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Investigating Science Student Teachers' Ideas about Function and Anatomical Form of Two Human Sensory Organs, the Eye and the Ear

Halil Kunt
Dumlupınar University, Faculty of Education, Kutahya, TURKEY

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The purpose of this research was to determine science student teachers' level of knowledge about the anatomical structure of two sensory organs, the eye and the ear, in addition to vision and hearing processes. Conducted with 86 science student teachers, research utilized drawing methods and open-ended questions as data collection instruments. The results showed that when science student teachers' answers with regard to vision and its structures compared with their answers concerning hearing and its structures, their success rate was higher for hearing and its structures. Even though students were sufficiently informed about the anatomical structures constituting eyes and ears, it was observed that a significant percentage of the students were incompetent with regard to their understanding of how seeing and hearing takes place and correctly showing the anatomical structures constituting both eyes and ears on a schema. Human organ/organ system education may contribute to an increase in teaching capacity.

Keywords: ear, eye, vision, hearing, student teachers' ideas.

INTRODUCTION

There are many ways to gather information about students' understanding of conceptual events (White & Gunstone, 2000). Concept mapping (Hazel & Prosser, 1994), interviews about instances and events (Osborne & Cosgrove, 1983), interviews about concepts (Abdullah & Scaife), word association (Bahar et al, 1999; Maskill & Cachapuz, 1989), open-ended questions (Eisen & Stavy, 1988) and drawings (Kunt, 2013; Martlew & Connolly, 1996; Prokop et al 2006) can be given as examples of these methods. Drawings are a simple research instrument that can provide easy comparison, and in science fields they are used as beneficial research methodology to understand common mistakes and alternative concepts (Bahar et al., 2008; Bowker, 2007; Köse, 2008; Prokop and Fanèovièová, 2006). While many children dislike answering questions, they can complete drawings easily, in an

Correspondence: Halil KUNT,
Dumlupınar University, Faculty of Education, Kutahya, TURKEY
E-mail: halilkunt@gmail.com
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enjoyable and quick way (Pridmore & Bendelow, 1995). Also, drawing is a beneficial alternative means of expression for children who have difficulty expressing their ideas verbally (Rennie & Jarvis, 1995).

Many studies have been done to investigate human anatomy and especially children's understanding of human body functions (Gellert, 1962; Nagy, 1953), cell biology and genetics (Flores et al., 2003; Lewis & Wood-Robinson, 2000; Marbach-Ad & Stavy, 2000), and whole body (Prokop & Fančovičova, 2006; Reiss & Tunnicliff, 2001; Reiss et al., 2002). Some researchers studied children's ideas about organs or organ systems, such as the brain and the mind (Johnson & Wellman, 1982), digestive system (Rowlands, 2004; Teixeira, 2000), urinary system (Tunnicliff , 2004), skeleton (Tunnicliff & Reiss, 1999a) or heart (Bahar et al., 2008).

According to these studies, even though the heart is one of the most talked about organs, university students have many misconceptions about its function (Prokop and Fančovičova, 2006). They also suggest that drawing is more effective that most other methods in revealing students' knowledge about size, shape and location of internal organs. As stated by Bahar et al., (2008) when science student teachers' drawings of the internal structure of heart were being investigated it was observed that many student teachers have both incorrect and insufficient knowledge with regard to this organ.

From past to present, the studies related to the five senses have been carried out with young age groups and focused on the conceptualization of sense organs and comprehension of these concepts. Collis et al (1998), in their study designed to investigate the understanding of visual phenomenon in children, emphasized conceptualization of vision and understanding of visualization. They asked students to explain what they saw after giving them some shapes to contemplate and investigated their answers. Mazens and Lautrey (2003) studied children's conceptual understanding of sound and sought to explore the nature and structure of sound.

In the present study, science student teachers' understanding of structures and functions of the eye and the ear were studied. Student teachers may transfer their own incomplete and/or incorrect understanding to their students due to their lack of understanding and education or un critical use of textbooks. (Bahar, 2003; Barras, 1984; Sanders, 1993; Wandersee et al., 1994). Therefore, student teachers' undergraduate education is of great importance in preventing these misconceptions. This research aims to investigate science student teachers' knowledge of sight and anatomical structure of the eye in addition to hearing and anatomical structure of the ear by using drawings and open ended question methods.

METHOD

Sample

The study was carried out with 86 science student teachers who were active students during the 2012-2013 academic year. 73 of these student teachers were female while 13 of them were male. Due to the significant difference in numbers between the genders this research did not focus on gender differences. The age of the participants varied between18 to 22. These students received high school education from different schools, from primary to high school and during their undergraduate education they were given enough information concerning sight and hearing and the structures constituting them that they were expected to have a certain level of competency in this regard.

Data collection instruments

Drawing methodology (e.g. Bahar et al, 2008; Dove et al., 1999; Reiss & Tunnicliffe 2001; 2002) and open-ended questions (Leach, Driver, Scott & Wood-Robinson, 1995) were used as a data analysis method.

Research was done in four stages

Level 1: At this stage, students were asked to respond to the following scenario.

"While driving in the morning, a car appears right in front of you. From the moment you see the car, until you hit the brake, list the structures which will be used during eye-leg perception of sense of sight and nervous system-target organ signal delivery process".

At this level students' understanding of how seeing takes place is evaluated.

Seeing: Light, cornea, pupilla, lens, retina, cone cell, n. opticus, brain, occipital cortex, efferent nerve.

Level 2: At this stage, students were asked to correctly denote the layers of the eye and draw the shape of it and show the parts of it on the figure. At this level, students are evaluated with regard to their knowledge of anatomical structures constituting eyes and their locations. (Figure 1)

Layers of eyeball: Tunica fibrosa, tunica vasculosa, tunica nervosa.

Eye figure: Cornea, iris, pupilla, lens, sclera, corpus ciliare, retina.

Level 3: At this level, students were asked to respond to the following scenario.

"While you are walking, from the moment you hear the voice of a friend calling you from behind until you stop walking, list the structures which will be used while the perception of sound sense takes place between ear and brain as the nervous system delivers a signal to stop to the target organ".

At this level students' understanding of how hearing takes place is evaluated.

Hearing: Audio, tympanic membrane, structures in tympanic cavity (malleus, incus, stapes), perilymph, endolymph, stimulation of corti organ, n. cochlearis, brain, efferent nerve.

Level 4: At this level, students were asked to correctly denote the parts of the ear, draw its shape and show the parts of it on the figure. At this level, students are evaluated with regard to their knowledge of anatomical structures constituting the ear and their locations. (Figure 2)

Parts of ear: External ear, middle ear, internal ear

Ear figure: Auricular**,** tympanic membrane, structures in tympanic cavity (malleus, incus, stapes), sacculus, cochlea, utriculus, canales semisirculares.

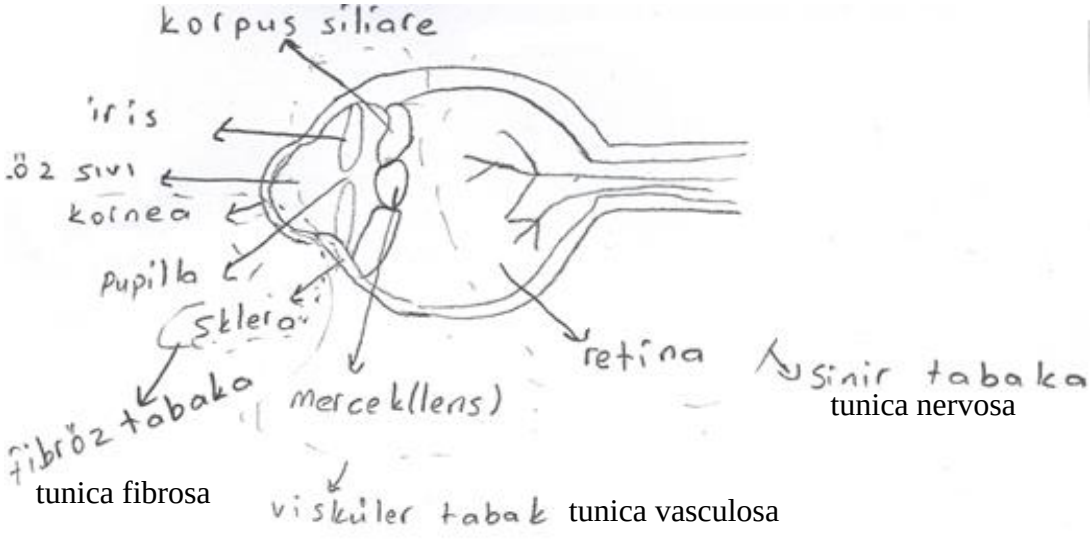

Figure 1: A students drawing evaluated of the eye.

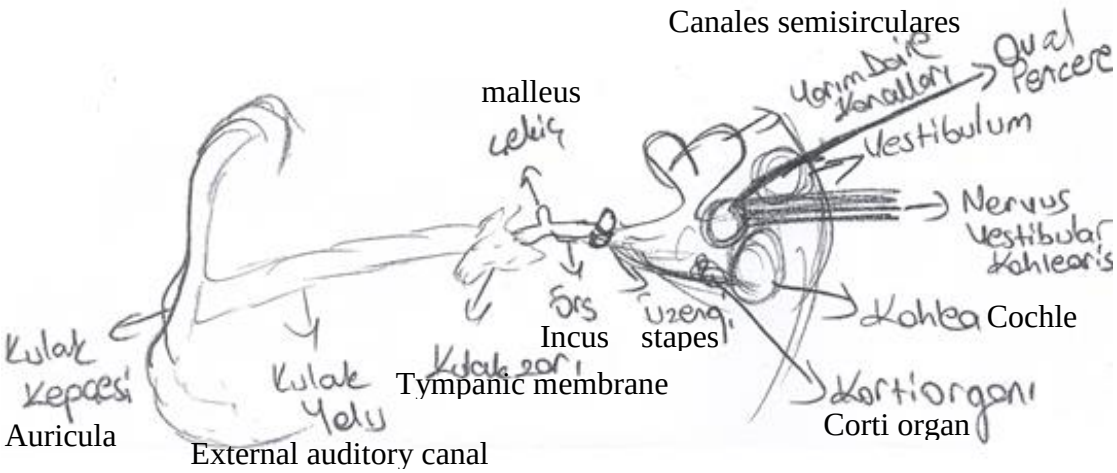

Figure 2: A students drawing evaluated of the ear.

RESULTS

For this research, the evaluation of students' success was inspired by previous research (Bahar et al, 2008; Prokop & Fančovičova, 2006; Reiss & Tunnicliffe, 2001). For example, the correct denoting of eyeball's three layers and seven structures was determined by the eye drawing in describing the vision event and if a student had written and shown nin of these structures correctly his/her score would be nine (Figure 1).

In Table 1, students' knowledge about vision and the structure of the eyes is presented. Although science student teachers understand the anatomical structures of the eye to a sufficient degree, it was observed that a significant majority of them had either wrong or insufficient knowledge about how seeing takes place and ability to show the structures constituting the eye on the figure.

In Table 2, students' knowledge about hearing and ear structure is identified. Science student teachers' knowledge scores with regard to hearing, structures constituting the ear and showing these structures on the schema were higher than their knowledge scores about seeing, structures constituting the eye and showing these structures on the schema. However, it was observed that the noticeable majority of the student teachers had either incorrect or insufficient knowledge about how hearing takes place and ability to show the structures constituting the ear on the figure.

Table 1. Students' competencies with regard to knowledge of vision and eye structures

	Knowing how seeing takes place	Knowing the structures constituting the eye	Being able to show the structures constituting the eye on a figure
N	86	86	86
Mean	2.6±3.2	7.1±2.2	3.1±2.4
Min-Max	0-10	3-10	0-9

Table 2. Students' competencies with regard to the knowledge of hearing and ear structures

	Knowing how hearing takes place	Knowing the structures constituting the ear	Being able to show the structures constituting the ear on a figure
N	86	86	86
Mean	4.7±3.2	7.5±1.8	4.4±2.0
Min-Max	0-10	3-10	0-9

In Table 3, students were compared based on their scores with regard to their knowledge about seeing and the structure of the eye, scores were grouped under two categories (0-4 score range and 5-10 score range). When the findings were analyzed, 73 (84.9%) of the science student teachers scored within the 5-10 score range knew the structures constituting the eye, while 20 (23.3%) of them were able to show the location of these structures and 18 (20.9%) of them knew how seeing occurs. The results showed that, students knew the structures constituting the eye, yet they did not know what these structures do or where they are located. With its layers and structures, the eye is one of the most complex human body parts and this characteristic may be the cause of some of the confusions students have on this topic.

In Table 4, students were compared based on their scores with regard to their knowledge about hearing and the structure of the ear, scores were grouped into two categories (0-4 score range and 5-10 score range). Analysis of the findings showed that 78 (90.7%) of the science student teachers scoring within 5-10 score range knew the structures constituting the ear, while 45 (52.3 %) of them were able to show the location of these structures and 58 (67.4%) knew how hearing takes place. Results show that science student teachers' knowledge of hearing and how hearing takes place was better than their knowledge of seeing and how seeing occurs. This situation may be explained by the relative ease of listing the parts of the ear as external, middle, and internal as well as the distinctive characteristics of the ear figure with pinna, eardrum and ear bones making these structures more known and preventing confusions with other structures. Among the 58 (67.4%) students who scored within 5-10 score range with regard to knowing how hearing occurs, only 39 (35.3%) of them were also able to demonstrate the structures constituting the ear correctly and out of the 45 (52.3%) students who were able to show the structures constituting the ear on the figure only 32 (37.2%) of them scored within the 5-7 score range. Below these level misconceptions were more frequent.

Table 3. Frequency distributions of students' knowledge scores with regard to seeing and eye structures

	Knowing how seeing takes place	**Knowing the structures constituting the eye**	**Being able to show the structures constituting the eye on a figure**
Score between 0-4 N (%)	68 (79.1%)	13 **(**15.1%**)**	66 **(**76.7%**)**
Score between 5-10 N (%)	18 (20.9%)	73 **(**84.9%**)**	20 **(**23.3%**)**

Table 4. Frequency distributions of students' knowledge scores with regard to hearing and ear structures

	Knowing how hearing takes place	**Knowing the structures constituting the ear**	**Being able to show the structures constituting the ear on a figure**
Score between 0-4 N(%)	28 (32.6%)	8 (9.3%)	41 (47.7%)
Score between 5-10 N(%)	58 (67.4%)	78 (90.7%)	45 (52.3%)
Frequency of some scores			
0	19 (22.1%)		5 (5.8%)
5	23 (26.7%)		10 (11.6%)
6	0		17 (19.8%)
7	16 (18.6%)		5 (5.8%)

DISCUSSION AND CONCLUSION

One of the most important reasons for students' mistakes is that their teachers make the same mistakes (Bahar, 2003; Sanders, 1993). Considering that fact that the participants of this research will be teachers in one year, importance of correcting the misconceptions of the student teachers and providing a better undergraduate education for them to prevent the transfer of these misconceptions to new generations become clear. This study was undertaken in order to investigate science student teachers' ideas about vision and the structure of the eye as well as hearing and the structure of the ear by using drawing methods and open-ended questions. The results attained from this study were beneficial to classification of the student teachers' knowledge levels with regard to vision and hearing in addition to their anatomical structures. When science student teachers' answers with regard to vision and its structures are compared with their answers concerning hearing and its structures, it was seen that their success rate was higher for hearing and its structures. Even though for both organs students were sufficiently informed about the anatomical structures constituting eyes and ears, it was observed that a significant percentage of the students were incompetent with regard to their understanding how seeing and hearing takes place and correctly showing the anatomical structures constituting both eyes and ears on the schema. The majority of students were not able to build connections between the structures of the eye and ear with their locations and functions. In general, the most common misconceptions are misrepresentation of the sequence of the structures in seeing (after the lens directing light on the iris and then from iris connecting it to the brain directly, or without listing any intermediate structures transferring light from the eyes to the brain etc.), mixing up the location of the structures while showing the parts of the eye on the figure (showing wrong locations or randomly displaying them etc.), mixing up the order of the structures in hearing (ear bones being represented in front of the ear drum etc.), and while locating the parts of the ear on the figure mixing up their positions (wrong or random representations etc.).

These findings were unanticipated, since over primary, secondary and undergraduate education, all educational program curricula teach the five senses. This situation indicates that most of the knowledge students attained during this training was memorized, because, even though they knew the names of these structures in theory, they did not know their functions or could not show their location on a figure. One of the reasons behind all these mistakes and lack of knowledge might relate to teaching methods and these misconceptions are quite resistant to correction and elimination by traditional teaching methods (Bahar, 2003; Wandersee et al.,1994). In Turkey, in most schools and universities, teachers and faculty members use teacher center educational strategies and multiple choice format tests used in these learning environments to encourage the memorization and reproduction of knowledge (Bahar, 2003, Prokop et al., 2007; Usak, 2005). Practicing teaching only in a theoretical way without application reduces the level of learning and sustainability of the knowledge. For this reason, it is necessary to use student-centered teaching strategies allowing students to be mentally and physically involved (Riemeier & Gropengießer, 2008) such as conceptual maps and networks (Tekkaya, 2003) and computer technologies (Cepni et al., 2006; Yesilyurt & Kara, 2007). In addition to these teaching strategies, especially while teaching human anatomy by investigating the organs of different living organisms in laboratories, using tactile, visual and auditory senses, and analog hands-on activities, correct and more sustainable knowledge and learning experiences might be provided for the students (Kunt, 2013).

In summary, science student teachers were competent in the anatomical structures constituting eyes and ears; however, it was detected that they also had

many misconceptions and insufficient knowledge with regard to functions and locations of these structures. Application based teaching particularly, in addition to the new teaching strategies in human organ/organ system education may contribute to increase in learning these subjects.

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