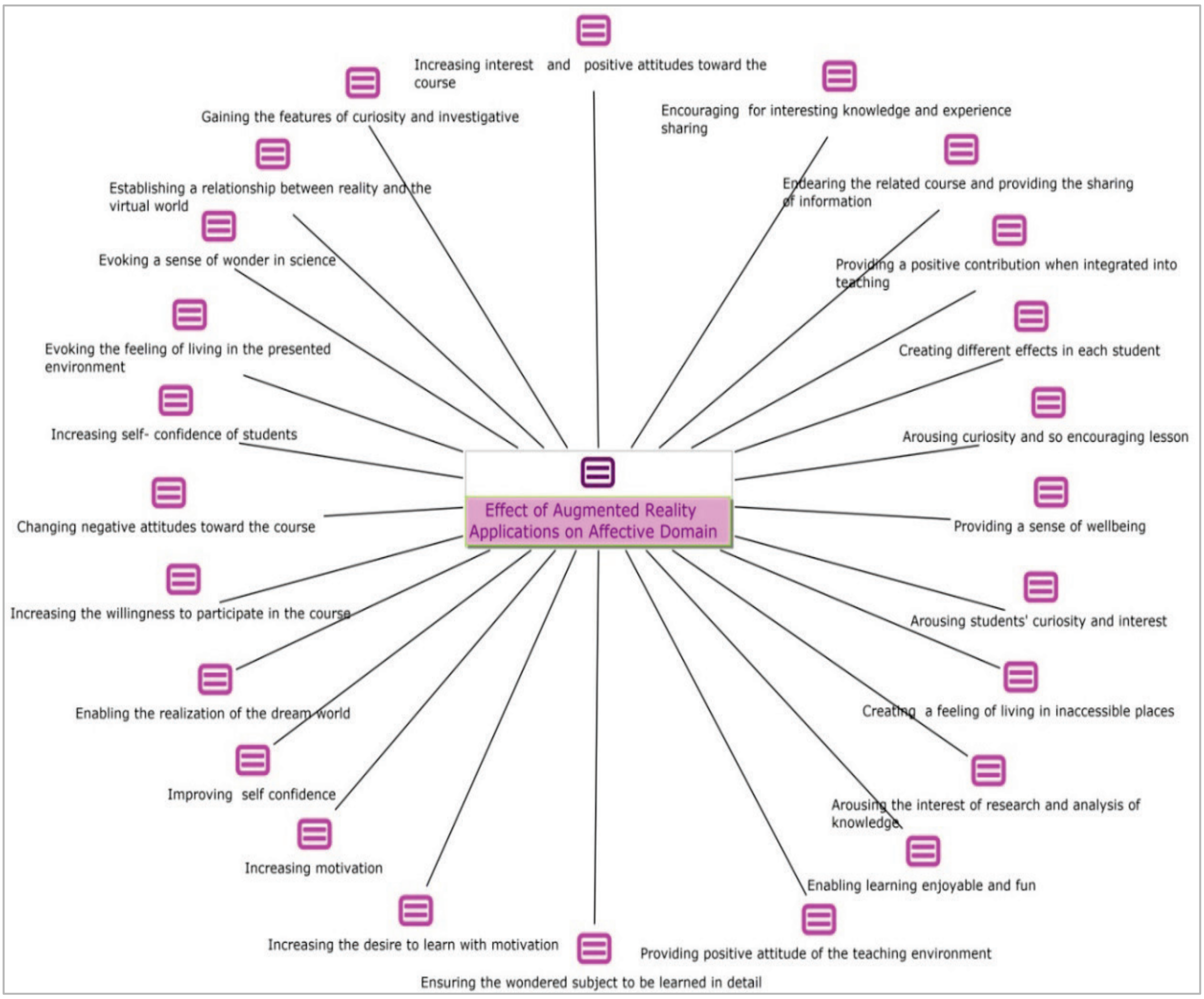

Figure 4. The effect of ARAs on Affective Domain

Themes that are specified about ARAs having significant effects on affective dimensions can be seen in Figure 4. Some of the remarkable statements of these themes are as follows: "Arousing students' curiosity and interest ", "Increasing motivation", " Creating a feeling of living in inaccessible places" and " Changing negative attitudes toward the course", which have expressed that ARAs affect learning positively by addressing the students sensually. Also, some of the quotes which are the point of origin of these themes can be expressed as reflecting the students' ideas directly like: "*It offers learning by doing-practicing by integrating ARAs into education*...(C3-007)"; "…*When it is integrated, lessons become more enjoyable, easier and more fun; moreover, they become more understandable*...(C4-052)"; "… *4D applications create a sense of reality when giving the lesson. It turns the subject from abstractness into concreteness*. (C3-028)"; "*The applications eliminate the negative ideas of the students against the lessons.* (C3-019)".

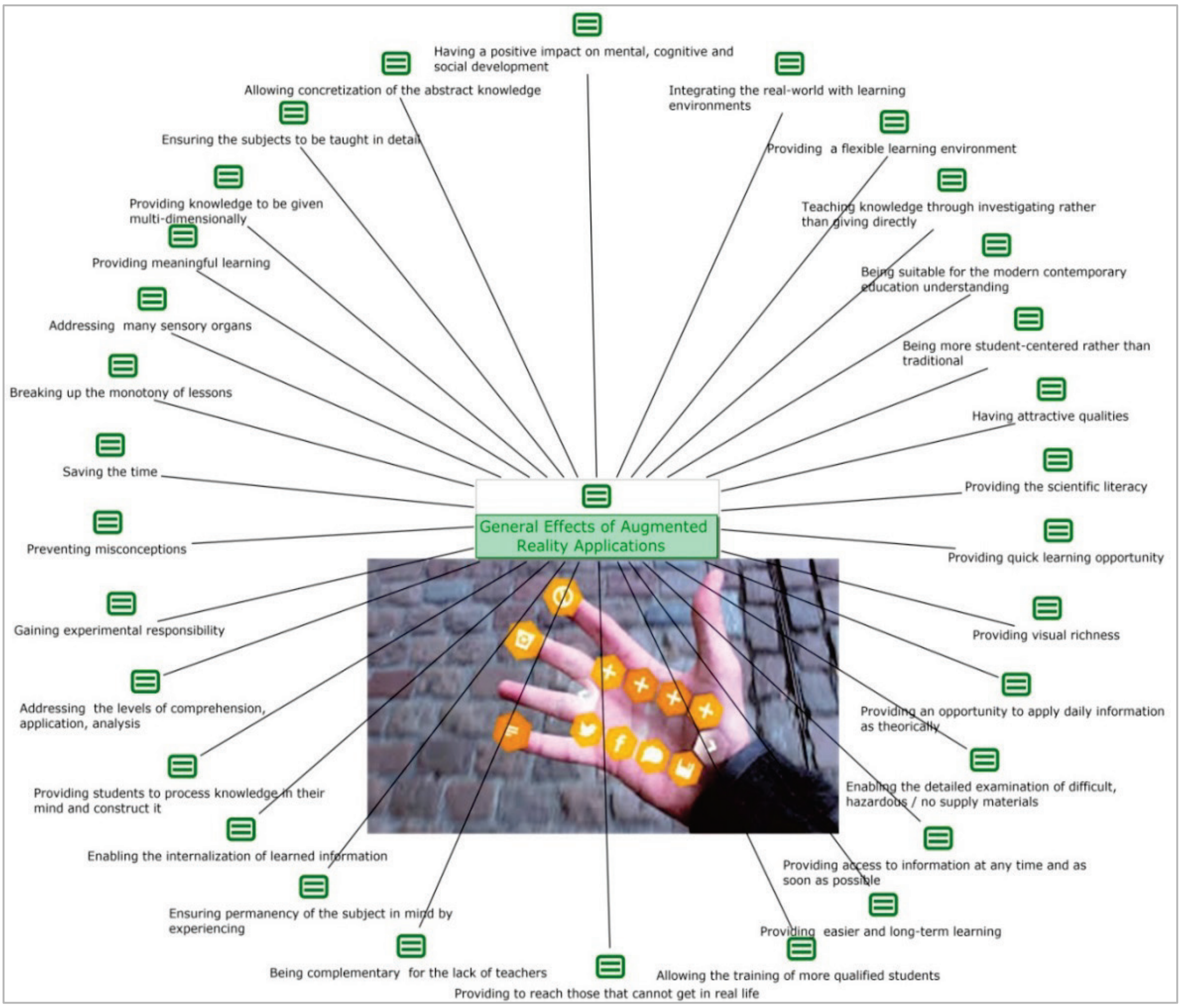

Figure 5. General Effects of ARAs

In Figure 5, it is seen that some themes are reached such as "Allowing concretization of abstract knowledge", "Addressing many sensory organs", "Saving the time", " Providing knowledge to be given multi-dimensionally" and "Addressing the levels of comprehension, application, analysis and synthesis". Some of the statements quoted from these themes have been expressed as comprehensive and extensive statements regarding ARAs, such as: "*…thanks to these applications that are integrated into education, the information learned can be implemented in comprehension, implementation, analyses and synthesis phases. Abstract information which is made visual some to a concrete state and it becomes understandable…* (C4-011)"; "*…In the embodiment of abstract concepts, it creates some sort of a simulation environment in astronomy, physics, geography and chemistry lessons…* (C3-007)"; "*Not only one sense organ is used; many sense organs are used, which enables permanent learning…* (C4-019)" and "*this application provides an opportunity for economic, useful and practical lessons …* (C4-046)".

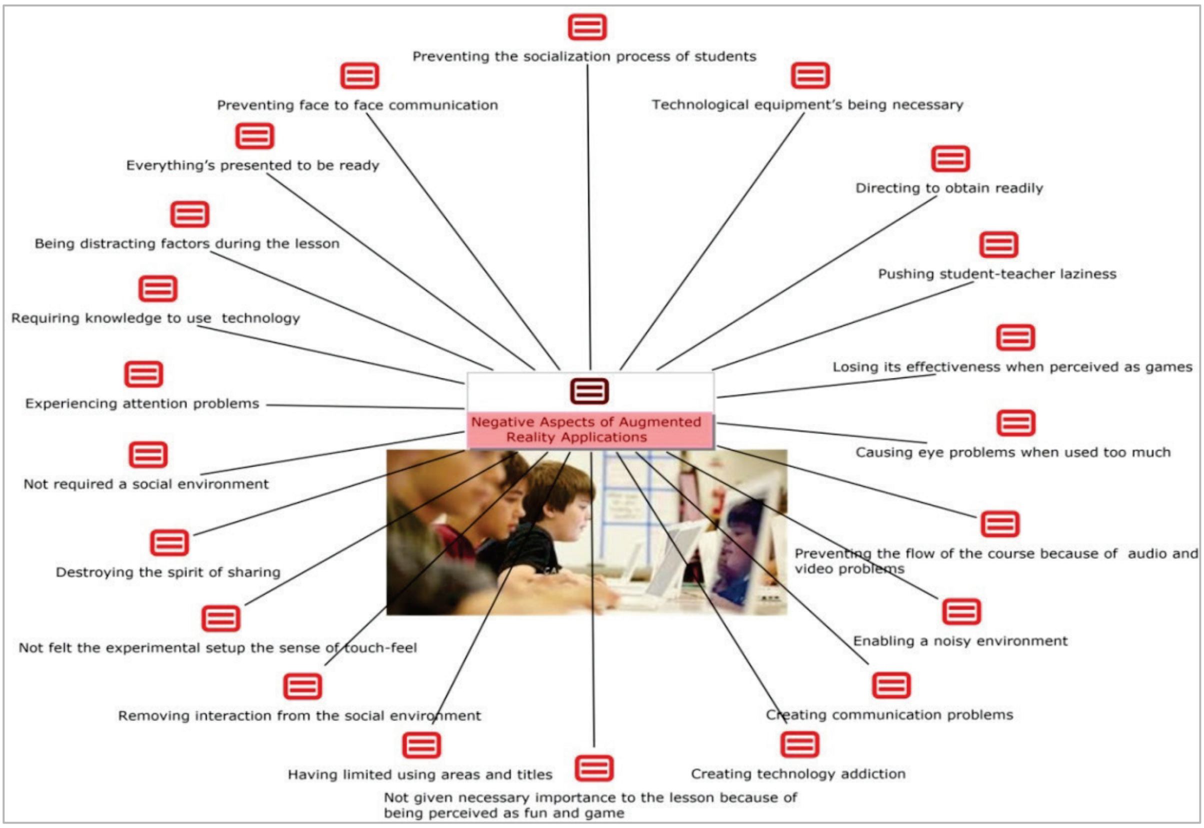

Figure 6. Negative Aspects of ARAs

In the last model, there are codes considering the negative aspects of ARAs as well as positive ones referred to above. The most striking ones can be stated as "Creating communication problems", "Causing eye problems when used too much", " Not feeling the experimental setup with the sense of touch-feel", "Technological equipment's being necessary" has been identified like this. The quoted passage of the related codes can be expressed as "*I don't think it offers very significant contributions from the social aspect. I believe that it may reduce the communication between people. Just as it happened in internet use (C4-012)*"; "*…being too intertwined with the technology may increase eye problems (C3-028)*"; "*… negative aspect of it is a student's realizing that it happens in a virtual platform rather than holding something with his/her hands and feel and live that atmosphere (C4-021)*" can be expressed. These expressions emphasize that the related application has different negative sides.

Conclusion and Discussion

The results discovered by meta-analytical and thematic assessment as regards ARAs which are explained as offering virtual objects created by computer technology instead of the real objects (Sugano, Kato, & Tachibana, 2003) were discussed in this part. Firstly, meta-analytical data of 12 studies have been examined and as a result of the analysis according to REM, the influence the effect size of these studies' academic success scores have been found at a positive, meaningful but low level with the value as ES=0.360 according to Cohen (1992). This means that ARAs do not have a large influence on the academic success of the students. On the other hand, it is understood that the study is in a reliable scale on the Normal Quantile Plot chart and the analytic results in publication bias calculation is also found to be reliable (N_{FS}=72.6).

Findings of the thematic analysis in which the aim is to have a complementary point to meta-analysis results have been evaluated within the themes determined as the the effects of ARA's different aspects. In terms of learning environment, ARAs have been recorded to integrate the real world with the learning environment and to visualize abstract and complicated situations through digital objects. It has been stated that experts have developed ARAs in order to find solutions in troubleshooting especially the problems seen in some students who have problems in understanding and comprehending the abstract objects (Shelton & Hedley, 2002). In this way, by reaching students at any level, it is understood that it contributes significantly to eliminating the concept errors, solving learning difficulties and perceiving complicated situations. ARAs, which is one of the innovations brought to the learning environment by the self-renewing and developing technology as required by the current information age (Korucu et al., 2016), has lately made its presence prominently felt in all fields especially in education, health, sports, etc. Although studies on ARAs started forty years ago (Duenser, Grasset, & Billinghurst, 2008; Swan & Gabbard, 2005), this application can easily reach large audiences with the widespread use of mobile technology and it is seen that studies regarding this subject have increased recently.

Another point of view that stands out in the current study is that ARAs provide positive contributions at the cognitive level such as enabling logical learning, creating opportunities for making experiment-observation, making sense of theoretical knowledge and enabling development of visual intelligence. Additionally, increasing the motivation by arousing interest and curiosity in the students has been put forward as another advantage of the application. In this context, in the study conducted nationally by Uluyol and Eryılmaz (2014), views regarding ARAs received by the teacher candidates have been found to be in furtherance of the research in favor of these applications' increasing motivation. Moreover, it is understood from the findings that ARAs has changed negative attitudes towards the lessons and caused them to endear the lessons. Studies supporting these findings and discovering the positive effects of ARA on the attitude have not been encountered in literature (Küçük et al., 2014; Wei & Elias, 2011). In the research, it has been emphasized that there are some negative aspects of ARA other than the aforementioned contributions. Some of these negative aspects are that technological applications can stand in the way of the communication between the students, may cause eye problems and require technological hardware. It has been understood that the lack of technological knowledge causes some students to have a negative opinion of the use of these applications. It is also seen in the studies carried out in the related literature that similar conclusions have been drawn (Klopfer & Squire, 2008).

When the research results are evaluated in a general context, the findings related to ARA should be considered in a way that it has had positive effects on the social, cognitive, affective development of the students; made the learning environment realistic and thus affected academic success positively by providing convenience in learning. A well designed ARA which can affect the students positively in attitude: social, affective and cognitive aspects can be advised to be used for creating a productive environment which will increase their success. Especially for the researchers, ,t is recommended to carry out experimental studies on ARA in the future as technology and mobile applications are keeping on developing.

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Appendix 1. Studies Included in Meta-Analysis

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Appendix 2. Agreement Values of Themes related to ARAs

Figure 2. The effect of ARAs on Learning Environment

		K2		
		+	-	Σ
K1	+	17	3	20
	-	2	14	16
	Σ	19	17	36

Kappa:.720 p:.000

Figure 2. The effect of ARAs on Social Domain

		K2		
		+	-	Σ
K1	+	9	0	9
	-	1	7	8
	Σ	10	7	17

Kappa: .881 p:.000

Figure 2. The effect of ARAs on Learning Environment and Social Domain

		K2		
		+	-	Σ
K1	+	26	3	29
	-	3	21	24
	Σ	29	24	53

Kappa: .772 p:.000

Figure 3. The effect of ARAs on Cognitive Domain

		K2		
		+	-	Σ
K1	+	29	2	31
	-	3	19	22
	Σ	32	21	53

Kappa:.804 p:.000

Figure 4. The effect of ARAs on Affective Domain

		K2		
		+	-	Σ
K1	+	24	1	25
	-	2	15	17
	Σ	26	16	42

Kappa: .850 p:.000

Figure 5. General Effects of ARAs

		K2		
		+	-	Σ
K1	+	30	3	33
	-	4	22	26
	Σ	34	25	59

Kappa: .758 p:.000

Figure 6. Negative Aspects of ARAs

		K2		
		+	-	Σ
K1	+	21	1	22
	-	2	17	19
	Σ	23	18	41

Kappa: .852 p:.000