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Augmented Reality Application-based Teaching Material's Effect on Viscera Learning Through Algorithmic Thinking

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ABSTRACT The study aimed to examine AR-based teaching material's effect on viscera learning through algorithmic thinking by the primary school teacher candidates who are sophomores in the classroom teaching department in the spring term of the 2018-2019 academic year at a state university in the Eastern Black Sea and selected by convenience method. Viscera Information Form (VIF) and Application Process and AR Survey Form (APSF) were used as data collection tools in the study. VIF included subjects viscera in a human model and placed them in the skeletal structure. The other form, APSF, is about the application process and the material prepared with augmented reality. While the data obtained from VIF were analyzed under the researcher-defined categories regarding the participants' showing each viscera in a human torso model and placing them in the skeletal structure, the data obtained from APSF was processed with content analysis. The study results revealed that AR-based teaching material makes a positive contribution to the learning of viscera through algorithmic thinking. In addition, this is determined as AR-based teaching material contributes to understanding the related basic concepts through algorithmic thinking.

Keywords Algorithmic thinking, Augmented reality, Teaching material

1. INTRODUCTION

With technology taking a more incredible place in our lives day by day, the need for programs that provide solutions for the problems encountered in daily life has become increasingly essential. In search of solving an existing situation, programming can generate an answer to that problem thanks to a language that the computer can understand (Van-Roy & Haridi, 2004). Therefore, many programs need to be developed to meet the needs, and good programming education and teaching are provided. At present, where programs are so significant, programming education and teaching are also of equal importance, and therefore, programming education is tried to be given widely (Perry, 2009).

Algorithms, which play a crucial role in programming, determine how to achieve a solution by showing the processes step by step in a problem to be solved or in a plan to be implemented. Its definition as performing a task step by step in computer science and other disciplines is considered an indicator of its extensive use as a concept of algorithmic thinking (Selby & Woollard, 2013). That is to say, all finite and sequential operations used by individuals in their daily lives are carried out with algorithmic thinking (Akçay & Coklar, 2016). These sequential operations provide the individual with skills such as planning, offering different solutions to problems, dividing a task into sub-tasks, and algorithmic thinking (Ziatdinov & Musa, 2013). In this sense, algorithmic thinking is considered the primary programming step (Nunes et al., 2017).

Algorithmic thinking, which is frequently sought in programming education, is addressed at various levels in the literature. While Brown (2015) considers these levels to be understanding the problem, clearly presenting the problem, assessing the remedy, and creating an algorithm, Vasconcelos (2007) describes the sub-levels of algorithmic thinking as understanding the problem, determining the applicable theoretical concepts, presenting the problem qualitatively, creating the solution strategy, and stating the tested solution. In another study, Futschek (2006) classified the algorithmic thinking levels as presenting the problem clearly, analyzing, determining the basic actions required in the solution, creating the right algorithm, increasing the interpretation and efficiency by fully addressing the problem. Zsakó & Szlávi (2012) examined algorithmic thinking in 7 stages: understanding the problem, creating

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and analyzing algorithm steps, writing-coding-modifying the algorithm, and dividing more complex algorithms into sub-problems.

Developing algorithms is essential before learning any programming language (Nayak & Vijayalakshmi, 2013; Nunes et al., 2017). However, it is known that current teaching methods are insufficient for the programming and algorithm development process (Cutts, Connor, Donaldson & Michaelson, 2014; Esteves, Forseca, Morgado & Martins, 2011). Accordingly, the learning process will be positively affected by taking advantage of augmented reality technologies, where learners can intervene in the real environments around them and which provide human-computer interaction experience (Cai, Wang & Chiang, 2014), ensure access to the real world (Wu, Lee, Chang & Liang, 2013), increase the willingness and interest to learn (Cai, Wang & Chiang, 2014; Delello, 2014; Tomi & Rambli, 2013), ensure permanent learning, reduce misconceptions (Yoon, Anderson, Lin & Elinich, 2017), and offer student-centered approach (Delello, 2014). Additionally, the literature has many studies showing that AR technology positively affects the learning process of students, especially in science lessons (Cai, Wang & Chiang, 2014; Chiang, Yang & Hwang, 2014; Hsiao, Chang, Lin & Wang, 2016; Ibáñez, Di Serio, Villaran, & Kloos, 2016; Wang, Duh, Li, Lin, & Tsai, 2014). In this context, based on the positive effect of AR-based teaching material in the literature, it was thought that it would be helpful to use it in the learning of internal organs. In addition to this, since it is essential to array the process steps that need to be performed in the arrangement of internal organs (Ziatdinov & Musa, 2013), algorithmic thinking was taken as a basis in the scope of the study. Thus, candidates are expected to analyze the problem and implement solutions within a particular order. In addition, this study offers a new approach to the literature. Teaching AR-based teaching material with algorithmic thinking towards any subject or concept in the literature has not been encountered. In this respect, the study is considered valuable. Against this background, the study examines AR-based teaching material's effect on viscera learning through algorithmic thinking. The study seeks answers to the following questions:

- What is the AR-based teaching material's effect on viscera learning through algorithmic thinking?
- What are the opinions of the teacher candidates about the AR-based material and the application process?

2. METHOD

2.1. Research Model

This study examines the AR-based teaching material's effect on viscera learning through algorithmic thinking and uses the case study method. This method is a qualitative research design that helps researchers in obtaining in-depth information in a short time. The results obtained via this method are limited to the cases examined, and there is no concern for generalization.

2.2. Study Sample

The study sample consists of 32 primary school teacher candidates who are sophomores in the classroom teaching department in the spring term of the 2018-2019 academic year at a state university in the Eastern Black Sea and selected by convenience method. Teachers candidates are between the ages of 18-22. Also, the teachers' candidates' are 20 females, 12 males. Teacher candidates were coded as T1, T2, T3… T32 in the study.

2.3. Data Collection Tools

Viscera Information Form (VIF) and Application Process and AR Survey Form (APSF) were used as data collection tools in the study.

VIF is an information form applied as a pre-test and post-test. Participants are asked to show the viscera (lungs, heart, the stomach, liver, kidneys, gall bladder, small and large intestine) in a human model to place them in the skeletal structure.

Expert opinion was obtained from three science education experts. The VIF was updated in line with the experts' feedback and was turned into a pre-information form.

The other form, APSF, is a survey form consisting of two basic open-ended questions about the application process and the material prepared with augmented reality, which is applied only as a post-test. Expert opinion was obtained from one science education and one computer educational and instructional technology expert. This science educator has 15 years of experience, is skilled in technology integration in science education, and his experience to put her knowledge into practice. The other expert who computer educational and instructional technologyhas 10 years of experience and is skilled in educational technology and these technologies application on the learning environment.

2.4. Data Analysis

In the study, the data obtained from *VIF* were analyzed under the researcher-defined categories regarding the participants' showing each viscera in a human torso model and placing them in the skeletal structure. These categories and the criteria for them are presented in Table 1.

Based on the categories in Table 1, the researchers analyzed each teacher candidates' answers independently. First, the data obtained were categorized individually and placed in matrices, and then a consensus was achieved by comparing them. The reliability percentage in this test was calculated with Miles and Huberman (1994) formula (Reliability = [Consensus/Disagreement + Consensus]*100), and the percentage was reached as 0.94. The data obtained from *APSF* was processed with content analysis.

Table 1 Categories and criteria

Categories	Criteria
Correct **I**ndication-**C**orrect **P**lacement **(CI-CP)**	Indicating the viscus in the correct place in the skeletal structure and correct placement in the human model
Correct **I**ndication-Incorrect **P**lacement **(CI-IP)**	Indicating the viscus in the correct place in the skeletal structure and incorrect placement in the human model
Correct **I**ndication-**No** Placement **(CI-NP)**	Indicating the viscus in the correct place in the skeletal structure and no placement in the human model
Incorrect **I**ndication-**C**orrect Placement **(II-CP)**	Indicating the viscus in the incorrect place in the skeletal structure and correct placement in the human model
Incorrect **I**ndication-**I**ncorrect **P**lacement **(II-IP)**	Indicating the viscus in the incorrect place in the skeletal structure and incorrect placement in the human model
Incorrect **I**ndication **– No** Placement **(II-NP)**	Indicating the viscus in the incorrect place in the skeletal structure and no placement in the human model
No Placement-**C**orrect **P**lacement **(NP-CP)**	Indicating no placement of the viscus in the skeletal structure and correct placement in the human model
No placement-**I**ncorrect **P**lacement **NP-IP**	Indicating no placement of the viscus in the skeletal structure and incorrect placement in the human model
NP-NP	Indicating no placement of the viscus both in the skeletal structure and the human model

2.5. Teaching Material Developed Based on Augmented Reality Application

In this study, the teaching material developed based on an Augmented Reality (AR) application was used. This material was created based on the Futschek (2006) classification, namely presenting the problem, analyzing, determining the basic actions required in the solution, making the correct algorithm, increasing the interpretation and efficiency by comprehensively addressing the issue. AR material is related to viscera. The image of each organ has been identified as a trigger, and the AR application is embedded in these triggers. Spurs have been put in envelopes. There are also magnetic puzzle pieces in the envelope of each stimulus. A scientist takes part in the AR application embedded in triggers, asks riddles to the teacher candidates, expects them to find viscera in the correct way & order, and takes a detective role to solve the puzzles. This stage aims to enable the teacher candidates to present the problem through algorithmic thinking. Teacher candidates participating in the AR application must solve the puzzles like a detective and find out where the triggers are in the classroom. The aim here is that teacher candidates should identify the basic actions required for analyzing and solving. Puzzles are about viscera and cover instructions such as five steps to the left, three steps to the right, etc. The researchers placed these instructions in the classroom following the order in the puzzles before starting the application. The triggers representing viscera are arranged in the school in the same way as the indication and placement of human organs. For example, the heart in the scientist's puzzle was placed closer to the left lung. So, the aim is to create the correct algorithm. The teacher candidates who locate all the triggers in the correct order will also collect the puzzle pieces in the envelopes (Figure 1).

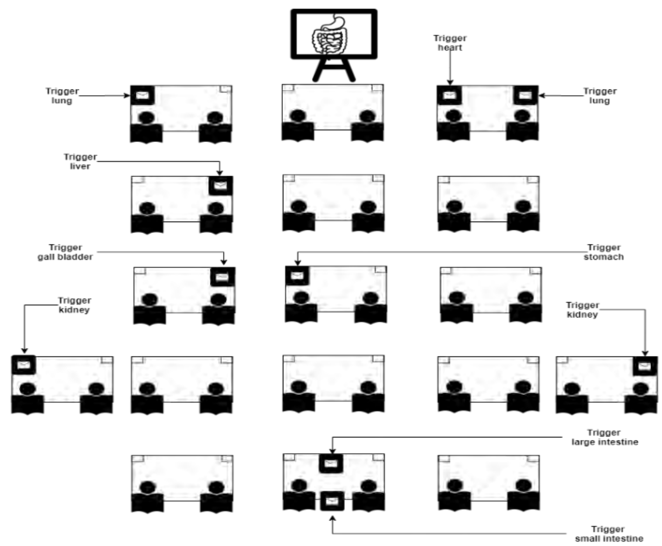


Figure 1. Placement of triggers in classroom

Teacher candidates who locate all puzzle pieces are expected to complete the puzzle on the classroom board. The mystery is again about the correct viscera indication and placement. The purpose of completing the puzzle is to discuss and interpret the problem with all aspects, increasing efficiency. All these stages' relationship with algorithmic thinking is summarized in Table 2.

Table 2 Relationship between algorithmic thinking and teaching material based on the AR application

Algorithmic Thinking Futschek (2006)	Features associated with algorithmic thinking in teaching material based on the AR application
1. Presenting the problem clearly	• A scientist takes part in the AR application and asks puzzles to the teacher candidates and expects them to find viscera in the correct way &

	order and take the role of a detective to solve the puzzles.
2. Analyzing 3. Identifying the basic actions required for the solution	• Teacher candidates participating in the AR application are required to solve the puzzles like a detective and find out where the triggers are in the classroom
4. Creating the correct algorithm	• Puzzles cover instructions such as five steps to the left, three steps to the right, etc.
5. Discussing and interpreting the problem with all aspects and increasing the efficiency	• Completing the puzzle correctly on the classroom board

2.6. Application Process

Before the application, VIF was applied as a pre-test for the teacher candidates, where the viscera were asked to be indicated in a human model and placed in the skeletal structure. Teacher candidates were then asked to experience the teaching material developed based on the Augmented Reality (AR) application. Some photos of the application are shown in Figure 2. During the experience, teacher candidates are expected to take on the role of a detective (Figure 2a-b), solve puzzles (Figure 2d-e, find the triggers in the classroom (Figure 2c), create the correct algorithm, and complete the puzzle correctly on the board (Figure 2d-f).

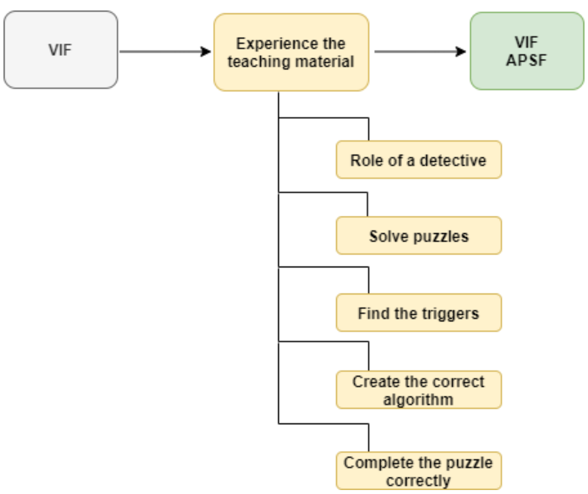
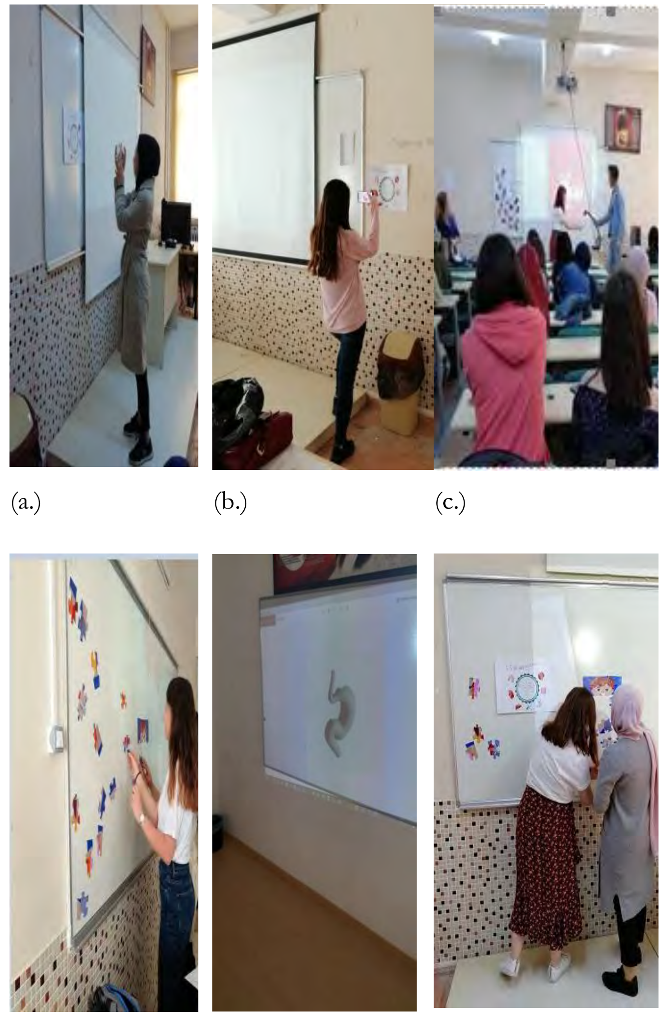


Figure 3. Research Application Process

After the application, VIF was applied to the teacher candidates as a post-test. Furthermore, APSF was also involved as a post-test on teaching material and application process based on the AR application. The research application process is schematized in Figure 3.



(a.) (b.) (c.)

(d.) (e.) (f.)

Figure 2. Sample images of the application process

2.7. Research Ethics

The participant teacher candidates' consent to data sharing was obtained, and they were ensured that they should not suffer any harm due to the research. Some private dialogues between the researcher and teacher candidates during the data collection and application process were not reflected in the study as per privacy and confidentiality principles. Moreover, the identities of the teacher candidates who participated in the data collection process were kept confidential, following the principles of research ethics.

3. RESULT AND DISCUSSION

3.1. The Result and Discussion for the first research question

The results obtained from the VIP as a pre-and post-test are presented in Table 3.

Table 3 Findings obtained from viscera information form

Categories	Viscera															
	Lungs		Heart		Liver		Stomach		Gall Bladder		Kidneys		Small Intestine		Large Intestine	
	Pre (f)	Post (f)	Pre (f)	Post (f)	Pre (f)	Post (f)	Pre (f)	Post (f)	Pre (f)	Post (f)	Pre (f)	Post (f)	Pre (f)	Post (f)	Pre (f)	Post (f)
CI-CP	9	25	11	26	5	17	9	16	2	13	4	15	1	12	1	12
CI-IP	2	-	1	-	1	2	3	5	2	2	6	3	2	5	1	5
CI-NP	4	4	4	4	1	7	4	8	2	9	3	8	2	10	3	10
II-CP	2	-	7	-	3	1	2	-	-	-	-	-	2	-	2	-
II-IP	8	1	5	-	9	2	9	2	7	-	8	2	12	1	12	1
II-NP	2	-	1	-	6	-	3	-	7	1	6	1	7	1	7	1
NP-CP	-	2	1	2	-	-	-	-	-	1	1	-	-	-	-	-
NP-IP	2	-	1	-	-	-	-	-	1	1	1	-	4	-	3	-
NP-NP	3	-	1	-	7	3	2	1	11	5	3	3	2	3	3	3

As shown in Table 3, while 9 of the teacher candidates' answers in the pre-test for lungs were in the CI-CP and eight were in the II-IP category, there were no answers in the NP-CP category. In the post-test, 25 of the solutions of the teacher candidates are in the CI-CP category, while one is in the II-IP. This result indicates that 25 teacher candidates showed the lung's location in the human model and skeletal structure correctly following the application. In the pre-test for the heart, 11 of the answers of the teacher candidates were in the CI-CP; 7 of them were in the II-IP category. In the post-test, 26 of the solutions of the teacher candidates were in the CI-CP category, while there were no answers in the II-IP class. This result also indicates that 26 teacher candidates showed the lung's location in the human model and skeletal structure, placing them correctly after the application. Findings on lungs and heart (Table 3) have revealed that 25 out of 32 teacher candidates gave answers for lungs in the DG-TF category in the post-test, while 25 out of them for heart in the same category. That shows that most teacher candidates indicated and placed the lungs and heart correctly in the human model and the skeletal structure. Prokop & Fancovicova (2006) research specified that 69.2% of the students referred to the lungs as the second viscus after the heart. Similarly, in the study conducted by Lee (2015), lungs are frequently indicated by the participants as the most critical organ in terms of respiratory tract learning. In addition, academic studies on body systems reveal that students know organs like lungs and heart of all age groups (Pelaez, Boyd, Rojas & Hoover, 2005; Prokop & Fancovicova, 2006; Zvi-Assaraf, Dodick & Tripto, 2013). The possible reason for this is that the primary body organs and systems are taught in preschool education (Ahi & Balci, 2017). In parallel with the literature, the fact that nine teacher candidates indicate the lungs and 11 of them indicate the heart in the correct place in the human model and place them correctly in the skeletal system model during the pre-test maybe because they have learned the basic organs in education systems at different levels starting from the preschool period. However, 25 out of 32 teacher candidates indicate lungs, and 26 indicate the heart in the correct place in the human model and place them correctly in the skeletal system model in the post-test shows the effect of AR-based teaching material. It is a fact that AR-based teaching materials and/or AR technologies contribute to attract the interest and attention of the students to the lesson (Delello 2014; Dönmez-Usta, Durukan & Turan-Güntepe, 2020; Tomi & Rambli, 2013) and increase their motivation for the lesson (Kerawalla, Luckin, Seljeflot & Woolard 2006; Perez-Lopez & Contero 2013; Tomi & Rambli, 2013). Furthermore, AR-based teaching materials enable learning abstract concepts by materializing them through visualization facilities (Abdüsselam & Karal 2012; Özarslan, 2013; Shelton & Stevens, 2004) and facilitate understanding the complex topics (Kaufmann 2003; Shelton & Hedley 2002). Accordingly, the learner's success increases (Shelton & Hedley, 2002; Sirakaya, 2015). Teacher candidates' indicating the heart closer to the left lung reveals creating the correct algorithm. That can be interpreted as AR-based teaching material that contributes to the creation of the right algorithm. That also indicates that as Futschek (2006) stated, the presence of instructions in the AR-based teaching material to create the correct algorithm contributes to the teacher candidates in doing so.

In the pre-test for liver, 5 of the answers of the teacher candidates were in the CI-CP and 9 in the II-IP category, while 17 of them were in the CI-CP and 2 in the II-IP category in the post-test. In the pre-test for the stomach, 9 of the answers of the teacher candidates were similarly in the CI-CP and 9 in the II-IP category, while 16 of them were in the CI-CP; 2 in the II-IP category in the post-test. These results indicate that the number of teacher candidates who correctly place the liver and stomach in the human model and skeletal structure has dramatically increased. The number of those who did incorrectly has decreased. The results about liver and stomach (Table 3) show that the answers in the II-IP category in the pre-test have fallen in the post-test. In addition, it was determined that the solutions in the CI-CP category increased significantly in the post-test. This increase may be due to teacher candidates solving the puzzles like a detective and finding the triggers in the classroom. In the teaching material based on the AR application, the triggers with puzzles were placed in different parts of the class to be placed in the human model. Accordingly, the teacher candidates presented and analyzed the problem clearly and identified the basic actions required for a solution. That can be claimed to be related to studying the issue through the algorithmic thinking steps and determining the basic activities necessary for the answer. Similarly, Pruden, Levine & Huttenlocher (2011) stated in their study that mental rotations could be developed through visual maps and visualization of games. In algorithmic thinking, visualizing a problem that is not easy to solve but can readily be understood can help figure out the basic concepts associated with algorithms (Futschek, 2006). Therefore, it can be said that the fact that the teaching material based on the AR application includes visuality helps to understand the related basic concepts through algorithmic thinking

In the pre-test for gall bladder, 2 of the answers of the teacher candidates were in the CI-CP and 7 in the II-IP category, while 13 of them were in the CI-CP in the post-test. Also, no teacher candidate answer was in the II-IP category. In the pre-test for kidneys, 4 of the answers of the teacher candidates were in the CI-CP and 8 in the II-IP category, while 15 of them were in the CI-CP and 2 in the II-IP category in the post-test.

In the pre-test for the small intestine, 1 of the answers of the teacher candidates was in the CI-CP and 12 in the II-IP category, while 12 of them were in the CI-CP; 1 in the II-IP category in the post-test. In the pre-test for the large intestine, as is the case for the small intestine, 1 of the answers of the teacher candidates was in the CI-CP and 12 in the II-IP category, while 12 of them were in the CI-CP and 1 in the II-IP category in the post-test. Pre- and post-test categories of teacher candidates for the small and large intestines are similar. However, the number of those who indicate and place correctly in the post-test has increased significantly. The results about the gall bladder, kidneys, and small and large intestines (Table 3) show that the answers in the II-IP category in the pre-test significantly were reduced in the post-test. Besides, it was determined that the solutions in the CI-CP category increased considerably in the post-test. That may be related to the teacher candidates presenting and analyzing the problem clearly, defining the basic actions required to solve it, and creating the correct algorithm. The teacher candidates' successful implementation of almost all steps, that is, their ability to think algorithmically and give correct answers, can be reasoned by the contribution of the teaching material based on the AR application. Similarly, ISTE (2015) suggests using algorithmic thinking skills with technology-supported activities. In addition, it is claimed that the creativity and productivity of learners who create the correct algorithm improve (Yecan, Ozcinar & Tanyeri, 2017). In such a case, teaching material based on the AR application may have contributed to developing metacognitive skills.

The results obtained from the first question of the study reveal that most teacher candidates reached the correct information by discussing and interpreting the problem with all aspects. The teacher candidates who found all the triggers in the right order in the teaching material based on the AR application will have collected the puzzle pieces. Since the puzzle is about the accurate viscera indication and placement, they have to assess all organs in the right place and order, solving the problem. They must discuss and interpret the problem with all aspects, thereby increasing efficiency. The teacher candidates' correct indications in the human model and correct placements in the skeletal structure may result from this. Also, since algorithmic thinking is defined as performing a step-by-step task in other disciplines and computer science (Selby & Woollard, 2014), it is thought that algorithmic thinking can be used frequently in the process. Unlike computer education, this study used algorithmic thinking in science education. In this respect, the results of the study are valuable.

3.2. The Result and Discussion for the second research question

The results obtained from the APSF "as post-test are presented in Table 4.

Table 4 Findings obtained from APSF

Categories	Answers of Teacher Candidates (f)		Sample Answers for the Categories
Effect on the learning process	Positive	30	T13: I found the learning process entertaining and compelling as I was active during the activity.
	Neutral	1	T19: It seems as if it varies between those on good terms with technology and those who are not.
	Negative	1	T21: Technological materials are sometimes so much involved in the process. It wears me out. The topics could be explained in a regular and fundamental way.
Effect on topic/concept learning	Positive	29	T28: The students play the detective role, and locating some things with clues increases the memorability of the learned organ. The concept explanation was illustrative, instructive, and entertaining.
	Neutral	-	
	Negative	3	T25: I already knew about the organs. I graduated from a healthy high school, so the concepts did not affect my learning.
Increasing learner's motivation/interest in the learning environment	Positive	30	T22: It makes us wonder about the next step as we proceed step by step. T26: Solving puzzles and finding envelopes increased the motivation during learning, as they were interesting.
	Neutral	-	
	Negative	2	T14: It is difficult to achieve a suitable environment; increasing the interest depends on the environment, so it seems complicated. T29: It was a little boring. It seems to impose a lot of burden on students.
The learners' activeness in the process	Positive	27	T5: Since we are directly involved in the activity, we are active in the process, and this is good.
	Neutral	3	T31: I think it varies a little depending on whether the student wants to be active or not.
	Negative	2	T15: It's boring to be so active. The learner is very active during the process, and this makes it dull.
Learner's interaction with the material	Positive	26	T2: Taking on the detective role increased our interaction with the material.
	Neutral	5	T30: Interaction with the material? I don't know. Maybe yes, maybe no.
	Negative	1	T7: I could not establish any interaction.
Use of such materials in the learning environment	Positive	28	T11: Such materials must be used in the learning environment as they give the student an active role in the process, make it fun, and arouse curiosity. Our age is the age of technology.
	Neutral	2	T13: If the school has facilities, then we use them. Otherwise, it is difficult to use.
	Negative	2	T6: Facilities of the school or learning skills may not be sufficient. It is difficult to use such materials.

The opinions of the teacher candidates are collected under six basic categories. These categories are as follows: the learning process, topic/concept learning, increasing the interest/motivation in the learning environment, learners' activeness in the process and their interaction with the material, and the use of such materials in the learning environment. In addition, the opinions in these categories are listed and exemplified as positive, neutral, and negative. As shown in Table 4, most teacher candidates expressed positive opinions in all categories. However, in the variety of the AR application-based teaching material's effect on the learning process, it is noteworthy that such materials are sometimes involved too much, making the people worn out. The cognitive load theory mentions that it is essential to properly use many components such as sound, text, pictures, graphics, and animations when designing multimedia to present information effectively and efficiently (Anglin, Vaez, & Cunningham, 2013; Barron, 2004). In this context, it is expected that the teaching process should be structured effectively to reduce the cognitive load, and mental structures are formed easily by allocating the working memory space to practical bag (Kılıç-Çakmak, 2007). Thus, by creating well-designed multimedia contents, candidates can be prevented from seeing the relevant materials as a burden in the learning process. For example, in the topic/concept learning category, teacher candidates familiar with the topic expressed positive opinions and stated that they did not learn the concepts thanks to the material based on the AR application.

One of the two teacher candidates, who stated negative opinions in the category of increasing the motivation/interest in the learning environment, expressed that s/he found it boring as it imposes a lot of burden on the student. In the category of the learners' activeness in the process, three teacher candidates gave neutral opinions. T15, one of the two teacher candidates who expressed negative views in this category, stated that being too active creates boredom. The variety of the learner's interaction with the material has the most significant number (5) of neutral answers among all categories. In using such materials in the learning environment, the technological facilities and competence of the school or teacher play a significant role in opposing and neutral responses.

The findings on the second question of the study (Table 4), which aimed to reveal the teacher candidates' opinion about the material based on AR and the application process, show that most of the teachers generally expressed positive (f = 30, 29, 30, 27, 26, 28) opinions. In their study on augmented reality applications in a learning environment, Ramazanoğlu & Aker (2019) stated that students have a favorable view. Specific studies in the literature specify that the use of teaching materials based on the AR applications or AR technologies in the learning environment makes lessons entertaining (Yıldırım, 2016), increases motivation and interest (Chiang, Yang & Hwang, 2014; Ramazanoğlu & Solak, 2020), ensures effective learning (Ibáñez, Di Serio, Villarána & Kloosa, 2014) and that these materials are desired to be used in various learning environments (Küçük, Yilmaz & Goktas, 2014). This is consistent with the study results. On the other hand, some teacher candidates gave a neutral or negative response, namely not desiring to be very active in the process, knowing the concepts, not being able to establish the expected interaction with the material, and the school's facilities and teachers' skills preventing the use of such materials. These opinions can be accounted for because they are familiar with topic/concept learning through current teaching methods.

4. CONCLUSION

According to the results of this study AR-based, teaching materials and AR technologies attract the students' interest and attention to the lesson and increase their motivation for the task. Besides, AR-based teaching materials enable learning abstract concepts by materializing them through visualization facilities and facilitate understanding the complex topics. In this context, it can be a positive effect on the success of teachers candidates'. However, unlike the results, some teacher candidates think neutral or negative, namely not desiring to be very active in the process, not establishing the expected interaction with the material, and the school's facilities and teachers' skills preventing the use of such materials. These opinions can be related to being familiar with topic/concept learning through current teaching methods.

One of the results in this study, teacher candidates' indicating the heart closer to the left lung reveals that they can create the correct algorithm. In this context, AR-based teaching material can contribute to the creation of an accurate algorithm. In this direction, it is recommended to develop materials related to AR-based and algorithmic thinking on different subjects and concepts such as excretory system, digestive system, respiratory system.

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Compliance with Ethical Standards

Conflict of Interest: The authors declare that they have no conflict of interest.

Ethical Approval: The work described has not been previously published. All authors approved this manuscript.

Consent Statement: Study participation was voluntary, and participants were required to accept (or decline) the terms of the consent forms before completing the study.

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