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STUDENTS' IDEAS ABOUT THE HUMAN BODY: DO THEY REALLY DRAW WHAT THEY KNOW?

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Abstract. *There are several ways for gathering information about student's knowledge. Interviews or written tests with open-ended questions may effectively elicit students in-depth thinking, but they are difficult to quantify and some times subjective. In contrast, drawings have been considered as a simple research instrument that enables easy comparisons at the international level. We investigated relationships between the level of understanding shown by university students' written responses focused on the function of bodily organs/ organ systems and their ideas about the human body drawn on separate sheets of paper. We failed to find any relationship between these two methods. We propose that using the method of drawing in combination with written responses (or interviews) would provide more reliable information about children's understanding about scientific phenomena including the human body.*

Key words: *human body, research methods, drawings, misconception.*

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Introduction

Students' ideas about natural phenomena have been investigated by various methods. In the case of the human body, numerous misunderstandings were identified either by interviews and/or drawings. Reiss & Tunnicliffe (2001), Reiss, Tunnicliffe, Andersen & Bartoszeck *et al*. (2002) used children's drawings to provide a reliable projection of what children know about the human body. Organs and organ systems that are drawn more frequently are believed to be better understood than systems that are not included in the drawing. The relation between respondent's knowledge gathering from the written responses and its drawing is the central focus of this study.

Background

Research on children's interpretations of natural phenomena has been initiated by early works of Piaget (1929, 1930). Recently, numerous studies examining children's misconceptions (Fisher, 1985; Tekkaya, 2003), alternative conceptions (Arnaudin & Mintzes, 1985), private concepts, preconceptions (Gallegos, Jerezano & Flores, 1994) and naļve theories (Mintzes, 1984) exist. These works are focused on how children's explanations and ideas differ from those of scientists. It has been implicitly believed that children do not know anything before they arrive at school (Mintzes, 1984). Carey (1985) claimed that children before age 10 do not understand biological as 'biological' at all, but rather misunderstand them as 'psychological' and thus have an undifferentiated psychology/biology theory. Further theoretical and empirical studies showed evidence that children posses biological knowledge at much younger ages than Carey had supposed. Inagaki (1990), Hatano & Inagaki (1994), Inagaki & Hatano (1993) showed that young children's biological knowledge is significantly affected by early experiences with live organisms.

Several studies explore children's concepts about the human body. Nagy (1953) gave a written test about the human body to 220 children between the ages of 5 and 11. She asked them to draw various body organs and asked several questions about the processes of digestion and respiration. Unfortunately, she did not examine the relationships between children's drawings and knowledge. Extensive study of children's body knowledge was done by Gellert (1962). She interviewed 96 hospitalized children between the ages of 4 and 16. She asked them to list the organs that are inside the body and subsequently instructed them to draw specific major organs (e.g. heart, stomach) and asked about their functions. She found numerous misconceptions about the location and function of some body organs. Johnson & Wellman (1982) in two sub-studies interviewed 87 children and adults between the ages of 5 and 87 to examine their ideas about mind and brain.

More recently, Jaakkola & Slaughter (2002) interviewed 89 children in two sub-studies to examine their understanding of life as a biological goal of body functioning. They found a conspicuous increase in body knowledge between the ages 4 and 6. Tunnicliffe & Reiss (1999) in a cross-sectional study of 175 participants aged from 4 to 20 years used children's drawings to examine their ideas about the endoskeleton of one invertebrate and some vertebrates including human. In their subsequent studies (Reiss & Tunnicliffe 2001, Reiss, Tunnicliffe, Andersen & Bartoszeck *et al*., 2002) the same method was used to examine the knowledge of children of various age groups about human organs and organ systems. 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 present in 93 % of drawings, organs from skeletal, nervous, respiratory, digestive and other systems followed. In contrast, the occurrence of *organ systems* as defined by Reiss & Tunnicliffe (2001) was different; digestive, respiratory and urinogenital systems were drawn relatively most frequently, and the presence of each *organ system* did not exceed 25% of all drawings.

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.

Recently, Prokop, Fančovičová & Tunnicliffe (unpublished manuscript) found a compromise between these two approaches examining relationships between drawings of two organ systems (the urinary and endocrine) after two types of instruction ("*Draw what you think is inside your body*" versus "*Draw the xx* [i.e. urinary and endocrine] *system that is inside your body*"). However, significant correlation was found only for one (urinary) of two examined organ systems. This means that drawing could not express children's knowledge about the human body in detail; in contrast, the results can be more or less influenced by the interview protocol.

It can be concluded that, the method of drawing provides information about *location*, but not other aspects of body organs/organ systems. Moreover, participants may have difficulties either (a) to express what they know in drawings or (b) with their skills to draw.

Relationships between children's mental models body expressed through drawings and their knowledge about function of organs/organ systems have never been systematically examined. In

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the present study, combining two methods – gathering written responses (Leach, Driver, Scott, & Wood-Robinson, 1995) and drawings (Reiss & Tunnicliffe, 2001), we examined what students know about the organs they drew.

Purpose

This study was conducted to assess Slovak university students' knowledge about the human body. The study focuses on the following questions:

1. Is there a correlation between organs/organ systems students draw and their knowledge about these organs?
2. What misconceptions do Slovak students have about the human body?

Methodology of research

A total of 133 first year university students who have been studying to become primary teachers participated in this study. All students studied at Trnava University. The mean age of students was 19.5 year (range 18 – 23). The majority of students were females (115 of 127, six students did not provide data about their age and gender). Thus, our study was not focused on gender differences. Participants had been previously studying at various high schools, some of them did not have biology as a school subject and others did. These differences increased the potential of our research, because different students' backgrounds would result in greater diversity of their knowledge about human body.

Research was conducted during the first lectures of human anatomy in October 2005. Students were normally being taught the subject human anatomy for one semester from October to December 2005.

Students' knowledge about the human body was examined by two different methods that are not mutually exclusive: 1) a human biology knowledge questionnaire (HBKQ) and 2) by the method of drawing.

Although multiple-choice are commonly used for this kind of research, this method often fails to explore the reasoning process and sources of conceptual problems within subjects. Written tests with open-ended questions may more effectively elicit students' in-depth thinking, but they are difficult to quantify and some times subjective (Özay & Öztas, 2003). The questionnaire consisted of 30 open-ended questions regarding seven organ systems (digestive, respiratory, circulatory, endocrine, urinary, nervous and reproductive). The skeletal and muscular systems were not included, because they were the subject of the first lectures and thus it could affect students' scores. Questions were related to the *function* of various organs/organ systems. Five questions were focused on the understanding of the function of the digestive, urinary and reproductive systems, four questions on the circulatory, respiratory and endocrine systems and three questions on nervous system. Each question was focused on different organs within a particular organ system. For example, in case of the digestive system, we asked students about the function of the small intestine (Question 1 and 27), liver (Q 8), stomach (Q 15) and colon (Q 22). A similar approach was used for the remaining organ systems. Two independent professors of human anatomy reviewed the questionnaire in order to maintain validity. The full version of the HBKQ is available from the author upon request. The HBKQ and drawings were anonymous, students were asked to write only their age and gender.

The method of students' drawing was followed from previous studies by Reiss & Tunnicliffe (1999, 2001), Tunnicliffe & Reiss (1999) and Reiss, Tunnicliffe, Andersen & Bartoszeck *et al*. (2002). The researchers asked children "*Draw what you think is inside your body*". We asked the same question immediately after our participants finished the HBKQ mentioned above. Students were asked to draw what is inside them on a blank sheet of the HBKQ.

The HBKQ was scored by each of us separately as *right*, *wrong* and *don't know* categories. If our scorings differed we discussed the answers until we agreed on the category to be awarded.

Wrong categories were then separately coded to examine students' misconceptions about the human body.

Drawings were scored following a seven point scale developed by Reiss & Tunnicliffe (see references above, Tables 1 & 2, Figure 1).

Table 1. Seven point scale used for scoring organ systems (Reiss & Tunnicliffe, 2001).

Level 1	No representation of internal structure.
Level 2	One or more organs (e.g. bones and blood) placed at random.
Level 3	One internal organ (e.g. brain or heart) in appropriate position.
Level 4	Two or more internal organs (e.g. stomach and intestine) in appropriate positions but no relationships indicated between them.
Level 5	One system indicated (e.g. gut connecting head to anus or connections between heart and blood vessels).
Level 6	Two or three major systems indicated out of skeletal, circulatory, digestive, gaseous exchange, reproductive, excretory and nervous.
Level 7	Comprehensive representation with four or more systems indicated out of skeletal, circulatory, digestive, respiratory, reproductive, excretory and nervous.

Table 2. Definitions of each organ system (Reiss & Tunnicliffe 2001).

Skeletal system	**Skull, spine, ribs and limbs.**
Respiratory system	Two lungs, two bronchi, windpipe which joins to mouth and/or nose.
Nervous system	Brain, spinal cord, some peripheral nerve (e.g. optic nerve)
Digestive system	Through tube and mouth to anus and indication of convolutions and/or compartmentalisation.
Endocrine system	Two endocrine organs (e.g. thyroid, adrenals, pituitary) other than gonads (scored within reproductive system)
Urinary system*	Two kidneys, two ureters, bladder and urethra
Reproductive system*	Two ovaries, two fallopian tubes, uterus and vagina *or* two testes, two ejaculatory ducts and penis.
Muscular system	Two muscle groups (e.g. lower arm and thigh) with attached points of origin.
Circulatory system	Heart, arteries and veins into and/or leaving heart and, at least to some extent, all round the body.

* Reiss and Tunnicliffe scored urinary and reproductive systems together as "urinogenital system". We scored them separately for more accurate interpretation.

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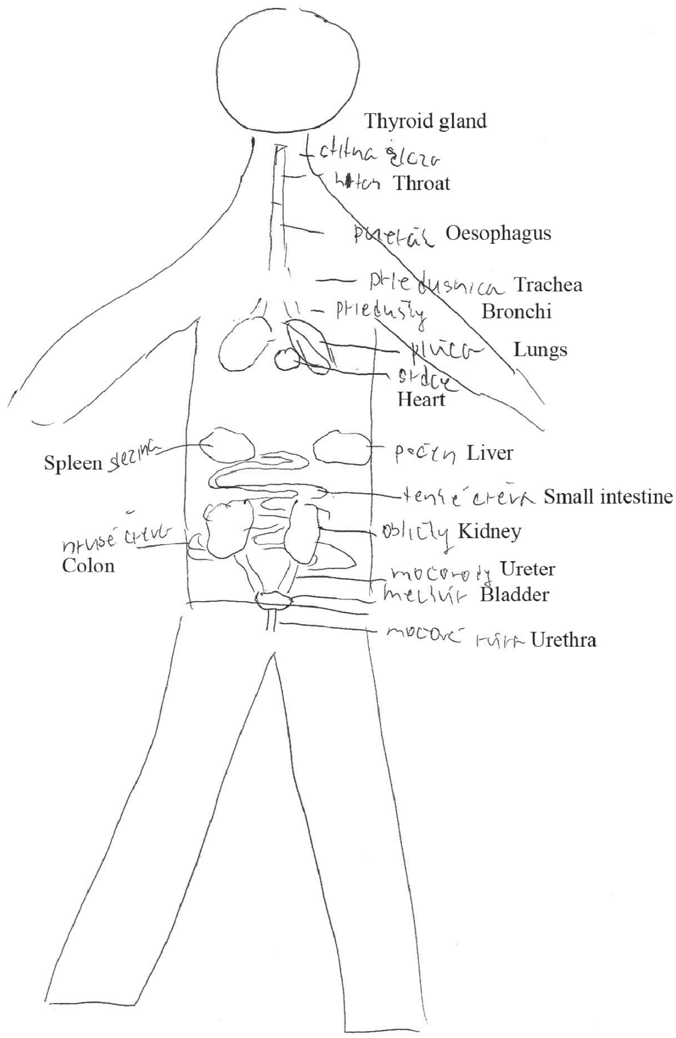

Figure 1. A drawing of the human body by girl studying at the university scored as level 5 (i.e. one system [urinary] indicated).

Results of Research

Reliability of the questionnaire

After coding on true/false and don't know responses, Cronbach's alpha of the whole HBKQ (hereafter test) was 0.79. Nunnaly (1978) propose that research instruments with reliability higher than 0.7 can be considered appropriate. Thus, our research instrument showed appropriate level of reliability and it allowed us to use the HBKQ in the further analysis

General relationships between drawing and test

Mean score of the test was 16.77 (SE = 0.56) from maximum 30 points (i.e. approximately 56%) with a range from 0 to 29 (n = 133). Mean level acquired from drawings of human body averaged at 3.34 (SE = 0.12) with a range from 1 to 6 (n = 133) from maximal level 7 (47.7%). This means that the relative success from the test was significantly higher than the score from drawings (*t*-test, $t = -3.259$, df = 264, $p < 0.001$, $n_1 = n_2 = 133$). Age does not play a role either in test score (r = -0.17, p = 0.85, n = 127) nor in score from drawings (r = -0.088, p = 0.325, n = 127). We failed to find a correlation between scores from drawings and the test (r = -0.098, p = 0.26, n = 133).

Test success vs. organ system drawn

Mean success per each organ system from the test significantly differ between each other (ANOVA, $F_{6,\ 924}$=11.32, p < 0.001). A subsequent Scheffé post-hoc test revealed that the reproductive, urinary, nervous and circulatory system acquired highest relative score in comparison with other organ systems (Figure 2). In contrast, the endocrine, respiratory and digestive system showed lowest relative score from the test.

The occurrence of organ systems in drawings was scored following Reiss & Tunnicliffe (2001). As shown in Figure 1, only few drawings (up to 13 %) fit these criteria. However, it does not mean that drawings were empty; instead, as indicated by the mean score from drawings, the majority of organs were drawn without marked relationships (e.g. intestines were not connected with the throat or kidneys were not connected with the ureter).

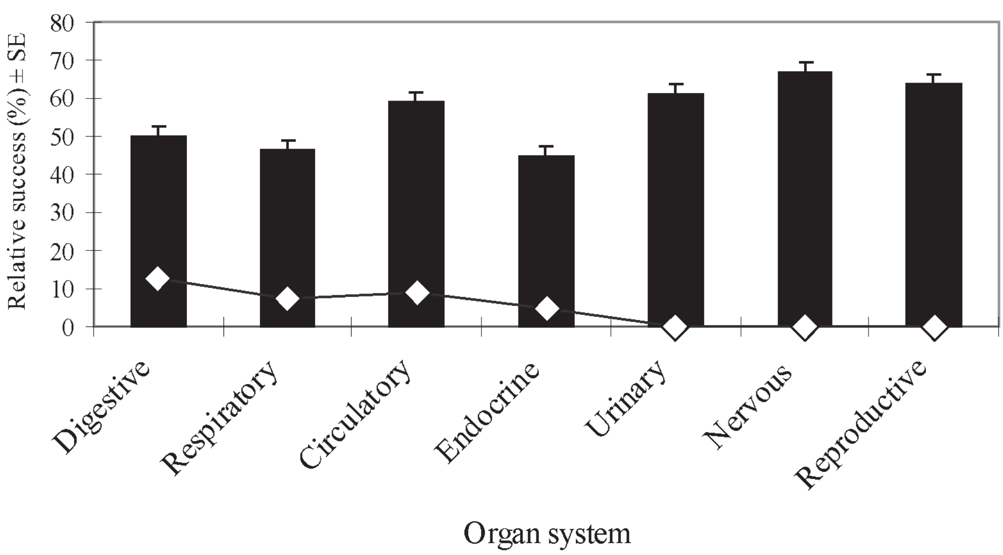

Figure 2. Relative success in knowledge about organ systems from the test (columns) and from drawing (line).

The most frequent organs drawn by students are presented in Table 3. Heart occurred in more than two-thirds of all drawings, lungs and stomach in more than half of the drawings. In contrast, organs of skeletal, endocrine, reproductive systems and muscles were least frequent. It can be explained by the difficulty to draw these systems, because, if for example the muscular system is drawn, it will 'cover' all the internal systems.

Table 3. The most frequent organs drawn by students.

	heart	lungs	stomach	brain	colon	liver	small intestine	kidneys	ureter	throat
N	95	92	75	66	58	57	54	42	36	25
%	71.4	69.2	56.4	49.6	43.6	42.9	40.6	31.6	27.1	18.8

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Because of the very low frequency of occurrence of organ systems drawn following criteria of Reiss & Tunnicliffe (2001), we decided to calculate relative success of drawing of each organ system more accurately. Especially, for example, if the endocrine system is defined as at least by two endocrine organs drawn (Reiss & Tunnicliffe, 2001), and a student drew only one (e.g. thyroid gland), the relative success was 50%. We scored all organ systems from drawings (except for the skeletal and muscular system, because they were not mentioned in the test and thus no correlations could be performed) following the mentioned procedure. Data was then compared by correlation coefficients to examine whether relationship between drawings and tests exist. Table 4 shows that, except for the digestive system, no significant correlations were found. Thus, we assumed that no relationships between test scores and knowledge expressed through drawings were found.

Table 4. Correlation coefficients calculated for data from the test and data from drawings (N = 133 students).

	Digestive	Respiratory	Circulatory	Endocrine	Urinary	Nervous	Reproductive
r	0.22	0.102	0.074	0.08	0.16	-0.051	0.02
P	0.01	0.243	0.4	0.372	0.066	0.559	0.823

Students' misconceptions about the human body

Misconceptions about the human body were extracted from the questionnaire. Table 5 shows that only one major misconception/poor understanding regarding the function of heart was widespread. In other cases the misunderstandings were weak and constituted 1 – 7% of responses on particular questions. Misconceptions found only in one student are not shown, but, interestingly, in one case a female thought that the bladder is connected with the colon.

Table 5 shows that some students have problems with understanding nutrition processes, processes of perception and ideas about artificial kidney. A relatively low number of misconceptions could be partly camouflaged by "don't know" responses. In average, about 40 % (SE = 3.65) of responses on each question were not provided (range 9 – 77%). Comparison of don't know responses showed that they were distributed similarly across all organ systems (Kruskal-Wallis ANOVA, H_6 = 8.85, p = 0.18).

Table 5. Misconceptions about the human body. Total N = 133.

Misconception	N	% from total
Heart beating prolongs life	63	47.4
Testes produce oestrogen	7	5.3
Sperms are hormones	2	1.5
Sperms enter ovaries for fertilization of ova	3	2.3
Liver produces digestive enzymes	9	6.8
Colon absorbs food	4	3
Pancreas absorbs nutrients	2	1.5
Artificial kidney is a new kidney from another human	9	6.8
Endocrine glands absorb nutrients	3	2.3
Thyroid gland directs all other endocrine glands	2	1.5
Perception is processed directly in receptors (eye, ear)	7	5.3

Discussion

The results of our study show that the knowledge of adult students about the human body in Slovakia is inconsistent. This was confirmed both by analysis of drawings of the human body and by written responses focused primarily on the function of bodily organs/organ systems. However, the expected relationship between drawings and written responses from the questionnaire was not confirmed, because we failed to find significant relationships between written responses and students' drawings.

Analyses of written responses show that students' understanding was poor especially in the case of the digestive, respiratory and endocrine systems. In contrast, drawings of organ systems showed opposite results, because especially urinary, reproductive and nervous systems were almost never drawn. Our findings contradict with general expectation that children have better knowledge about organ system they draw (cf. Reiss & Tunnicliffe, 1999, 2001). Instead, our data suggests that students' concept about *location* is independent from *function* of bodily organs or organ systems. This is because the organs drawn by students were generally well located, but the understanding of their function was usually lacking.

Using the drawing method raises several limitations. First of all, the space to draw in is limited and hence certain details would be difficult to show. Furthermore most of the systems are difficult to draw. A student could be just omitting certain organs/organ systems because drawing them is too much of a complex task or because there is not enough space on the paper provided. Secondly, serious social limitations could be applied to the reproductive system. Although the presence of reproductive organs was one of the least frequent, it cannot be believed that adult female students do not know that they have a vagina or a uterus. We suggest that omitting certain parts of the reproductive system while drawing might be because of certain 'taboos' that students might have because of their social background and their beliefs of what is 'proper' and 'acceptable' for a school-based test. Similar patterns have been reported by Reiss & Tunnicliffe (2001) who noted that none of the 158 drawings examined had a clitoris either drawn or labelled. Thirdly, different learners have different learning styles. Learning styles are defined by James & Gardner (1995) as "complex manner in which, and conditions under which, learners most efficiently and most effectively perceive, process, store, and recall what they are attempting to learn". Different learning styles might conflict directly with the methodologies used (i.e. drawing and test). In other words, students might be scoring badly not because they do not have knowledge of the human body but because the methodology that is used confuses them and does not allow them to express what they know.

Students' written responses showed a significant proportion of don't know responses which could partly camouflage their concepts about particular organs or organ systems. However, we found some misconceptions in almost all organ systems. Misconceptions about the human body are relatively well documented both in children and adults (Mintzes, 1984; Yip, 1998). For example, 4 to 6 year old young children believe that the body contains only recently eaten food (Teixeira, 2000). Younger children often suggest that the heart stores or purifies blood, older children associate heart with breathing (Gellert, 1962). We found out that heart is generally believed as necessary for life but without sufficient explanation *why*. Similar findings were reported by Nagy (1953) in case of the respiratory system. Several students have a poor understanding of where digestion takes place. For example, some of them thought that digestion is the function of liver, colon or pancreas. Also, the concept of 'hormones' seems to be less clear. Within the reproductive system, the place of fertilization seems to be unclear at least to some students.

Conclusion

Within commonly used research instruments (White & Gunstone, 1994), students' written responses show deeper understanding and causes of misunderstanding of human bodily organs. In contrast, drawings of the human body are effective to reveal students' concepts of size, shape

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and location of internal organs. Absence of correlations between these two approaches could not be considered surprising; Strommen (1995) similarly failed to find significant relationships between primary children's drawings and their responses on interview focused on knowledge about forest ecosystem. This fact, however, only refers about low validity of presented research instruments. Therefore, we propose that a combination of drawings with a questionnaire (or an interview) would provide more valuable data about children's concepts about the human body. We propose that using drawing as a means of understanding the level of knowledge of students could be greatly improved by conducting concurrent interviews, i.e. asking the students to explain what they drew.

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Резюме

ИДЕИ СТУДЕНТОВ О ТЕЛЕ ЧЕЛОВЕКА: ДЕЙСТВИТЕЛЬНО ЛИ ОНИ РИСУЮТ ТО, ЧТО ОНИ ЗНАЮТ?

Павол Прокоп, Яна Фанчовичова

Есть несколько способов сбора информации о знаниях студентов по интересующей нас проблеме. Так, интервью или письменные тесты с открытыми вопросами позволяют исследователю эффективно выявлять различные мнения студентов. С другой стороны, полученные данные трудно интерпретировать количественно, поскольку, они содержат определенную долю субъективности. Несмотря на данный факт, рисунки можно рассматривать как простой инструмент исследования, который позволяет осуществить сравнительный анализ результатов участников эксперимента из различных стран. Детские идеи о теле человека были исследованы разнами методами. Данное исследование было сфокусировано на изучении рисунков, которые обеспечивают получение информации о знании ребенком тела человека. Можно утверждать, что рисунки более эффективны в выражении конкретной формы, размера и местоположения внутренних органов, однако этот факт не свидетельствует о понимании ребенком функции изображаемых органов. Остаются сомнения и по поводу того, знают ли дети функцию органа (или системы органов), который они рисуют. Также в своей работе, мы исследовали отношения между уровнями знаний студентов университета полученных двумя способами. В письменных работах они дали ответы, которые были сосредоточены на функциях отдельных органов или систем органов. Анализ письменных ответов студентов показывает некоторые неправильные представления о человеческом теле. В рисуночных тестах авторы исследования были не в состоянии найти любые отношения между этими двумя методами. Они предлагают, что использование метода рисунка в комбинации с письменными ответами (или интервью) обеспечило бы более надежную информацию о детском понимании научных явлений, включая человеческое тело.

Ключевые слова: тело человека, методы исследования, рисунки, неправильные понятия.

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