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SCIENCE STUDENT TEACHERS' IDEAS OF THE HEART

**Mehmet Bahar, Murat Ozel,
Pavol Prokop, Muhammet Usak**

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© Pavol Prokop

© Muhammet Usak

Abstract. *The purpose of this study was to find out the level of science student teachers' understanding about the internal structure of the heart. The drawing method was applied to achieve this purpose with 120 third year science student teachers. The analysis of their drawings revealed that the majority of the science student teachers have several misconceptions as well as inadequate knowledge in terms of the heart's internal structure. The importance of the findings was critically analysed in the light of the literature, and some suggestions were proposed to remedy the emerged problems.*

Key words: *heart structure, drawing method, students' ideas.*

Introduction

There are many ways of obtaining information about students' understandings of scientific phenomena (White & Gunstone, 2000). The open-ended questions (Eisen & Stavy, 1988), the two-tier diagnostic test (Haslam & Treagust, 1987), concept mapping (Novak and Gowin, 1984; Novak, 1990), prediction-observation-explanation (Liew & Treagust, 1995), interviews about instances and events (Osborne & Cosgrove, 1983), interviews about concepts (Abdullah & Scaife, 1997), drawings (Martlew & Connolly, 1996; Prokop & Fančovičová, 2006; Erdogan & Erentay, 2007) and word association (Bahar, Johnstone & Sutcliffe, 1999; Maskill & Cachapuz, 1989) can be given as the example of these methods. Although each of these approaches has its own particular advantages and disadvantages and a useful distinction has been made between phenomenological and conceptually based approaches (Driver and Erickson 1983), one underused technique is that of eliciting ideas through children's drawings (Dove, Everett & Preece, 1999).

Drawings have been considered as a simple research instrument that enables easy comparisons at the international level (Reiss *et. al.*, 2002). While many children dislike answering questions, drawings can be completed quickly, easily and in an enjoyable way. Children's drawings provide a 'window' into their thoughts and feelings, mainly because they reflect an image of his/her mind (Thomas & Silk, 1990; Pridmore & Bendelow, 1995). As a technique for exploring ideas, drawing taps holistic understanding and prevents children from feeling constrained by trying to match their knowledge with that of the researcher (White & Gunstone, 2000). It is also a useful alternative form of expression for children who have difficulty expressing their thoughts verbally (Rennie & Jarvis, 1995). Moreover, some ideas, for example the environment

Mehmet Bahar

Abant İzzet Baysal University, Turkey

Murat Ozel

Gazi University, Turkey

Pavol Prokop

Trnava University, Slovakia

Muhammet Usak

Dumlupınar University, Turkey



or the human figure, are more easily communicated through drawing than written descriptions (Dove *et al.*, 1999).

White and Gunstone (2000) found that using drawings to probe understandings was a useful approach in researching children's learning. Drawings enabled them to visualize and reveal to the child and teacher 'qualities of understanding' that can be hidden through other research procedures. They explain how people readily think in images long before thinking in words and they expand upon this noting how humans tend to feel more satisfied if they can translate words into images. They also point out how 'complex notions are often represented by familiar, everyday images' in science.

On the other hand, as any other methods, it can surely be said that the drawing method has some limitations despite its advantages. Strommen (1995) found that children's drawings of forests yielded less information than interviews. In his study, children tended to draw multiples of a single type of animal or plant, rather than different species. This would suggest that drawings are of limited value in detecting children's ideas about species diversity. Another difficulty is that drawing is an open technique and consequently is difficult to score reliably (White and Gunstone, 2000). Also, what children produce is partly limited by their drawing ability; they may well have left something out because they could not draw it, or felt disinclined to bother (Dove *et al.*, 1999). As Arnold *et al.* (1995) note, although children may understand a concept, this does not necessarily mean that they can be able to draw it accurately. Also, where on the paper children choose to start the drawing can influence how they use the space available. Additionally, the drawings of the students might be misinterpreted by researchers if no additional method, such as interview, is used.

Various researchers used children's drawings to examine their ideas about the water cycle (Dove *et al.*, 1999), functioning of plant organs (McNair and Stein, 2001), the internal structure of animals (Prokop *et al.* 2007), and endangered species (Erdogan & Erentay, 2007). Many other researchers (Aronsson & Andersson, 1996; Guichard, 1995; Palmberg & Kuru, 1998; Tunnicliffe & Reiss, 1999) have used drawings in order to provide empirical data.

Several studies explore children's concepts about the human body. Gellert (1962) stated, in his study on students of 4 to 16 years old about the human body functions, that they had such misconceptions as "the heart is used for breathing". Prokop and Fančovičová (2006) also revealed that a maximum of 47.4% of the prospective primary school teachers had such misconceptions about the function of the heart as "heart beating prolongs life".

Both Gellert (1962) and Reiss & Tunnicliffe (2001) state that even very young children are typically informed about heart. Reiss & Tunnicliffe (2001, p. 396) reported that:

"...Interestingly, such hearts are often shaped as on Valentine's cards. We do not know for certain whether students think that this is what a heart literally looks like or whether in some cases they are representing the heart symbolically or as a shorthand derived from cards, cartoons or advertisements. However, the fact that several of the Year 9 and English undergraduates drew hearts thus suggests strongly that such hearts were intentionally being depicted in a non-anatomically correct fashion..."

Similarly, in their studies with 24 students (3-5 years old), in which face-to face interviews and drawings were used, Gatt & Saliba (2006) revealed that only 3 students could identify the right place of the heart; that only 4 students could identify the right figure of the heart and that most of the students believed that the content of the heart was blood, air and food. They also added that the knowledge of students about the heart didn't change as they grew older. On the other hand, some researchers (eg., Reiss & Tunnicliffe 2001, Reiss, *et al.*, 2002) who used drawings to examine the knowledge of children of various age groups about human organs and organ system stated different opinions. They asked children to "draw what you think is inside your body", then each of the drawings was hierarchically categorized in order to distinguish between drawings of different levels. They also recorded organs and organ systems drawn. They found that children's knowledge about the human body measured by the level of drawing increases with age; they also reported that the frequency of some organs or organ systems being drawn was significantly different. For example, organs from the circulatory system (mainly the heart) were observable in 93 % of drawings, organs from skeletal, nervous, respiratory, digestive and other systems followed. Reiss & Tunnicliffe (2001, p. 395) concluded that "...we hope that each student drew



much (ideally, all) of what they knew about the anatomy of their internal structure but we admit we have no formal evidence for this." Thus, it was suggested that children's drawing expressed their mental model about the human body. However, this approach was criticized by Khwaja & Saxton (2001) who conducted a simple experiment in which they first asked 10 year old children to "Draw what you think is inside your body" and subsequently they asked the same children to "Draw the bones that are inside your body". They found that the skeletal system was more frequently drawn after the 'second instruction' and the level of skeletal system drawn was conspicuously higher. Thus, the type of instruction seems to be a significant factor influencing quality of children's drawings about the human body.

Prokop and Fančovičová (2006) stated that considerable number of the university students had the misconceptions about the function of the heart even though the heart was the most mentioned organ of the human body. Thus, the understanding of pre-service science school teachers' concepts about the internal structure of the heart is an important area of research into pre-service science school teachers' ideas.

In the Turkish education system, pupils are taught about the circulatory system (and heart structure) not only in the primary but also in the secondary school level. In addition, students who are receiving their education at university level to become science teachers in university level are also taught about the circulatory system and heart structure in their biology courses in detail. This study aims to reveal the misconceptions of science student teachers regarding the internal structure of the heart. Several research studies (eg., Arnaudin and Mintzes, 1985) indicated that children at almost every level may have misconceptions about the circulatory system. As stated by Bahar (2003) one of the reasons behind misconceptions that students have in primary and secondary school levels is that the teachers may have the same misconceptions as their students. Therefore, revealing the preservice science teachers' misconceptions about the heart's internal structure and discussing possible implications of the findings may induce awareness of the misconceptions among teachers. The results of the present study will provide several ideas to teachers about teaching methods used for teaching heart and its structure. In this study, the drawing method was used to achieve all these aims.

Methodology of Research

A total of 120 third year science student teachers who were studying in the department of science teaching, at the Faculty of Education in Pamukkale University participated in this study. Their age ranges from 18 to 23 years. The majority of pre-service primary teachers were females (58.3%). But our study was not focused on gender differences. Participants had been previously studying at various high schools and all of them had biology as a school subject during which they learned about human transport systems. All the participants had biology classes during 5 terms at the years of the 2nd, 3rd and the 4th (There are two terms in each year). They were taught the circulatory system including the heart and other systems in both Biology II and Biology IV-anatomy courses; the former was in their 2nd year and the latter was in the second half of their 3rd year.

This research was conducted during the "Science-II" lesson, which takes place in the third year of the science teacher teaching programme in May 2007. In this lesson, the pre-service primary school teachers were informed generally about instruction methods like concept mapping, conceptual change texts, drawings and some practices are applied.

The research was conducted in two phases. In the first phase, during a lesson hour (45 min.), science student teachers were given necessary information about the drawings and sample activities. In the second phase, some drawings were made about the structure of the animal cell and the place of some human organs and organ systems. The pre-service teachers were asked to exchange their drawings and complete the missing parts of each other until the end of the lesson. Then, their drawings were re-changed. At the end of the lesson, ready-made pictures were demonstrated and they were asked to compare their own drawings with them. In this way, pre-service teachers' deficiencies in these subjects were highlighted.

In the second phase, science student teachers were told to draw to show their own ideas about the heart. They were asked to work individually and not to perceive the tasks as tests with right or wrong answers. They were given 20 min for the task to reduce the risk of copying from those finishing early or



drawings being inspired by their neighbours' ideas. Then all the drawings were scored independently by every researcher. The scoring results were compared; the differences about a few cases were opened for discussion and then a final decision about the scoring was made.

Results of Research

Three levels of conceptual understanding were identified for this investigation as a rubric: *non-representational drawings*, *partial drawings* and *comprehensive representation drawings*. The ranking was inspired by previous work in the field (e.g. Simpson & Marek, 1988; Dove *et al.*, 1999; Reiss & Tunnicliffe, 2001, Uşak, 2005); the knowledge about anatomy of the researchers and the outcomes regarding heart structure mentioned in the Turkish biology/science curricula. These three categories (Table 1) proved useful for classifying the science student teachers' responses in this study. The results of the science student teachers according to the three levels are given in Figure 1.

Table 1. Three point scale used for scoring the heart's internal structure.

Level 1	Non-representational Drawings: These drawings were without identifiable elements of the heart's internal structure. Answers, which included diagrams or formulations instead of the drawings, were also evaluated in this category.
Level 2	Partial Drawings: The drawings in this category demonstrated partial understanding of the concepts. Drawings of heart's internal structure were included.
Level 3	Comprehensive Representation Drawings: Drawings in this category were the most competent and realistic drawings of the heart's internal structure (Figure 4 a, b). Drawings showing sound understanding contained seven or more elements of the validated response for that particular statement (Table 2).

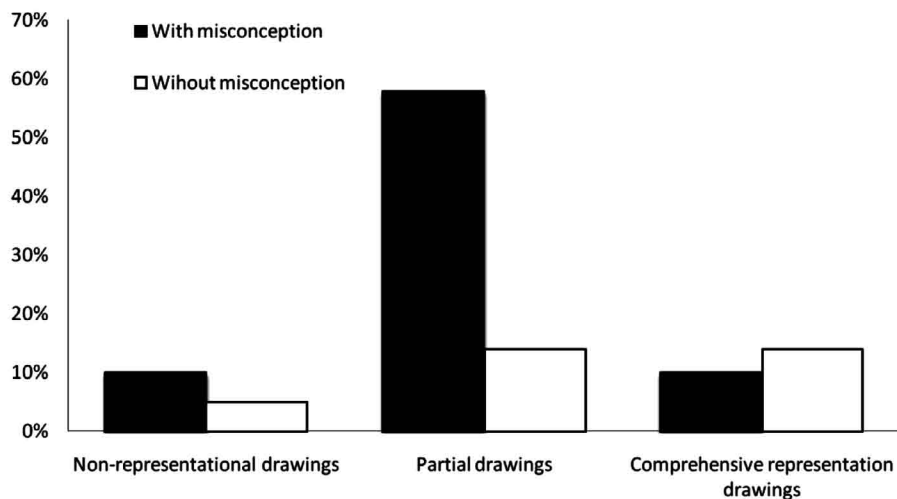


Figure 1. Levels of pre-service science teachers' conceptual understanding for heart internal structure.

As can be seen from Figure 1, although the number of students in the non-representational drawings category is not high, the significant percentage of the science student teachers had misconceptions in all categories especially in the partial drawings. In addition, the total number of science student teachers in comprehensive representation category was not high. All these results imply that the majority of the science student teachers had several misconceptions as well as inadequate knowledge in terms of heart internal structure.



Figure 2 shows two drawings of student teachers at the non-representational level and Figures 3a-b show two examples at drawing level 2 (partial understanding with misconceptions).

As seen in Figure 3a, the student teacher could show with arrows that the blood coming from the lungs and aorta artery first passes from the atria to the ventricles and then disperses to the whole body. In Figure 3b, on the other hand, another student firstly got confused with the left and right parts of the heart, but then could show with arrows as in 3a that the blood goes from the atria to the ventricles and then disperses to the whole body.

In Figure 4a and 4b, shows examples of drawings for the third category (comprehensive representation drawings with and without misconceptions)

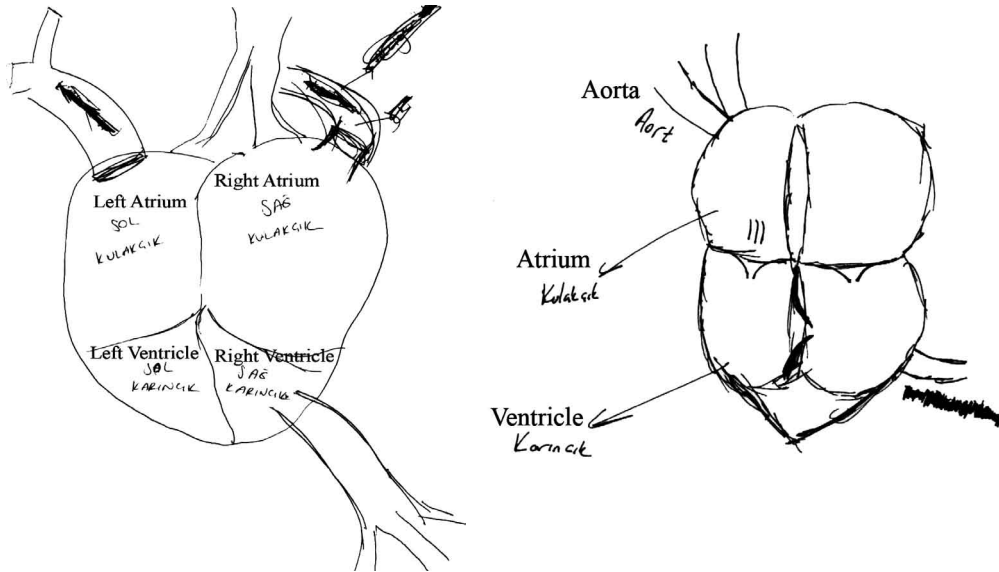


Figure 2. Two drawings at the non-representational level.

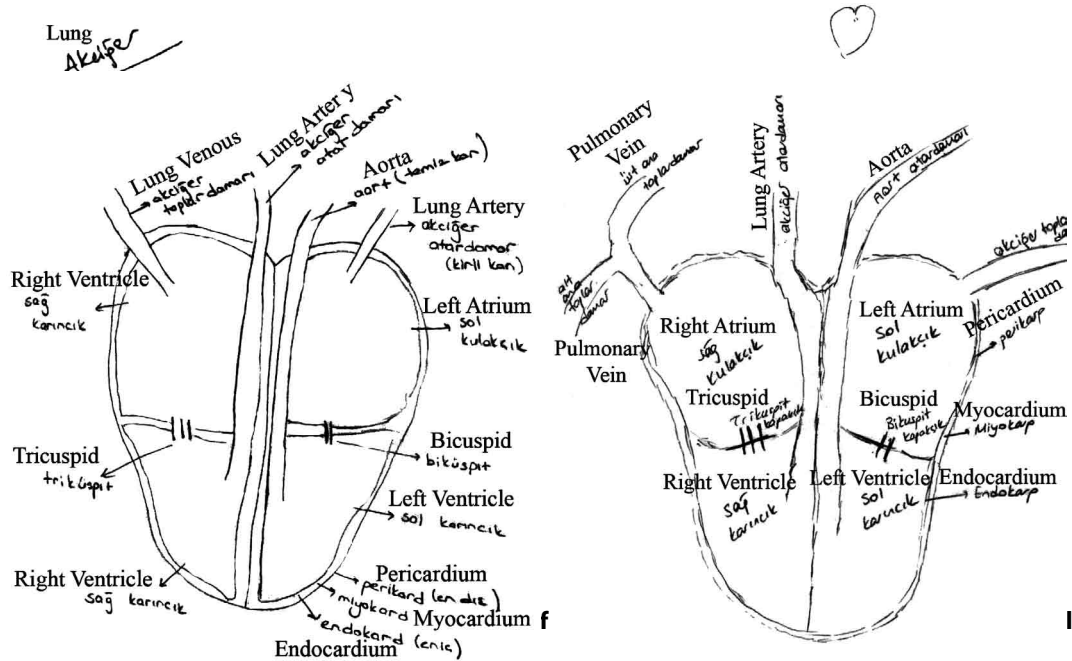


Figure 4. Drawings of the heart's internal structure for level 3 (comprehensive drawings).



Table 2 shows the terms related to the heart's internal structure used by the student teachers in their drawings. Right atrium, left atrium, right ventricle and left ventricle were used in more than 90% of the drawings, while tricuspid and bicuspid were used more than 50% and pulmonary vein was used 50%. On the contrary, pulmonary artery, aorta, superior vena cava, inferior vena cava, aorta vein and vena cava were the least used elements in the drawings respectively.

Table 2. The most frequent structure drawn by students.

	N	% from total
Right atrium	110	91.6
Right ventricle	110	91.6
Left atrium	110	91.6
Left ventricle	110	91.6
Valve (right)	70	58.3
Valve (left)	70	58.3
Pulmonary vein	60	50.0
Pulmonary artery	55	45.8
Aorta	50	41.6
Superior vena cava	25	20.8
Inferior vena cava	15	12.5
Aorta vein	10	8.3
Vena cava	5	4.1
Aorta artery	0	0

Discussion and Implications for Teaching

The aim of this study was to find out science student teachers' ideas about the internal structure of the heart by using the drawing method. All the results of this study imply that the majority of the science student teachers have several misconceptions as well as inadequate knowledge in terms of the heart's internal structure.

As mentioned earlier, the drawing method has several advantages as an educational tool as well as several limitations (White & Gunstone, 1992; *et al.*, 1995; Dove *et al.*, 1999). In this study in spite of the fact that science student teachers were informed about the drawing method and a practical session was applied; it may seem that the limitations of the method may have caused difficulties since the drawing of the internal structure of the heart may require more skills than drawing an ordinary concept.

One of reason behind all these misconceptions and inadequate knowledge might be related with the teaching methods that were used in the classrooms as well as the nature of misconceptions itself. Because, it is well known that misconceptions are strongly held and resist change despite the formal education process (Bahar, 2003). With regard to this statement it is important to answer the question 'why are the misconceptions resistant to change?' One of the answers can be related to the teaching strategies. Wandersee *et al.* (1994) stated that misconceptions are tenacious and resistant to extinction by conventional teaching (i.e. teacher-centered) strategies. As indicated in some studies done in other countries (Uşak, 2005; Toili, 2007), in the majority of the schools and in the universities in Turkey, teachers and lecturers use mainly teacher-centered strategies that promote memorization and reproduction the knowledge on the day of examination where the multiple choice format is mainly used (Bahar, 2003,



Prokop et al., 2007; Usak, 2005). Whereas in order to avoid misconceptions or to change misconceptions especially in the topic of heart structure, student-centered teaching strategies should be used so that students can be mentally and physically engaged. By doing so, students may have a chance to become aware of their misconceptions and challenge them for deeper and meaningful understanding. Technology may be used for these purposes, as well. Technological practices as using hypermedia and virtual reality techniques may offer greater promise in the area of providing challenging, conflict-inducing environments that would far exceed the ability of a text to alter perceptions related to heart structure.

The high percentage of misconceptions that science student teachers have might be more disturbing as they are candidate future science teachers in the secondary schools. As Wandersee et al. (1994) stated teachers often subscribe to the same misconceptions as their students. The findings in this research may support this claim because the similar misconceptions that science student teachers have might be transferred when they will be teaching in science classes.

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Mehmet Bahar	PhD, an Associated Professor at the Department of Department of Science Education, Faculty of Education, Abant İzzet Baysal Üniversitesi, 14280 Bolu, Turkey. E-mail: mehmet.bahar@gmail.com Website: http://www.ibu.edu.tr/
Murat Ozel	PhD Student Candidates at the Department of Science Education, Faculty of Education, Gazi University, 06500, Ankara, Turkey. E-mail: muratozel@nigde.edu.tr Website: http://www.gazi.edu.tr/
Pavol Prokop	PhD, an assistant lecturer at the Department of Biology, Trnava University, Trnava, Slovakia. E-mail: pavol.prokop@savba.sk Website: http://www.truni.sk/ & http://www.zoo.sav.sk/prokop/
Muhammet Usak	PhD, an Assistant Professor at the Department of Elementary Education, Eğitim Fakültesi, Dumlupınar University, 43100, Kutahya, Turkey. E-mail: musaktr@gmail.com & musaktr@dumlupinar.edu.tr Website: http://www.dumlupinar.edu.tr/

