caused by one or more unknown factors, and 2) artificial mutation, which is artificially made by known factor. This experiment asks you to learn about spontaneous mutation in *Escherichia coli* and calculate the mutation rate.

What are the possible research questions of this experiment?

Materials and instruments: culture of *E. coli*, nutrient broth, nutrient agar, sterile 0.1 M $MgSO_4$, 40 watt of UV light, sterile Erlenmeyer, 9 tubes which are filled with 9.9 ml of sterile nutrient broth and labeled as K 10^{-2}, K 10^{-4}, K 10^{-6}, L 10^{-2}, L 10^{-4}, L 10^{-6}, D 10^{-2}, D 10^{-4}, and D 10^{-6}, 3 tubes which are filled with sterile nutrient broth and labeled as K 10^{-7}, L 10^{-7} and D 10^{-7}, 6 Petri dishes which are filled with nutrient agar and labeled as NA-1, NA-2, NA-3, and NA-4, 6 Petri dishes which are filled with nutrient agar and 30 mg/l of penicillin (or another antibiotics) and labeled as NAA-1, NAA-2, NAA-3, NAA-4, NAA-5, and NAA-6, sterile tubes, cotton buds, 1 ml and 0.1 ml sterile syringes, 70% alcohol, antibiotics, and tin foil.

Please construct the experiment procedures related to the bacteria spontaneous mutation by using the materials and instruments above

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Science student teachers' ideas about the structure of the ear

Ideas de los estudiantes de licenciatura sobre la estructura del oido

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Abstract

The ear is of great importance for human beings when considered as a sense organ which fulfils the functions of hearing and balance in itself. The purpose of this research was to introduce the learning levels of science student teachers about the structure of ear. The learning levels of science student teachers about the structure of ear were researched by using a drawing technique in line with this purpose. In this research, 125 science student teachers were asked to draw the structure of ear and show the organs on it. Upon the analysis of the drawings made by the science student teachers one by one, it was concluded that most of them had partial understanding of the anatomic structure of ear (45%). However, it was found that some of them had some misconceptions and missing knowledge about where the malleus was found, where the auditory canal was found and what the internal ear, middle ear and external ear organs were in relation to the structure of the ear. It was important to reveal those findings from the science student teachers. The importance of the findings was analysed in detail in the light of the literature. Suggestions were presented in the light of these results.

Key words: ear structure, students' ideas, drawing methods.

Resumen

El objetivo de este estudio es exponer el nivel de comprensión de los candidatos para profesor en ciencias físicas en cuanto a la estructura de la oreja así como las estructuras que se encuentran en ella. Con este motivo se llevó a cabo un estudio sobre el nivel de comprensión de los candidatos respecto a la estructura de la oreja. En este estudio se pidió a 125 candidatos para ser profesor en ciencias físicas, dibujar la estructura de la oreja e indicar los órganos comprendidos en ella. Cuando fueron analizados los dibujos hechos por los candidatos uno por uno, se reveló el resultado de que la mayoría tenía conocimiento parcial de la estructura anatómica de la oreja (45%). Pero se constató que algunos de ellos tenían conceptos erróneos en lo que se refiere a la estructura de la oreja; a la ubicación del martillo, del canal auditivo, y no sabían identificar los órganos del oído interno, medio y externo así como les faltaba ciertos conocimientos. La constatación de estos datos ha sido reveladora. La implicación de estos datos se analizó a la luz de la literatura. Se ofrecieron las propuestas con el fin de ayudar a estructurar la información con vista a eliminar los problemas.

Palabras clave: *estructura de la oreja, ideas de los estudiantes, métodos para dibujar*

INTRODUCTION

It is expected to turn knowledge into behaviour in the meaningful structuring of knowledge. Meaningful learning of the concepts is the process of structuring learning and settlement. Meaningful learning becomes much easier when teachers and students add their own comments. Recently, most of the studies on learning have focused on active learning. The constructivist approach is one of these approaches. During this process, students establish a connection between the knowledge that they have obtained before and the knowledge they have obtained later. The knowledge of each of the students may be different from the others when their past experiences and knowledge are taken into account (Gagnon & Collay, 2001; Michael, 2006). The mental models of the students are of importance in structuring the knowledge (Hatano & Inagaki, 1997). Learning concepts and establishing relations with other concepts is also of great importance in obtaining meaningful learning (Novak & Gowin, 1984). According to Gagnon and Collay (2001), constructivism highlights learning rather than teaching. It takes the mental moulds of the learners into account. It gives importance to the content of the constructed learning. It gives the learners a chance to create new knowledge and comprehension from real experience. Some of the reasons which complicate learning and teaching biological science related topics are listed as: the topic involves invisible biological events and abstract concepts; there are too many interconceptual relations; the concepts in the topic are pronounced very similarly; the topic remains beyond the cognitive levels of the students; and the topic is not suitable for performing tests (Bahar, Johnstone & Hansel, 1999).

In the research which has been done recently about understanding, many techniques are used to set forth the conceptual understanding of the students. Open-ended questions (Eisen & Stavy, 1988), two-tier diagnostic tests (Maier, Wolf & Randler, 2016; Haslam & Treagust, 1987), interviews (Abdullah & Scaife, 1997), concept maps (Novak & Gowin, 1984), word association tests (Bahar, Johnstone & Sutcliffe, 1999) and drawings (Cardak, 2015; Prokop & Fancovicova, 2006) might be given as examples of these techniques. Using drawings to access a student's thinking has been a feature of educational research. Students can present a broad spectrum of ideas through drawings (Rennie & Jarvis, 1995). This is in contrast to what is exposed by standard written texts, where students can repeat what they learned in class without revealing their misconceptions (Scherz & Oren, 2006). Drawings introduce many dimensions of understanding rather than a single dimension. Whether or not the change which is expected during learning occurs can be set forth through the drawings made by the students. The drawing technique is used in order to determine whether the knowledge is meaningfully learned. Research also shows that the drawings of the students are a useful means to reveal the understanding of the students in studies in the science field. (Bahar, Ozel, Prokop & Usak, 2008; Cardak, 2009, 2015; Dikmenli, 2010a; Dikmenli, 2010b; Kose, 2008; Prokop & Fancovicova, 2006).

As a technique for exploring ideas, drawing taps holistic understanding and prevents students from feeling constrained by attempting to match their knowledge with that of the researcher (White & Gunstone, 1992). Thus, science researchers use the drawing technique in order to reveal the understanding of the students. The drawing technique could have some disadvantages besides some advantages just like every technique. Strommen (1995) found that children's drawings of forests yielded less information than interviews. In this study, the researcher found that the students drew a limited number of animal and plant examples rather than different species. It had a limited value in setting forth the species diversity of the living things according to the drawings of the students (Dove, Everett & Preece, 1999). Several researchers used children's drawings to examine their ideas about the digestive system (Cardak, 2015), cell division (Dikmenli, 2010a), carbon cycle (Dikmenli, 2010b), the water cycle (Cardak, 2009), the heart (Bahar et al., 2008), the functioning of plant organs (McNair & Stein, 2001) and the internal structure of animals (Prokop, Prokop, Tunnicliffe & Diran, 2007) in order to reveal the understandings of the students.

In his research on science student teachers understanding about the digestive system and organs in 2015, Cardak revealed some misconceptions about the fact that digestive system learning levels and digestive system organs are disconnected structures and which organs are responsible for digestion. In their study, Bahar et al. (2008) revealed insufficient knowledge and misconceptions about the internal structure of the heart based on the drawings made by the science student teachers. Prokop and Fancovicova (2006) also revealed that a maximum of 47.4% of prospective primary school teachers had such misconceptions about the function of the heart as "heart beating prolongs life".

Recent research has emphasized the importance of teaching anatomy and physiology topics. The preliminary knowledge of the students was of importance while teaching these topics. A limited amount of research has been made about face-to-face, hands-on, constructive laboratories in relation to teaching anatomy and physiology. Many studies were located which explore the use of online or virtual laboratories versus hands-on (Hilbelink, 2009; Johnston & McAllister, 2008; O'Byrne, Patry & Carnegie, 2008). Drawing technique was used not only to reveal the understanding of the students but also as a means of teaching in anatomy and physiology lessons (Clavert, Bouchaib, Duparc & Kahn, 2012; Kotzé, Mole & Greyling, 2012; Naug, Colson & Donner, 2011).

We perceive our environment through our sense organs. We see most things through our sense organs such as eyes, ears, nose, tongue and skin. When considered in this regard, the sense organs in the human body are important. The human body receives alerts from the external environment through the receptors in the sense organs and transmits them to the brain. Being one of our sense organs, the ear is of great importance as it is related to hearing and balance. There are several topics in biology which students have difficulty in understanding. Human anatomy and physiology related topics are among them. Research about ear structure and hearing is limited. In the Turkish education system curriculum, ear structure is taught in several lessons in elementary, middle and high school. Additionally, university science students learn about ear structure in general biology and human anatomy and physiology lessons.

This research aims to reveal the science student teachers' state of understanding the structure of ear. What are the levels of understanding of the science student teachers regarding the structure of ear? Moreover, an answer was sought for the question: What are the misconceptions of the science student teachers about the structure of the ear?

METHODOLOGY

In this study, drawing technique was used in order to reveal the understanding levels of the science student teachers about the internal structure of ear.

Participants

A total of 125 student teachers who are studying at Necmettin Erbakan University Ahmet Kelesoglu Education Faculty participated in this study in Turkey. University science student teachers voluntarily participated in the study. The age average of the student teachers who participated in the research was 20.7 (range = 18–25). Approximately 78% of the participant students were female. However, gender differences were not taken into account in this study. This research was carried out in March 2015. The participants of the research gained their knowledge about the structure of the ear in elementary, middle and high school, social studies, science and technology as well as biology lessons. Additionally, science student teachers learned their knowledge about the internal structure of ear in general biology, human anatomy and physiology and teaching technologies and material design lessons. The ear topic was taught in teaching technologies and material design lessons through model and material design.

Data collection and analysis

The students who participated in the research were asked to draw and show the structure and sections of ear in the human being in an empty A4 paper. The science student teachers were given 30 minutes to draw and show the internal structure of ear. The drawing technique allows the students to reveal their understanding levels deeply and in a detailed manner (Rennie and Jarvis, 1995). There is evidence that student science teachers' drawings may serve as a useful tool for probing their level of understanding of natural phenomena and for identifying the gap between students' misconceptions and scientific ideas (Reiss & Tunnicliffe, 2001; Tunnicliffe & Reiss, 1999). The student science teachers' answers to the drawing activity were analysed using a coding framework prepared by Kose (2008) and Reiss and Tunnicliffe (2001). And then, the drawings were given scores one by one by the researchers. Moreover, the drawings were also evaluated by two different biology and science education experts. The results were compared; score differences about a few cases were opened for discussion, and then a final decision about the scoring was made. The drawings were addressed as a whole and analysed through a scoring method that took the units on the drawing into consideration. The elements on the ear drawings were taken into account rather than the drawing capacities in the evaluation of the drawings. Five understanding levels were determined for the student teachers: no drawing, non-representational drawings, drawings with misconceptions, partial drawings and comprehensive representation drawings. Details of the levels are as follows (Cardak, 2009; Dikmenli, 2010a; Kose, 2008):

Level 1: No Drawing: Students replied, "I don't know," or no response was given to the statement.

Level 2: Non-Representational Drawings: These drawings included identifiable elements of the structure of the ear. In addition, the answers which included diagrams or formulations instead of the drawings were evaluated in this category. This category is illustrated by examples in Figure 1.

Level 3: Drawings with Misconceptions: These types of drawings showed some degree of understanding of the structure of the ear but also demonstrated some misconceptions; however, these were misconceptions held by scientists or stated in science texts. This category is illustrated in Figures 2a and 2b.

Level 4: Partial Drawings: The drawings in this category demonstrated partial understanding of the concepts. Drawings of the structure of the ear were included (Figure 3).

Level 5: Comprehensive Representation Drawings: Drawings in this category were the most competent and realistic drawings of the ear's internal structure (Figure 4). Drawings showing sound understanding contained seven or more elements of the validated response for that particular statement (Table 1).

RESULTS

In this research, in order to reveal the conceptual understandings of the student science teachers from their drawings, levels were created as follows: no drawing, non-representational drawings, drawings with misconceptions, partial drawings and comprehensive representation drawings (e.g. Bahar et al., 2008; Dove, Everett & Preece1999; Reiss & Tunnicliffe, 2001; Simpson & Marek, 1988; Usak, 2005); regarding the knowledge about anatomy of the researchers and the outcomes regarding ear structure mentioned in the Turkish biology/ science curricula. These five categories proved useful for classifying the science student teachers' responses in this study. The categories are shown in Table 1.

Table 1. Levels of science students' conceptual understanding of the structure of the ear

Level	Understanding	N(125)	%
Level 1	No drawing: Students replied, "I don't know," or no response was given to the statement.	4	2
Level 2	Non-representational drawings: These drawings were without identifiable elements of the ear structure. Answers, which included diagrams instead of the drawings, were also evaluated in this category. This category is illustrated in Figure 1.	11	9
Level 3	Drawings with misconceptions (These types of drawings showed some degree of understanding of the structure of ear but also demonstrated some misconceptions Figures 2a and 2b.)	17	14
Level 4	Partial drawings (The drawings in this category demonstrated partial understanding of the concepts. This category is illustrated in Figure 3.)	56	45
Level 5	Comprehensive representation drawings (Drawings in this category were the most competent and realistic drawings of the ear structure. This category is illustrated in Figures 4.)	37	30
Total		125	100

Based on the drawings of the student teachers, the most dominant level was level 4 where partial drawings were made as seen in Table 1 (45%). A total of 45% of the science student teachers made drawings with partial understanding. The category with comprehensive understanding drawings was 30%. The representative drawings of the student teachers were very few (9%). Student teachers know the structure of the ear partially. Additionally, it was clearly revealed that there were some misconceptions and missing information in some drawings (14%). The percentage of the science student teachers who had misconceptions was important. It is necessary to focus on them when we consider the fact that they will become teachers in the forthcoming years. All these results show that the student teachers had some insufficient information about the structure of the ear. Only four of the student teachers did not make drawings.

Drawings were analysed one by one, and the frequency of the organs which were drawn by the student teachers with regard to the structure of ear is shown in Table 2. In the drawings, there were mainly ear structure organs which are mostly responsible for hearing such as pinna, eardrum, ear canal, cochlea, malleus, incus, stapes, eustachian tube, semicircular canals, oval window, hearing nerves and vestibule. Most of the student teachers (82.4%) drew pinna; 62.4% of them drew the eardrum; 56.8% drew the ear canal. Other percentages are shown respectively in Table 2. It was found that student teachers drew the external ear, middle ear and internal ear organs in their drawings.

Figure 1 shows a non-representational level 2 drawing by a science student teacher. The science student teacher drew a diagram instead of a drawing. Figures 2a and 2b show the drawing samples of level 3 student teachers with misconceptions. As is seen in Figures 2a and 2b, the student teachers have misconceptions about the structure and location of the organs of the ear which are responsible for hearing. In Figure 2a, the student teacher thinks malleus, anvil and stapes bones are found in the internal ear. Moreover, the student teacher who made this drawing did not draw the nerves which are responsible for hearing and the semicircular canals in the internal ear. In Figure 2b, on the other hand, the science student teacher thinks the ear path is the eustachian tube. Moreover, this science student teacher drew only malleus which is found in the middle ear. He did not draw the anvil and the stapes bones. Likewise, this student teacher did not draw all the organs in the internal ear which are responsible for hearing. He only drew the cochlea. He did not draw the semicircular canals and hearing nerves.

Table 2. The most frequent structure drawn by students

	N(125)	% from total
Pinna	103	82.4
Eardrum	78	62.4
Ear canal	71	56.8
Cochlea	55	44.0
Malleus	51	40.8
Incus	41	32.8
Stapes	40	32.0
Eustachian tube	33	26.4
Semicircular canals	32	25.6
Oval window	29	23.2
Hearing nerves	19	15.2
Vestibule	17	13.6

In Figure 3, there is a partial drawing (level 4). The student teacher drew the pinna, the eardrum and cochlea in the internal structure, the semicircular canals and the Eustachian tube. However, there are some missing things. This science student teacher had a partial understanding of the structure of the ear (Figure 3). In Figure 4, there is a drawing by the student teacher with comprehensive understanding who did not have any misconceptions. The student teacher drew and wrote the names of more than seven organs. The student teacher fully drew all the organs of the external ear, middle ear and internal ear. All the organs of the ear were in their correct place. In Figure 5, on the other hand, the student teacher only drew the pinna. He did not draw the organs in the middle ear and the internal ear (Figure 5).

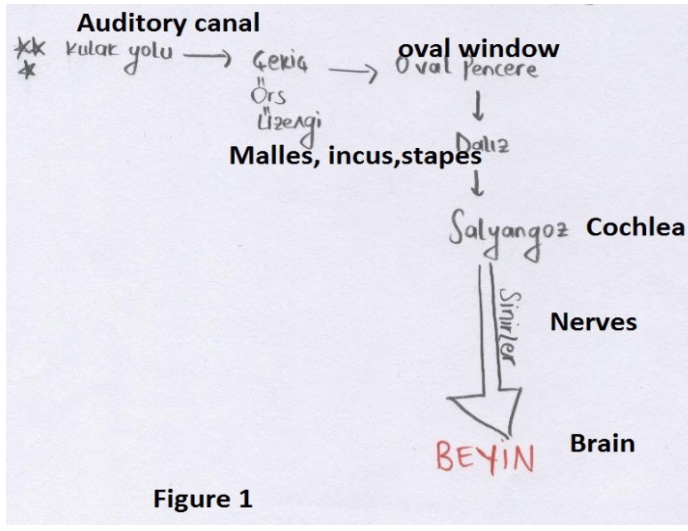
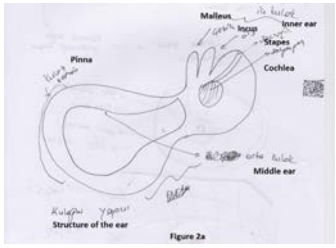
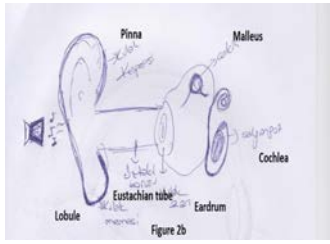


Figure 1. Example of level 2 (non-representational drawing) (Student 35)





Figures 2a and 2b. Examples of level 3 (drawing with misconception) (Student 61 and Student 70)

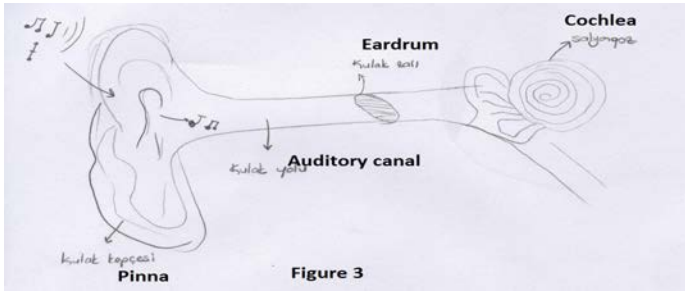


Figure 3. Example of level 4 (partial drawing) (Student 18)

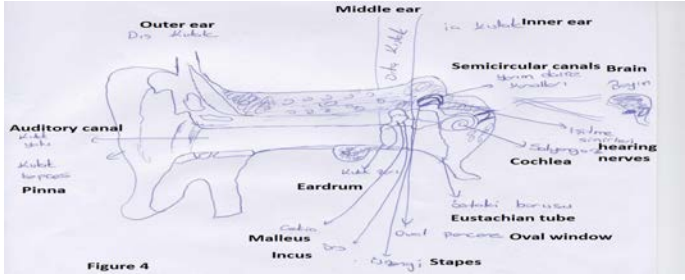


Figure 4. Example of level 5 (comprehensive representation drawing (Student103)

In Figure 6, the student teacher drew the malleus which is in the middle ear on the pinna. And, he did not draw the stapes. The student teacher also had misconceptions about the location of the organs in the structure of ear (Figure 6).

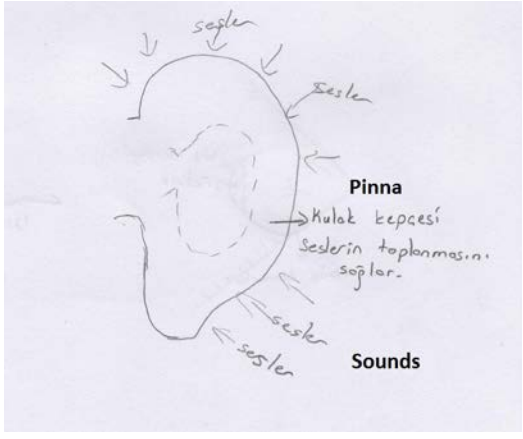


Figure 5. Drawing with misconceptions in relation to the internal structure of ear (Student 42)

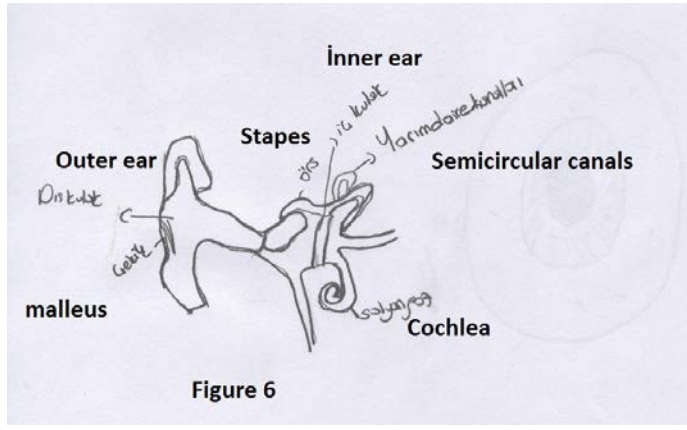


Figure 6. Drawing with misconceptions in relation to the internal structure of ear (Student 56)

DISCUSSION AND IMPLICATIONS

The purpose of this study was to determine the understanding of the science student teachers about the structure of the human ear by using the drawing technique. In general, the findings of this study showed that science student teachers had knowledge with partial understanding. And, they also had some insufficient knowledge and misconceptions about the structure of the ear and the location of the organs. One of the misconceptions of the student teachers was that the malleus is located on the pinna. Another one was that the ear path was shown as the Eustachian tube. Also, some of the student teachers drew the malleus, anvil and stapes bones within the internal structure borders. Additionally, another student drew sound entering from the internal ear and hearing starting from the internal ear. In this research, nearly half of the student teachers (45%) had partial understanding (Figure 3). The student teachers with partial understanding were those who could not fully draw all the elements which are scientifically acceptable. They showed less than seven organs in the structure of the ear. A total of 30% of the student teachers made comprehensive drawings. These student teachers were those who showed at least seven of the organs of the ear. The results of this study showed that the drawing technique was effective in revealing the understanding conditions as in the other studies (Bahar et al., 2008; Cardak, 2015; Dikmenli, 2010a; Kose, 2008; Prokop et al., 2007).

As we have previously mentioned, the drawing method had some advantages as well as disadvantages in revealing the understanding levels of the student teachers (Dove et al., 1999).In this study, the science student teachers were informed about the drawing method, and a practice session was done. However, it seems that the limitations of the method may have caused difficulties since the drawing of the structure of the inner ear may require more skills than drawing an ordinary concept.

One reason why the science student teachers had all these misconceptions and insufficient knowledge could originate from the teaching methods and techniques used, for misconceptions are quite resistant to change (Bahar, 2003; Pfundt & Duit, 2004). Wandersee, Mintzes and Novak (1994) state that misconceptions cannot be removed by traditional teaching strategies. Additionally, forming and correcting mental maps and models through constructivism and hands-on learning is extremely advantageous (Wandersee, Mintzes & Novak, 1994). In most of the education level in Turkey, teachers and lecturers use mainly teacher-centred strategies that promote memorization and reproduction of knowledge on the day of examination where the multiple choice format is mainly used (Bahar et al, 2008; Bahar, 2003). Recently, there has also been research about the effectiveness of the of use of face-to face, hands-on, constructive laboratories, drawing technique in teaching anatomy and physiology topics (Clavert et al., 2012; Kotzé, Mole & Greyling, 2012; Naug, Colson, & Donner, 2011). Some research even revealed that online and virtual laboratories should be used (Hilbelink, 2009; Johnston & McAllister, 2008; O'Byrne, Patry & Carnegie, 2008).

The teaching strategies in which student teachers will be more active should be used in order to avoid the misconceptions about the internal structure of the ear and minimize and change the missing knowledge and

misconceptions of the student teachers. Learning by doing and through experience, face-to-face, hands-on learning strategies will be effective in preventing and changing misconceptions. Primarily, it is necessary to determine the misconceptions in order to change the misconceptions of the students. Moreover, teaching technologies and virtual reality techniques are certainly effective in teaching internal ear structure topics and providing conceptual change in order to assist meaningful learning. Missing knowledge and misconceptions can also be eliminated by using exploring creative constructivist approach strategies where students are active during teaching. When we consider science student teachers as teachers of the future, the importance of misconceptions becomes greater and misconceptions should be eliminated. Being an important source of knowledge for students and to be most effective, teachers should teach by using face-to-face, hands-on, virtual laboratory, online laboratory etc. activities in teaching anatomy and physiology lessons.

CONCLUSION

In general, the findings of this study showed that science student teachers had knowledge with partial understanding. And, they also had some insufficient knowledge and misconceptions about the structure of the ear and the location of the organs. One of the misconceptions of the student teachers was that the malleus is located on the pinna. Another one was that the ear path was shown as the Eustachian tube. Also, some of the student teachers drew the malleus, anvil and stapes bones within the internal structure borders. Additionally, another student drew sound entering from the internal ear and hearing starting from the internal ear. In this research, nearly half of the student teachers (45%) had partial understanding (Figure 3). The student teachers with partial understanding were those who could not fully draw all elements which are scientifically acceptable.

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