Analysis of Elementary School Students' Understanding for Human Body Through Drawing of the Human Organism

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Abstract: The purpose of this study was to analyze elementary school students' understanding of the human body by drawing the human organism. Data was gathered by open questionnaires of drawing for human body. The open questionnaire was taken with 530 elementary school students from 3rd to 6th grade. The results were as following: First, elementary school students show the highest understanding of the skeletal system, the digestive systems, the respiratory systems, the circulating system and the muscular system respectively. Second, elementary school students' understanding of the human body improved as the grade goes up. Third, it seems that elementary school students have had their own knowledge about the human body through environmental surroundings before learning about the human body.

Key words: human body, elementary school students, drawing, understanding

Ⅰ. Purpose and Necessity of the Study

Students' prior knowledge cannot be easily changed since they have been formed through direct and indirect experience in the students' everyday life (Sinatra, 2005; Taber, 2001). Teachers need to utilize the findings related to students' prior knowledge or determine its extent at the beginning of each school year to prevent inaccurate prior knowledge formed during the early elementary grades from continuing onwards to the late elementary grades (Kim & Jeong, 1995; Reiss *et al.*, 2002).

Various methods to investigate students' prior knowledge can be used. There are also several studies conducted to deduce students' knowledge and ideas about a specific topic visually through the use of drawing activities (Alerby, 2000; Braund, 1998; Guichard, 1995; Reiss *et al.*, 2002; Tunnicliffe & Reiss, 1999). Children in the concrete operational stage in cognitive development, such as those in the elementary school, likes to draw. Their drawings represent what they know, which helps teachers to guide students in their learning (Guillaume, 1998). Drawing can also be used as a means of expression for students who have a difficulty expressing themselves using words (Oh & Kim, 2010; Reiss & Tunnicliffe, 2001; Reiss *et al.*, 2002; Rennie, 1995). In line with this, drawing activities have widely been used in science education as a more accessible method to determine students' ideas, concepts and knowledge, as compared to other types of activities (Edens & Potter, 2003; Mayer & Anderson, 1991).

A number of domestic studies have also been conducted on the use of drawing to determine students' knowledge and concepts about particular subjects. These include a study on the elementary students' concepts of a magnetic field (Kwon & Shin, 2007); a research study on an instruction model using molecular-level drawings for a 7th grade class (Roh, *et al.*, 2003); a research study on the understanding of 8th grade students about the earth through the use of pictures (Oh & Kim, 2010) and a study on the effects of 7th grade students' learning about the concept on the material particles through the use of drawing activities (Han *et al.*, 2006).

On the other hand, studies on the misconceptions regarding biology concepts

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focusing on the physiology of plants and animals have also been conducted (Lee *et al.*, 2006). These studies show that although there have been numerous concepts related to the structure and properties of the human body in science textbooks, middle school students who had learned about human organ systems and their independent functions since they were at elementary school, have been unable to adequately describe human organs and their characteristics (Kim, 2009).

Students' prior knowledge formed through direct experience and indirect circumstance have been accumulated as times go by without being dealt with them in the science curriculum(Cho *et al.*, 1995). That is one reason why middle school students are unable to adequately explain about the human organs. Therefore, It is necessary to investigate students' prior knowledge that have studied them in the science curriculum and to develop effective instructional strategies in order to improve students' scientific knowledge about internal human organism.

In addition, a study on the structure and functions of the human body has been conducted (Kim & Jeong, 1995). However, the investigation on the understanding of the internal human organs and changes in contents corresponding to school year has not been carried out. In line with this, it is necessary to determine how prior knowledge of elementary school students about the internal human organs are formed. This will, in turn, help in the formulation of learning strategies about the internal human organs for middle school students.

This study attempted to analyze the level of students' understanding about the internal structure of the human body through drawing activities. It has also aimed to identify the differences in terms of gender and school years, which range from the third grade to the sixth grade. The researchers have also evaluated the level of understanding of elementary school students about the internal organs of the human body. The findings of the study are expected to be helpful in determining the extent of elementary school students' understanding about the internal structure of the human body corresponding to the grades they are in. This, in turn, will help contribute to the formulation of instructional strategies or methods when teaching about internal human organs to students.

Ⅱ. Research Methods

1. Subjects of the Study

A questionnaire survey has been conducted to investigate elementary students' understanding of the internal human body. The survey focused on a total of 20 classes ranging from the third to the sixth grade in 5 elementary schools located in D metropolitan city. In terms of gender, the 20 classes included in the study were composed of 274 male students and 256 female students, totaling 530 students. The respondents were also comprised of 79 third graders, 150 fourth graders, 166 fifth graders and 135 sixth grade students.

2. Questionnaires

Questionnaires with open-ended questions with the use of pictures have also been widely used to investigate students' understanding of internal human organs (Braund, 1998; Guichard, 1995; Reiss & Tunnicliffe, 2001; Reiss *et al.*, 2002). In this study, an open or unstructured questionnaire has been created with figures representing a human body based on the survey methods used by Reiss, Tunnicliffe(2001) and Reiss *et al.*(2002), and expert of science education and doctor of science education revised the questionnaire for elementary school students. No comments on the internal human organs can be found in the questionnaire used in the survey., Respondents were required to freely describe their knowledge about the human anatomy using two-dimensional drawings as

well as relevant descriptions.

3. Methods for Data Collection and Analysis

A total of 630 questionnaires were sent by post to 5 elementary schools located in D metropolitan city for this study. The mailing was done after the purpose of this study had been explained to teachers and consent of targeted students from the third grade to the sixth grade has been obtained. The teachers encouraged students to respond to the questionnaires for 30 minutes of discretionary time. A total of 530 questionnaires have been returned by mail, indicating a recovery rate of 83.8%.

The study has also utilized the framework for analysis of the human anatomy used by Reiss and Tunnicliffe (2001), Tunnicliffe and Reiss (2001), and Reiss *et al.* (2002) with a few modifications to comprehend students' prior knowledge generally about internal human organs, though the science curriculum of elementary school presented bones, muscles, digestive organ, respiratory organ, circulatory organ, excretory organ, sensory organ.

Under this framework, the human body has been divided into eight (8) organ systems, including the skeletal system, respiratory system, nervous system, digestive system, endocrine system, reproductive system, muscular system and the circulatory system. In addition, the framework for classifying drawings of the human anatomy made by the student respondents shows a total of 7 levels, ranging from Level 1 to Level 7 as shown in Table 1.

Two researchers have classified the students' drawings according to the levels indicated in Table 1 through consultation. They also analyzed the organs and organ systems presented in the students' drawings. Drawings with inaccurate representations of the human organs that couldn't be categorized according to the framework used to analyze the eight organ systems have been classified in other categories with a consensus among the researchers. The results have also been analyzed using a version of SPSS 18.K after coding.

Ⅲ. Research Results and Discussion

1. Percentages of Students' Drawings Corresponding to Levels of Classification

The classification of the students' drawings of the human anatomy that were gathered by the study is presented according to levels in Table 2 below. The highest percentage of students' drawings is categorized as Level 2 drawings, with 63.2% (335 drawings). 17.7% (94 drawings) of the drawings fell into the Level 1 category while 10% (53 drawings) belonged to Level 4. A

Table 1

Levels and Definitions Used for Classification of Students' Drawings of the Human Anatomy

Levels	Definitions
Level 1	The student is unable to draw any one of the internal human organs.
Level 2	The student is able to illustrate at least one or more internal organs in an arbitrary location.
Level 3	The student is able to illustrate one internal organ in an appropriate location.
Level 4	The student is able to illustrate more than two internal organs in an appropriate location but is unable to show how they relate to one another in detail.
Level 5	The student is able to draw an entire organ system of the human body.
Level 6	The student is able to draw at least 2 to 3 major organ systems of the human body.
Level 7	The student is able to draw more than 4 major organ systems comprehensively.

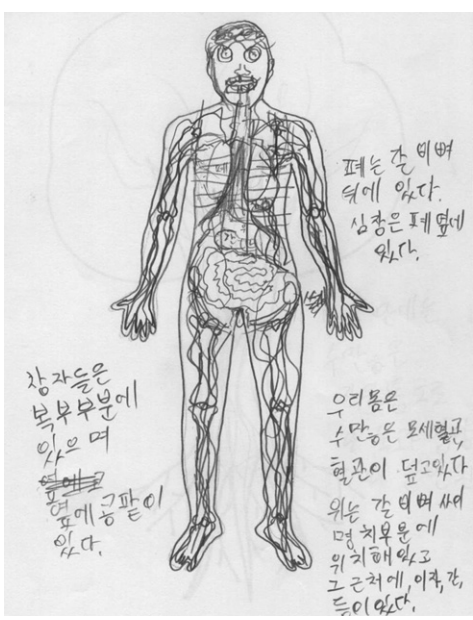
Table 2
Drawing Level of Students for the Internal Structure of the Human Body

drawing level	level 1	level 2	level 3	level 4	level 5	level 6	level 7	Sum
Frequency (%)	94 (17.7)	335 (63.2)	11 (2.1)	53 (10.0)	16 (3.0)	21 (4.0)	0 (0.0)	530 (100)

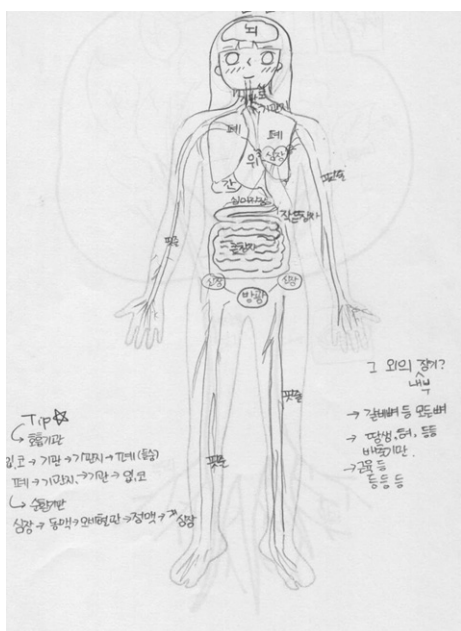
total of 4.0% (21 drawings) of the drawings were classified as Level 6, 3.0% (16 drawings) as Level 5 and 2.1% (11 drawings) as Level 3 drawings. Drawings corresponding to the level 7 category were not found among the collected drawings from the students. More than half of student's drawings fell into categories above level 2, indicating that most of elementary school students are aware of at least one or more internal organ of the human body.

Most elementary school students showed level 2 drawings of the human body represented by a skeleton with arms and legs, as shown in Figure 1b. This can be attributed to students' prior knowledge about the internal structure of the human body as acquired through reading, field trips and mass media, such as books and TV (Guichard, 1995; Tunnicliffe & Reiss, 1999).

The study also finds that the students' illlustration of the major organ systems tend to be incomplete. They managed to illustrate organs belonging to the digestive and circulatory systems that are familiar to them. However, they failed to illustrate a comprehensive representation of all the organs belonging to a specific organ system, as shown in Figure 1b. As shown in the drawing, the bones were not connected by the joints in the representation of the skeletal system. In addition, only some parts of the lungs had been drawn to represent the



a) level 2



b) level 6

Fig. 1 *Drawing Level of Students*

respiratory system. Moreover, the digestive tract from the mouth to anus has also not been clearly drawn to represent the digestive system. Reproductive organs were not clearly outlined when drawing organs belonging to the endocrine system and respiratory systems. When drawing the circulatory system, the position of the heart was also not accurately represented.

These results consider that elementary school students understand each internal human organ separately, rather than understanding them organizationally. Therefore, instructional strategies of enlightening students about internal human organs organizationally are needed.

In particular, the science curriculum doesn't present relations about bones and muscles in middle school and high school. Thus, instructional strategies focused on basic understanding about structure, and the function of bones and muscles such as making model of human organism, model of bones and muscles will help elementary school students understand relation between bones and muscles.

2. Drawing Levels by Elementary Grade

Figure 2 shows the levels corresponding to the 530 drawings of the human anatomy from elementary school children from the third grade to sixth grade levels. The results showed that Level 2 drawings had the highest frequency of occurrence. Frequency of Level 2 drawings from the fourth graders was higher than those from the third grade. However, the frequency gradually decreased as grades go higher from the fourth grade to the sixth grade, indicating an increasing awareness about the internal organs among the school children. In general, results showed that the higher the grade level, the higher the level of the drawings. However, the frequency of Level 1 drawings showed the second highest frequency of occurrence, particularly from students in the third grade to the fourth grade., This indicates that a few students still do not have much knowledge about the internal human organs even if they are already in the higher grades.

In addition, drawings classified as Level 1 and 2, which accounted for a rate of 17.8% were still found among students from the sixth grade who already studied the "Appearance of the Human Body" section in the science curriculum. This result indicates that students' knowledge and understanding about the internal human organs and the human anatomy is insufficient. Various instructional strategies of making a model of the human organism, showing video and et al rather than teacher's explanation about them will help students get the meaning of internal human

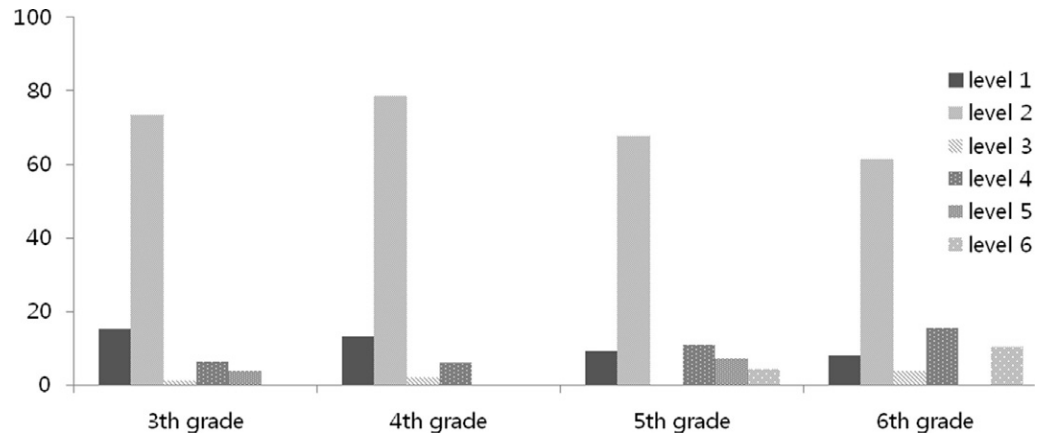


Fig. 2 *Drawing Level of Grade*

organism because elementary school students didn't observe internal human organism directly.

A two-way ANOVA has been conducted by the researchers to determine if the levels of students' drawings in terms of gender and grade levels are statistically significant. Table 3 shows the averages and standard deviations according to gender and grade levels. For male students, ANOVA results showed that the average reached 2.02 for third graders, 2.01 for fourth graders and 2.38 for fifth graders. Results also showed an average of 2.24 for sixth graders. For female students, results showed that the average amounted to 2.16 for third graders, 1.94 for fourth graders and 2.50 for fifth graders. Female students in the sixth grade also showed an average of 2.95. Results particularly showed that the average found for the levels increased as the grades go higher in female students. The averages found for the drawing levels for male students and female students were found to be 2.19 and 2.14, respectively. Based on this result, it can be concluded that there is a difference in levels between male and female students. In addition, the mean value of drawing levels from third graders appeared to be higher, as compared to those students in the fourth grade, which showed that there is a need for an in-depth research on the reasons for the differences found by the study.

Table 3
Average and Standard Deviation(SD) for Drawing Level According to Gender and Grade

gender	grade	students' number	average(SD) of drawing level
male	3th	41	2.02(0.76)
	4th	78	2.01(0.67)
	5th	84	2.38(1.36)
	6th	71	2.24(1.14)
	sum	274	2.19(1.07)
female	3th	38	2.16(1.00)
	4th	72	1.94(0.63)
	5th	82	2.50(1.30)
	6th	64	2.95(1.77)
	sum	256	2.41(1.31)
total	3th	79	2.09(0.88)
	4th	150	1.98(0.65)
	5th	166	2.44(1.33)
	6th	135	2.58(1.51)
	sum	530	2.29(1.19)

Table 4 below shows the presence of main effects and interaction effects according to gender and grade levels. A significant difference is found in terms of grade levels at $F=8.07$, $p<0.05$, indicating that as grades go higher, the understating on the internal structure of the human body gradually increases. The Duncan's post-verification method has also been carried out to determine if the result is due to the differences between the grade levels. The results showed that there is a significant difference between the students in the third, fourth and fifth grades and the students in the fifth and sixth grades at $p<0.05$.

A significant difference is found between the genders at $F=6.37$, $p<0.05$, indicating that the level of understanding about the human anatomy is higher in female students as compared to that of male students. This result is in contrast with the results of the study undertaken by Reiss and Tunnicliffe (2001) which showed that there are no differences in the understanding of the internal structure of the human body between males and females. In terms of drawing levels, the present study also showed interaction effects between the genders and grade levels at $F=2.95$, $p<0.05$.

Since students in the fifth grade learn about internal human organs or the human anatomy through the 2007 revised science curriculum, it is expected that the level of students' drawings increase as grade levels go higher. However, there are also cases where students who have not had the chance to learn human anatomy through the school curriculum already have

Table 4
Two-Way ANOVA of Drawing Level According to Gender and Grade

source	sum of square	degree of freedom	mean square	F
grade	32.52	3	10.84	8.07*
gender	6.37	1	6.37	4.75*
grade*gender	11.89	3	3.96	2.95*
error	700.89	522	1.34	
sum	751.67	529		

*p<0.05,

some knowledge about internal human organs. In particular, a number of students in the third grade were found to possess knowledge corresponding to Level 4 and Level 5. These results are consistent with the results of Duit & Treagust, 2003 Jones et al., 2000, which showed that many students have prior knowledge about the particular subjects before learning them formally in school. Results from the studies conducted by Braund, 1998; Reiss & Tunnicliffe, 2001 and Tunnicliffe & Reiss, 1999, also showed that students' knowledge about the internal human organs is acquired from experiences outside of class, such as field trips to museums, TV and reading at home.

3. Types of Organ Systems Illustrated by Grade Levels

Figure 3 shows a graphical representation of the types of organ systems presented by students in their drawings. Since the number of organ systems presented by students differs by individually, the frequency in terms of grade levels also varies. A total of 522 drawings of the different organ systems have been collected from the students. 47.9% of these drawings are comprised by the skeletal system, with 250 occurrences. Drawings of the digestive system follow at 27.4%, with 143 occurrences. The respiratory system accounted for 18.6% of the students' drawings, with 97 occurrences; the

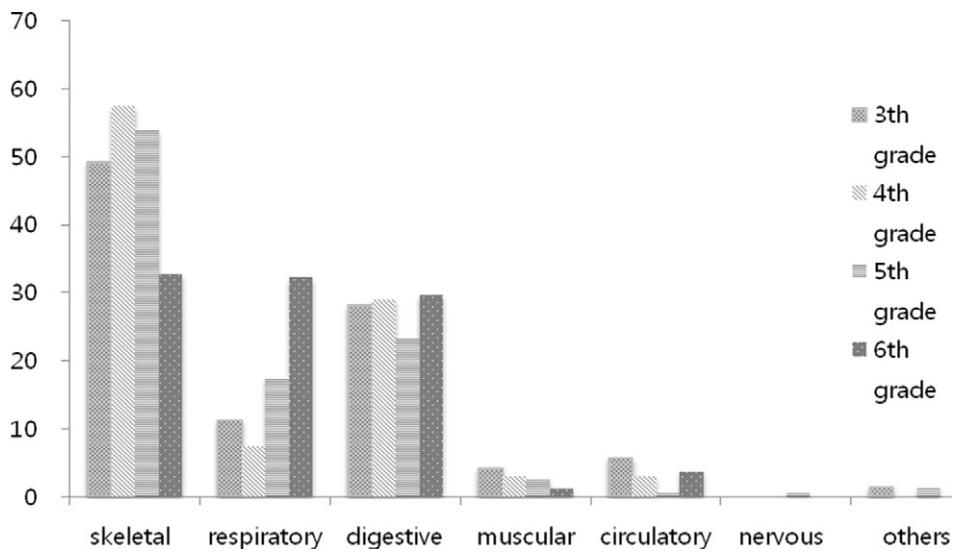


Fig. 3 *Type of Organ System According to Grade*

circulatory system 2.9% with 15 occurrences and the muscular system at 2.5% with 13 occurrences. Other organ systems comprised about 0.6% of the students' drawings, with 3 occurrences while the nervous system accounted for 0.2% with only 1 occurrence.

Students in the third grade presented 71 drawings of the organ systems. The skeletal system is represented in 49.3% of the drawings, with 35 occurrences while the digestive system comprised 28.2%, with 20 occurrences. The skeletal system constitutes 57.5% of the drawings from students in the fourth grade, with 77 occurrences while the digestive system follows at 29.1% with 39 occurrences from a total of 134 drawings. A total of 159 organ systems had been presented by students in the fifth grade. The skeletal system constitutes 54.1% of these drawings with 86 occurrences, followed by digestive system with 23.3% or 37 occurrences. Students in the sixth grade showed a total 158 organ systems. From this group, drawings of the skeletal system constitute 32.9% with 52 occurrences, followed by the respiratory system at 32.3% with 51 occurrences. No students submitted representation of organs belonging to the endocrine and reproductive systems.

Judging from the levels of the drawings of the human anatomy collected from the elementary school children, students tend to have a clearer understanding of particular organ systems, including the skeletal, digestive, respiratory and circulatory systems. A clearer understanding of the skeletal systems by the elementary school students as compared to the other organ systems is being attributed to their frequent exposure to illustrations and photos of human bones in the mass media, including the Internet. The study also found that the frequency of drawings representing the skeletal system gradually decreased while that of the respiratory system increased as grades go higher. This result is attributed to the students' learning about internal human organs through the science curriculum. In addition, students from all grade levels presented drawings of the digestive system but the level of the drawings varies. Only one student from the fifth grade presented the drawing of the nervous system. However, no drawings of the endocrine and reproductive systems have been presented by the students. The absence of drawings of the endocrine system is partly explained by the fact that information about the endocrine system is not included in the elementary science curriculum.

Based on these results, the present study found that knowledge of elementary school students' knowledge about the nervous, endocrine and reproductive systems is still not properly formed. In particular, it is likely that the instructional contents pertaining to the nervous system are not significant for students in the sixth grade who had already learned the internal structure of the human body (Reiss & Tunnicliffe, 1999). Improvement of students' conception with what they are already familiar with, are higher than in other cases learning about other new systems (kim, 2009). So it is considered that students' understanding of the nervous system are insufficient because they don't get accustomed to conceptions about the nervous system. Various instructional strategies with showing concrete activities that are familiar to students are needed to improve their conception about nervous system.

Ⅳ. Conclusion and Implications

An open-ended questionnaire design with the use of drawings has been utilized by the present study to determine the level of understanding of elementary students about the human anatomy, particularly the major organ systems. The study has targeted 530 students from the third to sixth grade levels and evaluated the survey results. Results of the analysis are summarized as follows.

First, the level of students' understanding of the internal structures of the human body is seen the highest for the skeletal system based on

the drawings submitted. If the level of understanding among the students is to be ranked, students' understanding of the digestive system, respiratory system, circulatory system and the muscular system follow the level of understanding for the skeletal system. In particular, students were found to have the highest level of awareness about bones, as compared to the other human organs, followed by blood vessels, digestive organs and respiratory organs. However, the study also found that students have meager knowledge of the nervous, endocrine and reproductive systems as compared to the other organ systems in the human body.

Secondly, the present study also found that as the grade go higher, the level corresponding to the students' drawings of the internal structure of the human body increases. This indicates the student's increased understanding about the human anatomy. However, the increase in understanding about the human anatomy among sixth graders is found to be not significant although they have already learned about the internal structure of the human body through the science curriculum. This is in comparison to the level of understanding among students in the fifth grade. In addition, the present study also found that students' understanding about nervous and reproductive systems could be considered inadequate.

Thirdly, the study also found that students possess basic knowledge about human anatomy before they learn the subject through the science curriculum. However, students failed to enumerate internal human organs as well as the organ systems found in the human body. In particular, they have little knowledge about three major organ systems, including the nervous, endocrine and reproductive systems.

Based on the results enumerated above, a number of educational implications can be deduced. One, various models pertaining to the human skeletal system are widely available while data about the nervous, endocrine and reproductive systems are limited. This can be cited as the reason for the insufficiency of students' understanding of the human anatomy, with the internal human organs in particular. Accordingly, teachers need to utilize teaching methods that effectively draw out students' interest while increasing learning time for organ systems other than the human skeletal system.

Second, students' awareness about the nervous system remains to be inadequate, though it is included in the elementary science curriculum. To address this lack of awareness, various learning methods to improve students' understanding about this particular organ system have to be conducted. Similar to the various learning resources available to attract students' interest, such as the use of human skeleton models when teaching, various teaching materials about nervous system should also be adopted. Finally, efficient teaching strategies also need to be formulated in order for teachers to facilitate significant learning among students.

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