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DEVELOPMENT OF LIGHT AND QR-CODE ASSISTED BRAIN LOBES AND THEIR TASKS MODEL AND VIEWS OF TEACHER CANDIDATES ON THE MODEL

(Research article)

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Abstract

The purpose of this study is to determine teacher candidates' opinions on the Light and QR-Code Assisted Brain Lobes and their Tasks model, which is a unique design that differentiates itself from other studies in the literature. The study employed the basic qualitative research approach. Teacher candidates studying at the Faculty of Education of a state university in Ankara in the fall semester 2021-2022 were included in the study. The study group consisted of 50 teacher candidates studying in the Biology Education and Science Education. The Material Assessment form was the data collection tool for the study. The first part of the form, contains a material evaluation rubric. The second part of the form had semi-structured interview questions aimed at getting more detailed views from participants about the model. From the material evaluation rubric, a material evaluation score was obtained. A five-stage thematic analysis method was used in the analysis of qualitative data obtained through open-ended questions. As a result, the model can be considered a teaching material that can be used effectively in the teaching of the relevant subject. It was determined that teacher candidates expressed many positive opinions about the model designed to teach the brain lobes.

Keywords: Teaching material, model, brain lobes, teacher candidate, QR code

1. INTRODUCTION

Today, science and technology are the most important factors shaping the standard of living, economic strength and level of development of societies. Science and technology are needed to solve the problems people face throughout their lives, to meet their needs, and so to raise their standard of living. Developing and using science and technology effectively requires some skills such as lifelong learning, good communication, and adaptation (Reiss, Millar & Osborne, 1999). The most effective way to provide these skills to individuals is through education. Biology, along with its scientific and social aspects, is a branch of science that encompasses life-related issues requiring knowledge and understanding, concerned with the study of living things (Reece, Urry, Cain, Wasserman, Minorsky & Jackson, 2013; Toman, 2018). The goal of biology, like any field of science, is to draw useful conclusions from nature for human beings, to understand nature, to use nature according to human needs, and to raise human living standards (Çıngıl Barış, 2020). Biology, which is there at every stage of life from birth to death, provides people and their families with nutrition/sustenance and good health, while helping people make sense of the universe (Ohlsson & Ergezen, 1997). For this reason, biology is one of the most important lessons taught in our country and in the world at all levels of education from elementary school to higher education (Cengiz & Ekici, 2019; Kırpık & Engin, 2009). Nevertheless, biology is accepted as a difficult course of study by students, in light of the studies conducted (Bahar, Johnstone, & Hansell, 1999; Jones & Rua, 2006; Lukin, 2013; Prokop, Prokop, & Tunnicliffe, 2007; Udovic, Morris, Dickman, Postlethwait, & Wetherwax, 2002). There are many reasons why biology is considered a difficult subject. These are: its abstract nature, teachers' focus on theory to the exclusion of practical methods for teaching, too much reliance on textbooks, perception of biology as something that needs to be memorized, teachers' insufficient subject knowledge, teaching of concepts without categorization, giving too much weight to details, fear and anxiety of failure in individuals (Aşçı, Özkan, & Tekkaya, 2001; Gülcan, 2021; Kılıç & Sağlam, 2004; Tekkaya, Çapa, & Yılmaz, 2000). In addition, according to the report published by the National Research Council (2012), biology requires undergraduate students to be able to analyze and synthesize concepts / relationships between concepts and complexities. Failure of students to acquire these skills before going to university may lead them to view biology as a difficult field of study. Misconceptions are both a reason and a consequence of considering biology a difficult major. Students were especially found to have learning difficulties and misconceptions about mitosis and meiosis, photosynthesis, ecology, circulatory system, digestive system, excretory system, respiratory system, nervous system and hormones, enzymes, evolution, and genetics (Adıgüzel & Yılmaz, 2020; Aymen Peker & Taş, 2020; Cerrah, Özsevgeç, & Ayas, 2005; Karakaya, Yılmaz, Çimen, & Adıgüzel, 2020; Pelaez, Boyd, Rojas, & Hoover, 2005; Prokop & Fančovičová, 2006; Sebitosi, 2007; Yoğurtcu, 2021). It is of great importance that teaching is supported by concrete teaching materials in order to avoid misconceptions among students and to help concretize abstract concepts in the minds of students. The assumption is this can prevent biology being seen as a difficult course of study.

Various studies have shown that the use of materials in education has many advantages, such as simplifying the content and making the subject easier to understand. Some of these benefits are that the materials engage more than one sensory organ; capture student attention and interest; support active learning; concretize abstract themes; promote individual differences, and provide permanent learning (Aykaç, 2014; Çalışoğlu, 2015; Çelikkaya, 2013; Çelikkaya, 2017; Sever & Koçoğlu, 2017; Yalın, 2004; Yanpar, 2009). Moreover, according to the results of a study, when the time variable is held constant, students remember 10% of what they read, 20% of what they hear, 30% of what they see, 50% of what they see and hear, 70% of what they say and write, and 90% of what they do (Dale, 1969). In other words, students learn better through hands-on learning (Anderson, 2018). And teaching materials are one of the most important tools to provide hands-on learning. One of the teaching materials frequently used in teaching environments is models.

While modeling is a series of operations to make an unknown goal clear and understandable based on available resources, the product that emerges as a result of this process is described as a model. (Harrison, 2001; Treagust, 2002). Models are scientific and mental activities used to simplify a complex object or process and allow people to more easily understand complex events (Paton, 1996). Students should use models and modeling to explain relationships, processes, or mechanisms between concepts, provide a scientific basis for their explanations, and develop possible solutions (Falk & Brodsky, 2013; Windschitl, 2012). Teaching through modeling is student-centered and creates environments in which students can create their own models, structures, and assessments (Brewe, 2008; Halloun, 2004). In this way, students have the opportunity to experience firsthand the excitement of learning about the world we live in (Jackson, Dukerich & Hestenes, 2008). Teachers often make use of models in learning environments. Because models are useful tools in understanding and using concepts in education and training (Real, 2019). Some of their useful aspects are: Since students use both their hands and eyes in modeling, more than one part of the brain is stimulated, so hands-on learning helps learning (Lavoie, 1993; Sadıç & Çam, 2012). Also, models are used to concretize abstract concepts, teach concepts, and make learning more permanent (Acher, Arcà, & Sanmartí, 2007; Çökelez, 2015; Şimşek & Hamzaoğlu, 2020). Again, when teaching with models, students' communication with each other and with their teachers increases, so models contribute to the development of social relationships (Yıldıran, 2004). In addition, teaching with models increases student motivation (Halis, 2002; Sezgin & Köymen, 2002).

Looking at the studies in the literature, models and modeling are utilized in many fields. For example, there are studies on the effect of models on the academic performance of teacher candidates (Demirhan, 2015), the study of students' mental models on the topic of cells (Ayvacı, Bebek, Atik, Keleş & Özdemir, 2016), the opinions of teachers, teacher candidates and students on models and modeling (Berber & Güzel, 2009; Çökelez, 2015). The purpose of this study is to determine teacher candidates' opinions on the Light and QR-Code Assisted Brain Lobes and their Tasks model, which is a unique design that differentiates itself from other studies in the literature.

2. METHODOLOGY

2.1. Research Model

This is a qualitative research study that aims to explain the preparation processes of a course material and to elicit teacher candidates' opinions about the prepared model. A research study modeled on this basis seeks to understand the meaning of a phenomenon from the onlookers' perspective and is concerned with how people interpret their experiences, how they construct their worlds, and what meaning they assign to their experiences (Merriam 2009). Primarily, the study focuses on the preparation stages of the light- and qr-code-assisted brain lobes and their tasks model. Subsequently, this model was presented to teacher candidates and their opinions on the model were obtained, depending on their own educational lives and experiences in teacher education. The aim in doing so was to reveal how teacher candidates make sense of the model.

2.2. Preparation Stages of the Model

When preparing the model, in the design stage, the following aspects were taken into consideration with guidance from an expert;

- In line with the objectives and learning outcomes of the Biology Course Curriculum of the Ministry of Education; 11th Grade Supervisory and Regulatory Systems and the Science Course Curriculum of the Ministry of Education and 6th Grade Supervisory and Regulatory Systems, it was determined what concepts needed to be taught, and in what order and using what techniques.

- To teach this concept more effectively, technological components (light, switch, sensor, face mask, software, qr code, etc.) were incorporated into the learning activity so students can learn through hands-on experience.

- The colors of the organ model (brain) to be used for the topic covered in the model were determined based on the corresponding image in the Biology textbook of the Ministry of Education.

- When planning the technical dimension of the model, care was taken to ensure that it could be operated with a simple and safe power supply (battery).

2.2.1. 3D design of the model

The 3D brain model, the main component of the designed model, was obtained with a nature-friendly material called PLA using a 3D Printer. Using acrylic dye, the brain lobes were painted in different colors based on the corresponding picture in the biology textbook of the Ministry of Education. A hole was drilled into each lobe of the right hemisphere of the brain using a drill (Figure 1).

Figure 1. 3D design, painting of the brain model, drilling of the lobes

2.2.2. Powering the model with software

Four different sensory systems representing the sensory organs were prepared in a computer environment using the Arduino software. "Pır" sensors were used to represent the sense of sight, "sound" to represent the sense of hearing, "gas" to represent the sense of smell, and "distance" to represent the sense of taste (Figure 2). For each sensor, a code was written in a computer environment and these sensors were made operational using the power sources they were connected to (battery or USB to connect to the PC environment). Led lights were placed in the holes in the brain lobes, and these lights were connected to the sensors with the help of conductive wires. Apart from these lights, 4 connections were made, independently of the sensors, to the table where the model was placed. The circuit was made operational with the switches attached to the ends of these connections (Figure 2).

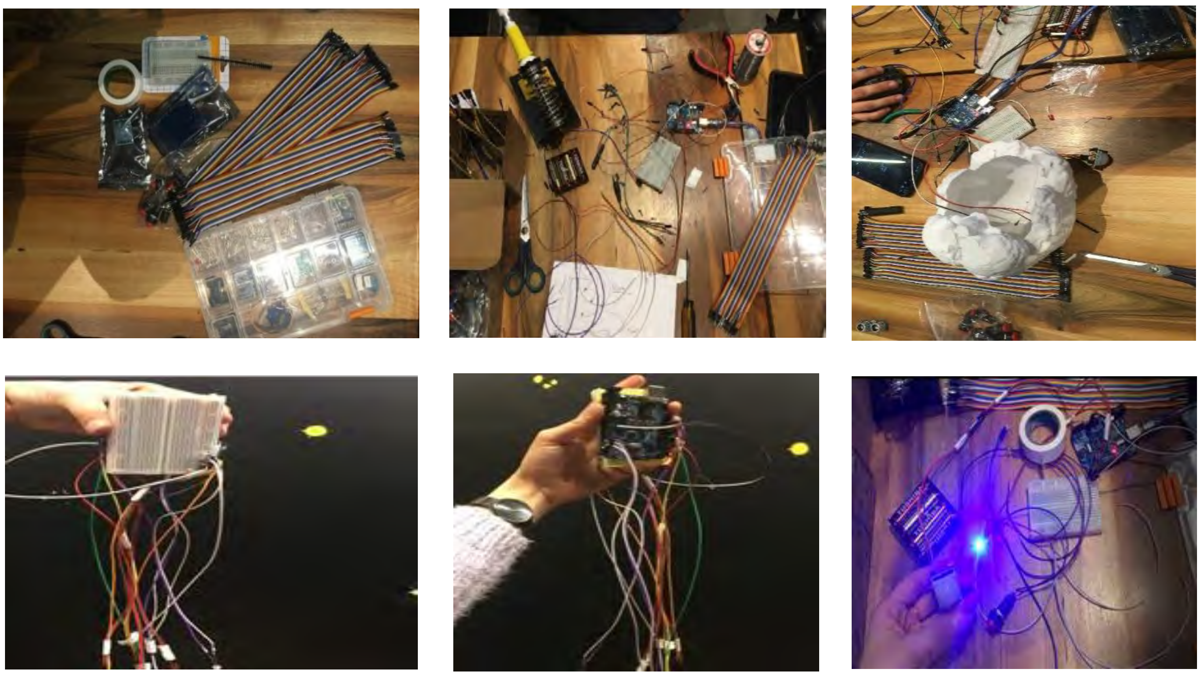

Figure 2. Powering the model with software and making the sensors operational with battery

2.2.3. Creating the mask and table

The face mask designed for the front lobe of the brain, was prepared in a sculpture workshop. Firstly, the mask was modeled from clay, then placed in a plaster mold and a fiber casting was performed. The face mask was then sprayed with paint. Two square boards of 40x40 cm were attached to each other at a 90^0 angle to form the table. Wooden pieces to enable the 3D brain and face mask to be positioned were placed on the table. The mask and brain model were fixed on these parts with a drill. Sensors were attached to the relevant parts of the mask using a silicone gun. Holes were drilled in the 4 corners at the base of the table and the switches were added (Figure 3).

Figure 3. Creating the mask and table

2.2.4. Adding QR code to the model

Texts and videos for the task of each brain lobe were loaded into QR Codes created in picture format using the QR Code Generator application. Each QR code was affixed next to the relevant switch on the table of the model in the form of barcodes. Thus, it was ensured that students could access information whenever they wanted outside of classroom hours. A picture of the brain lobe was pasted next to each QR code and switch. Glossy paper was preferred to ensure the durability of the pasted pictures and qr codes (Figure 4).

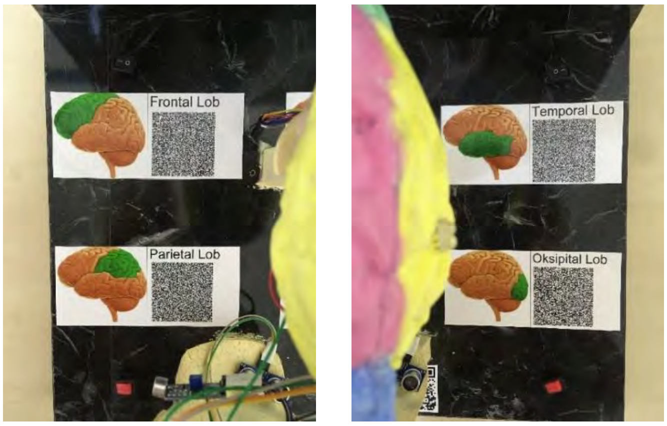

Figure 4. Adding Qr codes and pictures to the model

2.2.5. Incorporation of user instructions for the model

A guide was prepared showing how the model should be used. The information in these instructions for use was printed on 200x105 mm A3 paper, cut and folded to give it the appearance of a ladder, and placed in the pocket at the back of the table.

2.3. Study Group

It was considered important to get the opinions of teacher candidates about the developed model. For this purpose, teacher candidates studying at the Faculty of Education of a state university in Ankara in the fall semester 2021-2022 were included in the study. Participants were determined by purposive sampling, which allowed the researcher to choose the best candidates for the research study (Cohen, Manion, & Morrison, 2007; Patton, 2014). Accordingly, the study group consisted of 50 teacher candidates studying in the Department of Biology Education (N=15) and Department of Science Education (N=35).

2.4. Data Collection Tool

The Material Assessment form, developed by the researchers themselves, was the data collection tool for the study.

The first part of the form, contains a material evaluation rubric (graded rubric). There are two categories in the rubric, "Scientific Relevance" and "Appropriateness of Design Elements", with 17 criteria in these two categories that provide a basic assessment of the material. The criteria were scored using the options "Agree-Neither Agree nor Disagree-Disagree". While the material could get a maximum of 18 points in the "Scientific Relevance" category (9 criteria), it could get a maximum of 16 points in the "Appropriateness of Design Elements" category (8 criteria).

The second part of the form had semi-structured interview questions aimed at getting more detailed views from participants about the model. These questions are as follows:

1- What do you think are the implications (if any) of using this model in the classroom?

2- Would you consider using this model while teaching this subject? Why?

The opinions of two biology experts, two biology education, and one measurement and evaluation expert were sought to verify and validate the questions on the materials evaluation form created by the researchers. Necessary corrections were made in accordance with expert opinions to give the material evaluation form its final shape.

Before the material evaluation form was applied to teacher candidates, the model was presented and the model was exhibited. At this stage, the preparation steps of the model were explained, the working principles of the model were mentioned, and it was demonstrated how the model could be used as course material.

This phase, in which the model was exhibited, was carried out in class by the researchers themselves. This allowed researchers to brief teacher candidates, who in turn could ask any questions they had. This activity lasted approximately 90 minutes.

2.5. Data Analysis

2.5.1. Material evaluation score calculation

From the material evaluation rubric, the first part of the material evaluation form, a material evaluation score was obtained, and in accordance with the score obtained, it was decided that the material was scientifically relevant and the design elements appropriate. The average material score was calculated on the basis of the scores given by the teacher candidates to the model.

The material evaluation scores obtained from the rubric can be interpreted as given in Table 1:

Table 1. *Material scoring and interpretation indicators*

Form Categories	Score Range	Interpretation
1st Category Scientific Relevance	1-6	Material not fit for use.
	7-12	The materials needs improvement.
	13-18	Material fit for use.
2nd Category Appropriateness of design elements	1-5	Material not fit for use.
	6-11	The materials needs improvement.
	12-16	Material fit for use.

2.5.2. Analysis of semi-structured interview questions

Various steps are suggested for the analysis of qualitative data (Braun & Clarke 2006; Cresswell 2013; Robson & McCartan 2016; Yıldırım & Şimşek 2013). Accordingly, a five-stage thematic analysis method was used in the analysis of qualitative data obtained through open-ended questions (Braun & Clarke 2006): recognizing data, creating initial codes, searching for themes, reviewing themes, identifying and naming themes. First of all, the answers to the open-ended questions were written down and the organized data set was internalized via repeated readings. Possible initial codings were made during repeated readings and themes were created according to the codings and the notes taken. The codes were grouped under different themes and categories according to their relevance. Then, all data were reviewed and the suitability of the classification was checked. After the theme-category-code compatibility was achieved, the frequencies were calculated and thus the qualitative data were converted into quantitative data (Boyatzis, 1998).

The reliability of the codes was determined by calculating the inter-coder agreement. The ratio was found to be 81% and it was decided that the codes were consistent (Miles & Huberman 1994). In order to facilitate the understanding and interpretation of the data, direct quotations from the statements of the teacher candidates were included.

3. FINDINGS

In the first stage of the study, the 'Light and QR-Code Assisted Brain Lobes and Their Tasks Model' was developed, and afterwards the model was evaluated by asking the opinions of teacher candidates.

3.1. Findings Regarding Material Evaluation Score

First of all, the evaluation scores of teacher candidates for the material were calculated. Thus, the suitability of the developed model as a course material was investigated. The scores of the model according to the criteria in the material evaluation form are given in the table below.

Table 2. *Material evaluation scores*

Evaluation Category	Maximum Score	Total Score Received	(N)	Average Material Score ($\bar{X}$)
Scientific Relevance of the Material	900/18	898	50	17.96
Appropriateness of design elements of the material	800/16	659	50	13.18

Examination of the scores from the categories of scientific relevance of the developed material and appropriateness of the design elements show that the model received high scores from teacher candidates ($\bar{X}$=17.96/ 13.18). For this reason, it can be argued that the model is appropriate to use as a course material (See Table 1).

3.2 Findings Concerning the Semi-Structured Interview Questions

After calculating the fitness scores given by teacher candidates for the model, open-ended questions were asked to the teachers about the model and th findings were first presented in tables containing the basic opinions, followed by quotations of direct statements from the participants. With direct quotations, the letters "BTC" were used for biology teacher candidates and "STC" for science teacher candidates, and teacher candidate codes were created by adding sequence numbers.

First of the open-ended questions was, What do you think are the implications (if any) of using this model in the classroom? When the answers to this question were examined, it was seen that the effects of the model on the teaching of the lesson could be categorized as "positive effects" and "negative effects". Under these two themes, different categories and codes were created and presented in Table 3.

Table 3. *Possible effects of using the model on the teaching of the lesson*

Theme	Category	Code	*f*
Positive effects on the teaching of the lesson	Developing a positive attitude towards the lesson	Makes the lesson interesting/appealing.	36
		Pushes students towards active participation	10
		Reveals/develops a sense of curiosity.	9
		Increases motivation.	8
		Develops a positive attitude towards the lesson	3
		Generates interactions.	1
		Allows quick adaptation to the lesson	1
	Contributing to making the teaching of the lesson more efficient	Makes the information more memorable.	26
		Concretizes the subject.	22
		Allows better understanding/internalization of the subject.	2
		Helps students make sense of the subject.	1
	Supporting learning	Allows the subject to be understood/grasped better.	17
		Supports visual learning.	12
		Facilitates learning.	6
		Enables hand-on learning.	4
		Students learn while having fun (learning with games).	4
		Develops imagination.	2
	Supporting teaching	Makes the teaching process easier.	1
		Contributes to effective teaching.	1
		Can be used to evaluate the subject.	1
		Various skills can be gained by getting students to prepare the material.	1
		Allows a concrete teaching of the course.	1
		Fit for different educational levels.	1
Negative effects on the teaching of the lesson	Costly	A costly model.	9
	Impractical	May not be so easy to carry around.	9
		Can malfunction/ break apart.	7
		Can get damaged during use.	6
		It is a sensitive model.	2
		Its use can be time consuming.	2
	Creating a misconception	Misconceptions about the regions of the brain where senses are processed.	1
		Misconception due to LED lights.	1
		Misconceptions about brain size.	1
		Might make the subject seem too complicated.	1
	Negative impacts for the student	Not all students benefit equally.	2
		The student may get bored without teaching materials.	1
		Might look intimidating for junior classes.	1
		Can create problems with association.	1

Table 3 illustrates the categories of "developing a positive attitude towards the lesson", "contributing to making the teaching of the lesson more efficient", "supporting learning" and "supporting teaching" under the positive effects of the model on the teaching of the lesson. The positive effects with the highest frequency belonging to these categories are the codes of "making the lesson interesting/appealing, pushing students towards active participation, making the information more memorable, concretization of the subject, allowing the subject to be understood/grasped better and supporting visual learning". The codes in the category of supporting teaching have a very low frequency.

The statements of teacher candidates about the positive effects of the model on the teaching of the lesson are given below:

It enables students to adapt quickly to the lesson. It dispels any negative thought students might have about the subject. (BTC2)

Since the subject of the nervous system is abstract, it can be useful in terms of concretizing the subject and ensuring its permanence. Hands-on learning by students can make the subject more interesting. (BTC3)

Increases student motivation, makes them more interested in the subject being taught. It makes it easier to understand the subject by placing it on a more concrete basis. Contributes to the imagination of the students. (STC2)

Increases student interest. Makes the subject easier to understand. Captivates students' attention and pushes them to do more thinking. Makes it easier for the teacher to teach the subject in an understandable way. Enables concrete thinking. (STC10)

Students find the material interesting. It can be used for easy understanding, internalization and evaluation of the subject. Its rich content, videos and inclusion of other information on the subject are its other positive aspects. (STC22)

This material can increase students' interest in the lesson and raise their curiosity. Can provide permanent learning by concretizing abstract subjects. We can make students willing to prepare and develop such materials. We can get students to acquire new skills with this material. (STC27)

First of all, I think it is a remarkable material. I think it stays longer in the memory as students have a hands-on learning experience and see the outcomes of their actions. It can also facilitate learning. Because it is possible to test it with fun and practice… It will also attract more attention as it is three-dimensional. (STC34)

Under the negative effects of the model on teaching, the categories of "being costly", "being impractical", "creating a misconception" and "having negative impacts for the student" came to the fore. The codes "it is a high cost material, may not be so easy to carry around, can get damaged/can malfunction/break apart during use" from these categories had high frequencies.

The statements of teacher candidates about the negative effects of the model on the teaching of the lesson are given below:

The whole class cannot benefit equally from the brain model. I think it will be more effective for smaller groups or individual use. (BTC1)

I think that its use can be limited as it may be a problem to renew it and make new ones due to its cost. (BTC3)

Some children may be afraid of masks. Problems may arise if the maintenance of the electronic circuit is neglected. It is a costly product… (STC3)

This sense may be difficult to relate to in younger students, as the material lacks a sense of texture. Because the material is not strong enough, it may be damaged while being carried around or presented to students for examination. (STC24)

It may be hard to carry around. Continuous use can wear and tear as it has an electronic basis. (STC31)

It can be difficult for every student to take advantage of as it is difficult to carry around. The sensitivity of its parts poses the danger of easy deterioration. (STC40)

The second of the open-ended questions teachers asked was, Would you consider using this model while teaching this subject? Why? In reviewing the responses to this question, it was noted that all participants who answered the question indicated that they would use the model. Therefore, a single theme was created. Under this theme, different categories and codes were created and presented in Table 4.

Table 4. *Teacher Candidates' tendency to use the model and their reasons*

Theme	Category	Code	*f*
Reasons for using the model	Developing a positive attitude towards the lesson	Makes the lesson interesting/appealing.	22
		Raises curiosity	9
		Increases motivation.	7
		Pushes students towards active participation	3
		Reduces prejudices against the subject	2
		Makes learning more fun	1
		Makes good memories	1
	Contributing to making the teaching of the lesson more efficient	Allows permanent learning	14
		Concretizes the subject	11
		Allows better understanding/internalization of the subject.	4
		Allows the subject to be understood more easily	2
		It leaves memorizing out of the picture	1
		Makes the teaching of the lesson more efficient	1
	Supporting learning	Helps understanding/grasping of the subject	13
		Endears students to the subject / allows learning by having fun / playing	12
		Provides visual learning	7
		Facilitates learning.	7
		Enables hand-on learning.	3
		Benefits cognitive and psychomotor development	2
		Allows examination and exploration	2
	Supports teaching	Helps with the acquisition of intended learning outcomes	3
		Positively affects the teaching of the lesson	3
		Suitable for wrapping up the subject	1
		Suitable for different education levels	1
		Can be used to evaluate the subject	1
		Facilitates teaching of the subject	1
	Practical	Practicality of the material	3
		Compatible with current technologies	1
		Easily accessible (with QR code)	1
		Shows more than one detail	1

Under the theme of reasons why teacher candidates use the model, the categories of "developing a positive attitude toward teaching," "contributing to making the teaching of the lesson more efficient," "supporting learning," "supporting teaching" " and "practical" came to the fore. The codes "makes the lesson interesting/appealing, raises curiosity, allows permanent learning, concretizes the subject, helps understanding/grasping of the subject, endears students to the subject / allows learning by having fun / playing" from these categories had a high frequency.

Justifications given in Table 4 are similar to the statements given in Table 3 on the "positive effects of the model on teaching". This is a finding that reinforces positive views about the model.

A number of statements from teacher candidates are presented below:

I would use the material when teaching the topic. Because it is a very remarkable material that would help students grasp the subject better. Compatible with today's technologies and accessible by every student thanks to the QR code. (BTC11)

I would indeed consider using it. Because using it would make teaching the subject easier and students would be in a position where they do not just listen but also see, which would go some way towards concretizing the subject. (BTC15)

I would definitely consider using it. For students to see which lobe is activated would help them learn the subject. (STC6)

I would use this material when teaching a class. Because its shape would attract the attention of the students and motivate them to be more active in the classroom. At the same time, students would have something concrete and palpable to make learning more permanent. It is a very good model for concretizing an abstract subject. (STC19)

The material will be useful for students while teaching sensory organs and their functions in the 6th grade. It can be used for easy understanding, internalization and evaluation of the subject. It is also very important to allow students to explore for themselves by touching and examining things. It can also be beneficial in the cognitive and psychomotor development of students. It helps students learn the lesson or subject while having fun. It attracts student attention. For these reasons, I would like to use this material while teaching the subject. Students will definitely want to explore the material. (STC22)

I would definitely consider using it. It would not just benefit student motivation; I would also be more willing to teach. Using the material would help students concretize abstract concepts while having fun, and it would make learning permanent. So I would definitely use such materials. (STC24)

4. DISCUSSION

The purpose of this study is to determine teacher candidates' opinions on the Light and QR-Code Assisted Brain Lobes and their Tasks model, designed to teach students about parts of the brain. The findings of the study were obtained by analyzing the answers given by teacher candidates to the semi-structured interview questions.

First of all, the Material Evaluation Form was applied to the teacher candidates who were asked to examine the developed model in terms of scientific relevance and the suitability of its design elements. In line with the data obtained from the teacher candidates, the scientific relevance mean score of the model was X= 17.96 while the mean score for the suitability of design elements was X= 13.18. It is noteworthy that the scores obtained from the evaluation form for the model are quite high. For this reason, the model can be considered a teaching material that can be used effectively in the teaching of the relevant subject. When the literature is examined, there are studies showing that scientific views on models increase with the increase in education level (Yetim, 2015). Similar results were obtained in a study conducted by Alkan (2015). In the research, a model was developed for the subject matter of mitosis. In order to perform an assessment of the model in terms of its features and proficiency, open-ended questions were used to get opinions from education experts, science teacher candidates and science teachers. When the obtained data were analyzed, it became obvious that teacher candidates mostly made comments about the 'usefulness, compatibility with the learning outcomes and intelligibility' dimensions of the model.

After the evaluation form, semi-structured interview questions were asked to the teacher candidates. Firstly, they were asked, "What do you think are the implications (if any) of using this model in the classroom?". When the answers given to this question were examined, it was seen that the teacher candidates explained the effects of the model on the teaching of the lesson under two themes, positive and negative effects. The categories of "developing a positive attitude towards the lesson", "contributing to making the teaching of the lesson more efficient", "supporting learning" and "supporting teaching" were mentioned by teachers as the positive effects of the model. The literature review shows studies reporting similar results. For example, Gökçe Şahin (2008) found in her research that teaching through modeling had a positive effect on students' attitudes towards the lesson. A study carried out by Özcan (2016), revealed that supporting the biochemistry course with a 3D model contributed to the academic success of the students, the permanence of what was learned, and positive attitudes towards the lesson and motivation. It was also stated by the researchers that by using models in the lessons, it would be possible to actively involve students in the process and to achieve meaningful and permanent learning (Adadan, 2014; Akpınar, 2006; Zangori, Peel, Kinslow, Friedrichsen, & Sadler, 2017). Similarly, there are other studies reporting that the models ensure that the taught subject is concretized in the student's memory (Ayvacı & Bülbül, 2020; Ibiş, 2019; Moeck, Stone Sundberg, Snyder, & Kaminsky, 2014); that they are effective on the permanence of students' knowledge (Minaslı, 2009; Ulusoy, 2011); that they improve the reasoning, interaction and reasoning skills of students (Louca & Zacharia, 2012; Zangori & Forbes, 2016); that they promote students' creativity (Arslan, 2013; Ayvacı, Bebek, & Durmuş, 2015; Maloy, Kommers, Malinowski, LaRoche, & Trust, 2017), and that they increase student participation, attention, motivation and interest (Ibiş, 2019; Kwon, 2017; Sun, Chan, & Meng, 2010).

Teacher candidates summarized the negative effects of the model in categories such as being costly, being impractical, causing misconceptions, and creating negative impacts for the student. A review of the literature shows similar disadvantages about the models. According to Harman (2012), modeling may cause negative effects such as taking a long time, being costly, difficult to use in crowded classrooms, not being able to represent the truth, and not being suitable for every subject, similar to those reported in this study. In a similar vein, the use of models in educational environments causing financial difficulties (Oropallo & Piegl, 2016), their time-consuming nature with their application and preparation stages, there being no precise, accurate and complete models on the subject (Arslan, 2013), the students' inability to understand the modeling process, the nature of the model or the modeling process (Schwarz & White, 2005) were reported as other drawbacks of models in the literature.

Finally, teacher candidates were asked, would you consider using this model while teaching this subject? Why? Examination of the responses to this question revealed that all teacher candidates indicated that they intended to use the model when teaching their respective subjects. Teacher candidates cited the model's contribution to understanding in general, arousing curiosity, enabling permanent learning through concretization of the topic, increasing interest in the lesson and motivation to learn, and the model's usefulness, as reasons for considering to use the model. The literature review revealed studies with similar results. For example, Demirhan and Şahin (2018) aimed to determine the views of teacher candidates on different modeling processes related to various problems. The research found that in general, teacher candidates expressed opinions about modeling activities supporting theoretical knowledge and the retention of knowledge, increasing awareness of knowledge gaps, enabling hands-on learning, and creating an enjoyable learning environment. A study conducted by Berber and Güzel (2009), aimed to determine the perceptions of teacher candidates about the role and purpose of models in science, and to what extent they serve the intended purposes. It was found that teacher candidates are generally aware of the role of models in science. Similarly, Chittleborough, Treagust, Mamiala, and Mocerino (2005) measured students' knowledge about models and modeling at different levels from 8th grade to freshman year. The research determined that as students work their way up the grades, students' understanding of models improves and a better understanding of the role of models is formed. Similar to this study, the researchers stated that the students were aware of the importance of models in science. In a similar vein, Gilbert's (2002) study with teachers, investigated teachers' approaches to models and their attitudes towards the use of models in science teaching. The study found that the teachers gave positive reactions to teaching with models, but that they did not fully understand and apply the concept of modeling.

5. CONCLUSION

In terms of content, science and biology contain abstract concepts. Enabling students to develop an accurate understanding of abstract concepts by concretizing them depends upon the teacher's skills inside the classroom. Models are a great convenience for teachers, being important teaching materials that enable the concretization of abstract concepts (Ayvacı & Bülbül, 2020; Ibiş, 2019; Moeck, Stone Sundberg, Snyder, & Kaminsky, 2014). However, it is difficult for teachers who have little opportunity to develop and use models to support their students in this regard (Khan, 2011; Louca, Zacharia, & Constantinou, 2011). This study intended to elicit the opinions of teacher candidates about models designed to teach brain lobes and their tasks, and in response, teachers expressed many positive opinions. Future studies can contribute to the field by eliciting the opinions of teacher candidates on models developed for different subjects, and by investigating these models' impacts on different variables.

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