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A case study: what attracts teachers to augmented reality

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This study aimed to identify the reasons why teachers are interested in augmented reality (AR) technology. AR is a technology that allows simultaneous enrichment of real-world images with virtual objects. AR is used at all levels of education from preschool to graduate school. The teachers who liked the Facebook page were sent the online survey via a message. 205 teachers who responded voluntarily to the questionnaire constituted the study group. Criterion sampling method, which is a purposeful sampling method, was used in the research. Case study design which is one of the qualitative research methods was used in this research. To ensure the reliability of the study, the coding process was conducted by the first researcher and another domain expert, and the codes were cross-checked. The results of the study showed that the reasons teachers are interested in AR were classified under three themes: educational benefit (teaching more effective lessons, attracting students' attention to lessons, enriching the content of the course, facilitating easier understanding of subjects, ensuring more permanent learning, making lessons more fun were attractive for teachers), professional development (follow current educational technologies, develop specialized course materials, share what they know with other teachers, use this information with other subjects) and personal development (learning new things, benefit from academic studies, prepare projects).

Introduction

Teachers and researchers seek new techniques, methods, and tools to attract students and improve learning. Among these tools, the augmented reality (AR) (Wang, Callaghan, Bernhardt, White, & Peña-Rios, 2018) attracts attention with its exciting features. AR is a technology that allows simultaneous enrichment of real-world images with virtual objects (Azuma, 1997, 1999). In AR, instant images of the real environment are used as a backdrop and the virtual objects that are added simultaneously on the ground increase the reality **(**Akçayır & Akçayır, 2017). In short, AR can be defined as a technology where virtual objects

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(text, sound, graphics, video, animation, 3D model, etc.) are combined with real-world images using simultaneous interaction (Alsadoon & Alhussain, 2018; Chien, Su, Wu, & Huang, 2019; Ke & Hsu, 2015). In other words, users can see additional information provided by AR in addition to what they normally see where they look. For example, when we look at the road from the screen of the phone, we can give the information of the shops on the street being displayed. Because it contains virtual objects, AR can be confused with the concept of virtual reality. In some definitions, AR is considered as a derivative of virtual reality (Azuma, 1997), but it has significant advantages over virtual reality. While the user is fully involved in a virtual world in virtual reality, AR allows the user to perceive the real world by using virtual objects (Bower, Howe, McCredie, Robinson, & Grover, 2014). In this way, it is ensured that reality is enriched with virtual objects while users are prevented from abstracting from reality. In other words, users can access information that they would not normally perceive with AR (Delello, 2014; Wang et al., 2018). Hincapie, Diaz, Valencia, Contero and Güemes-Castorena, (2021) define AR as changing the perceptual reality by adding digital layers to the reality of users.

Although AR is a technology that is often heard in recent years, it is a technology that has been studied for many years. It can be argued that the requirement for expensive and heavy equipment that needed to be mounted on the back and the head to be able to work in prior years when it was first used hindered the spread of AR. Today, however, it is easy to use and develop AR applications in personal computers and portable devices. Especially the advances in mobile technologies has led to the transformation of AR into a technology used in all areas of life (Wu, Lee, Chang, & Liang, 2013). With its features, AR is a preferred technology in many different sectors such as military, marketing, advertising, medicine and automotive. AR allows customers to try products before they buy them. This is transforming marketing and advertising. AR is mostly used for training purposes in the military. It provides training in combat and other dangerous situations without the risk of death or injury. It has significant advantages for education and treatments in medicine. With the widespread use of mobile devices, AR is now used in educational environments as well (Alsadoon & Alhussain, 2018; Hincapie et al., 2021). Especially in the last decade, it can be argued that the use of AR in education is a very popular topic (Akçayır & Akçayır, 2017; Bacca, Baldiris, Fabregat, Graf, & Kinshuk, 2014; Ibáñez & Delgado-Kloos, 2018; Sırakaya & Alsancak Sırakaya, 2018). AR is a technology used at all levels of education from preschool to graduate school (Akçayır & Akçayır, 2017; Sırakaya & Alsancak Sırakaya, 2018; Wang et al., 2018). The results of studies conducted in the education of different subjects using AR (Figure 1) demonstrated that the use of AR in education provides many advantages (Table 1).

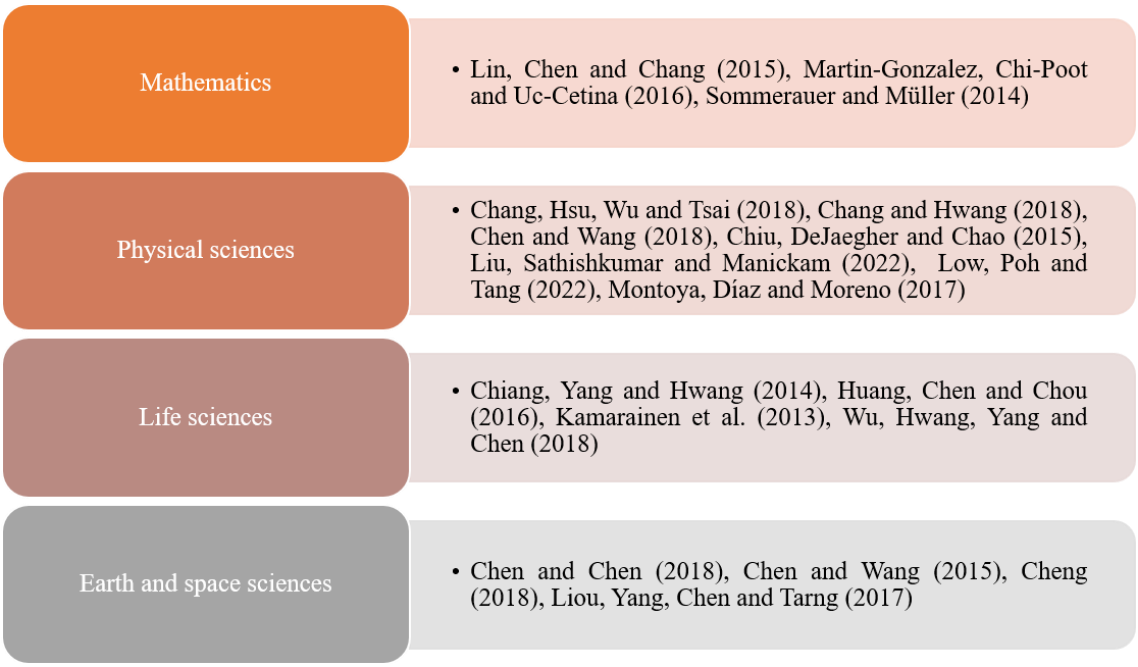

Figure 1. The AR Studies Conducted in Different Subjects

Table 1. Advantages of AR

Advantages of AR	References
Facilitating learning	Cai, Chiang, Sun, Lin and Lee (2017), Chen, Chou and Huang (2016), Cuendet, Bonnard, Do-Lenh and Dillenbourg (2013), Kao and Ruan (2022), Montoya et al. (2017)
Enhancing learning motivation	Chang and Hwang (2018), Chen and Chen (2018), Cheng (2018), Javornik, Marder Barhorst, McLean, Rogers, Marshall and Warlop (2022), Kao and Ruan (2022), Muliyati, Bakri, and Ambarwulan, (2019), Low et al., (2022)
Enhancing spatial ability	Bujak et al. (2013), Cuendet et al., (2013), Ferrer-Torregrosa, Torralba, Jimenez, Garcia and Barcia (2014), Krüger, Palzer and Bodemer (2022), Lin et al. (2015), Wojciechowski and Cellary (2013)
Enhancing attention	Cai et al. (2017), Chen et al. (2016), Huang et al. (2016)
Enriching interaction	Bujak et al. (2013), Cheng (2018), Kao and Ruan (2022), Wojciechowski and Cellary (2013)
Providing collaboration	Bressler and Bodzin (2013), Chang and Hwang (2018), Kao and Ruan (2022)
Enhancing engagement	Chang et al. (2018), Kamarainen et al. (2013), Liu et al., (2022), Wojciechowski and Cellary (2013)

In addition to these advantages, AR also supports learning approaches. AR is a tool that can be used in learning approaches such as constructivist learning (Chen & Wang, 2018; Delello, 2014), situated learning (Dunleavy, Dede, & Mitchell, 2009; Rasimah, Ahmad, & Zaman, 2011), game-based learning (Dunleavy et al., 2009; Tian, Endo, Urata, Mouri, & Yasuda, 2014), and inquiry-based learning (Delello, 2014; Kaufmann & Schmalstieg, 2003).

Importance of the Study and Research Questions

Considering all these features, it can be argued that AR has the potential to transform education (Bower et al., 2014) by affecting traditional learning and teaching processes (Billinghurst & Duenser, 2012). However, teachers, as implementors, have an important role

in achieving the expected impact. Teachers' views, expectations, requests, etc. on the use of AR in education should be identified. However, the studies conducted before mostly focused on the pedagogical effects of AR and the learner outputs and not many studies have been conducted with teachers. In one of these limited number of studies carried out with teachers, Timur and Özdemir (2018) aimed to determine the opinions of 8 science teachers on the use of AR in science education. Teachers in the study emphasized that AR can be effective in providing lasting and meaningful learning. Delello's (2014) study, which aimed to determine pre-service teachers' views on the use of AR in education, found that teacher candidates think AR increases motivation, engagement, teacher enthusiasm and community of practice. Ulusoy and Eryilmaz (2015) concluded that pre-service teachers regarded augmented reality as interesting, entertaining, and motivational. Again, in their work with pre-service teachers, Muñoz-Cristóbal et al. (2014) and Ke and Hsu (2015), emphasized that AR provides important opportunities in pedagogy education. In some studies, teachers' opinions were sought along with student experiences. At the end of the study conducted with 33 preschool students and 30 teachers, Yilmaz (2016) concluded that teachers like AR and have a positive attitude towards it. In their study with 71 secondary school students and 3 teachers, Kamarainen et al. (2013) reported that in teachers' opinion, AR increases interaction and provides deeper learning. As a result of the interviews conducted with 30 students and 2 teachers, Huang, Li and Fong (2016) stated that teachers regard AR to be fun and that they believe AR offers important opportunities to increase students' self-confidence.

Interest in AR is constantly increasing to create effective learning experiences (Wang et al., 2018). However, it is seen that the number of studies with teachers on the use of AR in education is insufficient. In addition, most of the studies that were previously conducted focused on pre-service teachers (Delello, 2014; Ke & Hsu, 2015; Muñoz-Cristóbal et al., 2014; Ulusoy & Eryilmaz, 2015) or centered on student opinions (Huang, Li & Fong, 2016; Kamarainen et al., 2013; Yilmaz, 2016). This research, which aimed to determine directly why teachers have an interest in AR use in education, is expected to contribute to fill the gap in the literature. In line with this objective, answers to the following research questions were sought:

(1) Why are teachers interested in AR?
(2) Why do teachers want to develop AR-supported instructional materials?

Methodology

Research Design

This research, it is aimed to determine reasons why teachers are interested in AR use in education and want to develop AR-supported instructional materials. Therefore, case study design which is one of the qualitative research methods was used in this research. Creswell and Poth (2017) define case study as a research approach in which the researcher examines one or more situations in depth with data collection tools. In case studies, the factors related to the situation are handled with a holistic approach and the focus is on how these factors affect the situation or how they are affected from the situation at hand (Cohen, Manion, & Morrison, 2005). Thus, researchers can obtain detailed information about the situation and create themes and sub-themes that make up the situation (Creswell & Poth, 2017). With case study, reasons, why teachers are interested in AR use, will be revealed in depth.

Study group and data collection

Criterion sampling method, which is a purposeful sampling method, was used in the research. While determining the sample in purposeful sampling method, situations which are thought to have rich background knowledge are selected in order to investigate the topic in depth (Fraenkel & Wallen, 2006). In the criterion sampling method, the situations that meet previously determined criteria are investigated (Fraenkel & Wallen, 2006). The following criteria were taken into consideration in the sample selection for this research:

- Being a teacher,
- Having an interest in the use of AR in education,
- Be willing to develop AR-supported teaching materials.

In order to access the study group, the researcher created a Facebook page in social media about the educational use of AR and posted relevant materials to ensure teachers liked the page. Content that will attract the attention of teachers interested in AR was shared on the Facebook page, enabling teachers to access and follow the page. The teachers who liked the Facebook page were sent the online survey via a Facebook message. The message provided information about the research. No personal contact was made with the teachers, as the message was sent on behalf of the Facebook page. 205 teachers who responded voluntarily to the questionnaire constituted the study group. Demographic characteristics of the study group are provided below (Table 2).

Table 2. Demographic characteristics of the study group

Variable	Level	Frequency	Percentages
Gender	Female	108	52,7
	Male	97	47,3
Age	Younger than 26	26	12,7
	Between 26-30	54	26,3
	Between 31-35	71	34,6
	Between 36-40	35	17,1
	Over 45	19	9,3
Level of education	Undergraduate	141	68,8
	Master's	60	29,3
	PhD	4	2,0
Teaching experience	1-3 years	48	23,4
	4-6 years	31	15,1
	7-10 years	51	24,9
	11-15 years	50	24,4
	16 years and more	25	12,2
Subject matter	Elementary school teacher	49	23,9
	Science	84	41,0
	Mathematics	17	8,3
	ICT	18	8,8
	Turkish	11	5,4
	Social sciences	7	3,4
	Other	19	9,3

Research data were collected by an online questionnaire composed of 2 open-ended questions developed by the researcher. The questionnaire consisted of easy-to-understand questions that would be used to determine why teachers were interested in AR and why they wanted to develop AR-supported instructional materials. Open-ended questions were only accessible to the participants who met the criteria determined in the sample selection. The questionnaire,

which was prepared by using similar studies (Delello, 2014; Yilmaz, 2016) in the literature, was finalized by making necessary revisions in line with the opinion of two experts.

Data analysis

The inductive approach proposed by Miles and Huberman (1994) was used in the analysis of the data collected with open-ended questions. Accordingly, a 3-stage process was carried out. The first stage included "data reduction", the second stage "data display" and the final stage included "conclusion drawing or verification". At the stage of data reduction, the first researcher read opinions of teachers and eliminated those that were out of context of the research. At this stage, 12 teachers who gave incomplete or inconsistent answers to online survey questions were excluded from sample. At the stage data display, researchers performed the coding process separately. Sub-themes were revealed by calculating obtained codes. And then, the process of revealing the themes from the sub-themes was carried out. The themes that emerged during conclusion drawing or verification stage were examined and discussed.

Data were analyzed by content analysis method. In content analysis, the data similar to each other are brought together around specific sub-themes and themes and interpreted in a way that the reader can understand (Cohen et al., 2005). In content analysis, a list of codes was prepared by examining the answers of the participants and sub-themes and themes were generated by combining similar codes (Miles & Huberman, 1994).

Validity and reliability

To ensure the reliability of the study, the coding process was conducted by the first researcher and another domain expert (analyst/researcher triangulation) and the codes were cross-checked (Patton, 1999). Agreement was reached since coding reliability in the themes was above 80% (first theme 0.91 second theme 0.89 third theme 0.90) in calculations (Miles & Huberman, 1994; Patton, 1999). The following formula is used in this calculation: $\Delta = C \div (C + \partial) \times 100$. In the formula, Δ : reliability coefficient, C : number of codes on which consensus is reached, ∂: number of codes on which there is no consensus. The responses of the participants were directly quoted, as proposed by Creswell and Poth (2017) in order to support the emerging themes, provide credibility and improve validity.

Results and discussion

When the data collected from 205 teachers were analyzed by content analysis method, it was seen that the opinions of teachers could be classified under 3 themes: educational benefit, professional development, and personal development. Professional development and personal development themes emerged in the second research question, while educational benefit theme emerged in the first research question.

Educational benefit

Teachers' interest in AR to provide educational benefit was collected under 6 sub themes. Data on these sub-themes and sample teacher opinions are given in Table 3.

Table 3. Educational benefit

Sub theme	f	%	Sample teacher opinions
Teaching courses more effectively	61	41,2	Teacher 173: "…I would like to learn more about AR, which is one of the newest applications of today's education technology, and teach science more effectively…" Teacher 42: "…I'm looking for different ways to make my lessons more effective. I think AR will shed light on me at this point."
Attracting student interest	26	17,6	Teacher 182: "…For a while I have been looking for activities and applications that will increase the motivation of my students and the efficiency of our courses. I think AR applications will be remarkable for students." Teacher 130: "I want to learn AR to make the math lessons more engaging…"
Enriching the course content	24	16,2	Teacher 12: "…I want to enrich the learning experiences of my students with AR." Teacher 23: "I would like to learn AR to offer my students an enriched classroom environment."
Providing easier understanding of subjects (learning via concretization)	15	10,1	Teacher 198: "…To facilitate learning by embodying abstract concepts with AR in mathematics." Teacher 46: "With AR, I aim to teach abstract concepts that students have difficulty learning."
Providing permanent learning	14	9,5	Teacher 117: "…AR is one of the most effective methods for permanent learning..." Teacher 78: "…To provide permanent of lessons by using AR..."
Making courses fun	8	5,4	Teacher 11: "I am interested in AR for my lessons to be more fun."

Teachers stated that they were mostly interested in AR in order to teach courses more effectively. This may be due to the fact that there are posts on the Facebook page that will attract the attention of teachers who are interested in AR. Studies show that AR increases student motivation, participation in class and cooperation. Similarly, Huang et al. (2016) and Kamarainen et al. (2013) state that use of AR provides students with a deeper understanding of the subject. These advantages of AR can play a role in more effective teaching during courses. According to the results of the research, teachers are interested in AR in order to attract the interest of the students and enrich the content of the course. As a matter of fact, studies (Cai et al., 2017; Chen & Chen, 2018; Chen et al., 2016; Huang et al., 2016) show that the use of AR has a positive effect on attracting students' interest. Teachers are interested in AR technology in order to enable students to learn more easily and to ensure more permanent learning. Wang et al. (2018) defines AR as the best visualization tool that can be used with graphics and 3D models. With the course materials developed with AR, students get the opportunity to examine objects from all angles and different locations (Shelton & Hedley, 2002; Shelton & Stevens, 2004). In this way, students learn more easily (Cai et al., 2017; C.-H. Chen et al., 2016; Montoya et al., 2017) by concretizing abstract concepts that they have difficulty visualizing (Küçük, Kapakin, & Göktaş, 2016; Laine, Nygren, Dirin, & Suk, 2016). Similarly, Zhang, Sung, Hou and Chang (2014) and Perez-Lopez and Contero (2013) conclude that AR provides more permanent learning outcomes. Some teachers stated that AR would make courses more fun as the reason for their interest in AR. It is noteworthy that a teacher reports that students learn better when they have fun and that AR facilitates learning by having fun by providing students with a variety of experiences. As a matter of fact, many studies have concluded that AR provides learning by having fun (Chen et al., 2016; Gun & Atasoy, 2017).

Professional development

Teachers' interest in AR for professional development were classified under 5 sub themes. The data related to these sub-themes and the sample teacher opinions are given in Table 4.

Table 4. Professional development

Sub theme	f	%	Sample teacher opinions
Being a more qualified teacher	53	44,5	Teacher 167: "I think it will be useful for my professional development. AR is a concept that will be used frequently in education in the future."
Following current educational technologies	26	21,8	Teacher 176: "I like to follow the new technologies and use them in my courses." Teacher 149: "…To follow current technologies."
Being able to develop specific course materials	19	16,0	Teacher 48: "I want to learn AR to be able to prepare teaching materials related to my branch."
Sharing with other teachers	15	12,6	Teacher 41: "I think AR will be an important concept in the future. I want to tell about AR to all teachers in my school." Teacher 73: "…I want to learn using AR to share with other colleagues."
Using with other topics previously learned (e.g. STEM, coding training)	6	5,0	Teacher 120: "…I think it can be used in STEM education. Therefore, I want to have knowledge and experience about AR."

A large number of teachers stated that they were interested in AR in order to become more qualified teachers. In addition, it is understood that teachers were interested in AR to follow current education technologies, to develop specific course materials, to share what they know with other teachers and to use what they together with other subjects. AR has visualization features that allows the use of subjects that cannot be normally applied in the classroom (Kerawalla, Luckin, Seljeflot, & Woolard, 2006; Shelton & Hedley, 2002; Wojciechowski & Cellary, 2013; Wu et al., 2013) and provides the opportunity to conduct dangerous experiments (Wojciechowski & Cellary, 2013; Yang, Mei, & Yue, 2018) in the classroom environment. By adding virtual objects simultaneously on real images, teachers can prepare specific course materials. As a matter of fact, Delello (2014) states that AR increases teacher enthusiasm. With its characteristic properties, AR technology can contribute to the professional development of teachers.

Personal development

Teachers' interest in AR for personal development was categorized under 3 sub themes. Data on these themes and sample teacher opinions are given in Table 5.

Table 5. Personal Development

Sub theme	f	%	Sample teacher opinions
Contributing to personal development by learning new things	47	53,5	Teacher 116: "…I want to gain new skills…" Teacher 139: "I see AR as a new experience to improve myself."
Using the knowledge in academic studies	20	27,0	Teacher 153: "I am interested in AR because I want to study AR in my master's thesis." Teacher 152: "I plan to study AR in my master's thesis."
Using the knowledge in preparing projects	7	9,5	Teacher 72: "I want to learn AR to use when preparing the project."

Teachers are interested in AR to contribute to their personal development by learning new things, to benefit from academic studies and to prepare projects. While some teachers stated that they wanted to work on AR technology in their graduate studies, some of them reported that they wanted to learn AR to prepare projects.

Teachers' interest in AR for educational benefit, professional development and personal development are given with tree map chart in Figure 2. A tree map chart provides a hierarchical view of data. The rectangles represent branches of the tree.

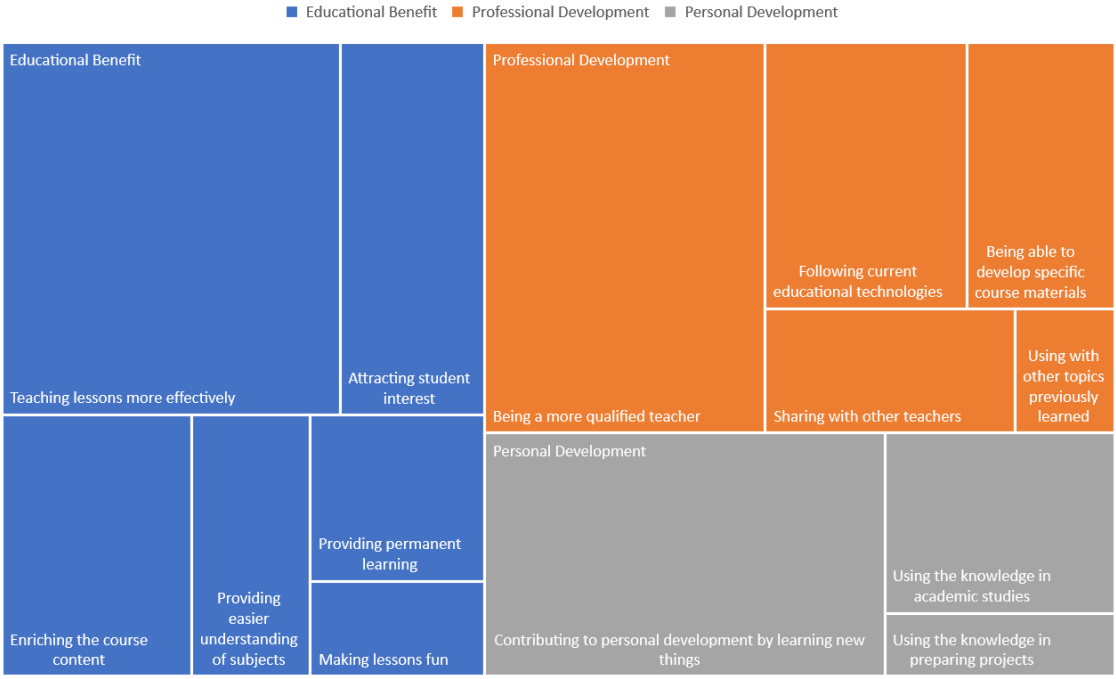

Figure 2. Treemap Chart of Teachers' Interests in AR

Figure 2 is a summary of the results obtained. The tree map chart lists the importance of themes as follows: educational benefit, professional development, and personal development. It is noteworthy that "teaching courses more effectively" sub theme has an important place in educational benefit theme. This is supported by previous studies (Huang et al., 2016; Kamarainen et al, 2013). In professional development theme, it is understood that teachers are most interested in AR for "being a more qualified teacher". The fact that AR enables unique learning experiences can have an impact in this case. By using AR, teaching of subjects that cannot be taught in the classroom can be facilitated. It is understood that almost half of personal development theme consists of sub theme "contributing to personal development by learning new things".

Conclusion

This study set out to determine the reasons why teachers were interested in AR technology. Data obtained from the online answers to the questionnaire with 2 open-ended questions by 205 teachers were analyzed by content analysis. The results show that teachers were interested in AR for educational benefits, professional development and personal development.

Results of the study demonstrated that the educational benefits of AR were the most important

reason for teachers' interest in AR. The educational benefits such as teaching more effective courses, attracting students' attention to courses, enriching the content of the course, facilitating easier understanding of subjects (learning by concretization), ensuring more permanent learning and making courses more fun were attractive for teachers. These findings can also be interpreted as teachers' awareness of the educational potential of AR. Future studies can move beyond awareness and examine teachers' attitudes towards AR, their readiness levels and competencies.

Based on their professional development, teachers were found to be interested in AR in order to become more qualified teachers, to follow current educational technologies, to develop specialized course materials, to share what they know with other teachers and to use this information with other subjects. It is noteworthy that teachers were interested in AR in order to become better equipped and distinguished teachers and to improve themselves professionally. Future studies can investigate in depth the contribution of AR to teacher development. Also, it was noteworthy that AR was considered by teachers as one of the most up-to-date educational technologies and could be used as a tool to develop specific course materials. One teacher emphasized the importance of using AR in education and stated that all teachers should learn AR. However, the integration of AR into education is not limited to teachers. Other stakeholders, infrastructure, curricula, administrators, and parents should also be considered. In future studies, models that examine how to successfully integrate AR into educational environments can be emphasized.

As a result of the research, it was understood that teachers were also interested in AR in order to contribute to their personal development. It is a remarkable finding that AR was considered as an important quality of personal development by teachers. The fact that teachers doing graduate work indicated that they wanted to study AR in their theses is an important finding. Future studies can examine n depth what AR means to teachers. For this, studies can be carried out with teachers who have received AR training or have AR experience.

Limitations of the study

The findings of this study show that AR is educationally valuable and attracts the attention of teachers. However, research is limited in several respects. The number of participants is limited to 205 who were accessed via be social media. This limitation complicates the generalization of findings. Another limitation is that the data in this study were based on the statements of teachers. The data are limited to teacher responses to open-ended questions which indicate that they are interested in AR. In addition, this research is limited in terms of the AR experiences of the participating teachers. It should be noted that participants' AR experiences and opportunities to use AR may differ from each other.

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