Exploring Drawing Skills and Mental Images of Secondary Students on Human Digestive System through Hand Drawing

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Abstract

In consideration of the potential of drawing as an assessment and learning tool, we explored how the secondary students used it to communicate their understanding of the human digestive system—a chapter in Class X. Six schools in Bhubaneswar—three affiliated to the CBSE, two to the Odisha State Board and one to the West Bengal State Board, were randomly selected. 478 students of Class X of these schools were used for the study. They were asked to draw and label the human digestive system and respond to a close-ended questionnaire. The results revealed that the drawing skills of majority of students were poor and not monitored by the teacher for assessing the understanding level of students on the human digestive system. Several misconceptions are prevailing in the mind of the students, related to the position, shape, size and colour of various digestive organs.

Introduction

Biology is the study of life which requires careful observation and description. One excellent way to describe an object is to draw it. Drawing, as a skill, is one of the basic science process skills which has not received due emphasis and yet, is very

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fundamental for effective instruction. Teachers do a great deal of telling and demonstrating at the expense of engaging learners in activities which will foster learning and even make the process enjoyable. Muindi (2008) stated that learning in science and mathematics is mostly rote, which makes it a passive affair where the student is not engaged in the process. Students are taught according to how questions in the examinations are framed, leaving no room for creativity. This makes teaching-learning teacher-centric with very minimal learner participation. In such a state, the learners hardly learn and practise one of the important science process skill—that is, drawing.

Students who usually do not want to reveal their opinion are willing to share their ideas through drawings (Keogh and Naylor 1998, 1999). Drawing is just a way to express things that students cannot express verbally in the early stages of their schooling. In that way, the teacher can effectively monitor their development (Katz et al. 2014) Drawing techniques are especially valuable in encouraging children of younger ages who have difficulty in expressing themselves verbally (Chin and Teou 2010; Holliday et al. 2009). According to educational psychologists, participatory learning is the most effective method of learning science. By observing the specimens, asking questions, engaging in discussion and making annotated drawings of specimens during biology practical sessions, the students get involved in the learning process. This makes learning effective, apart from promoting the development of other science process skills.

It has been argued that having students construct drawings, in addition to writing, has the potential to be a critical link in students' science learning (Prain and Tytler 2012; Wilson and Bradbury 2016). Researchers have argued that drawing should be recognised along with reading, writing and speaking as a means—to enhance engagement, to represent science, to reason, as a learning strategy, and to communicate (Ainsworth et al. 2011). There is an emerging line of research into how the use of drawings with young students can be used to understand their thinking about science topics, as the act of drawing is a part of the learning construction process (Cox 2005; Van Meter et al. 2006). There have been studies exploring students' decisions when making science drawings as an assessment tool for primary and secondary students (Rybska et al. 2014).

There are numerous advantages in applying drawing methods during schooling. Firstly, many scientists believe that this is a powerful instrument that reflects the way of thinking, emotions, internal representation and perception of students. Secondly, the introduction of drawing method provides a more

pleasant working environment for students, and drawing makes it possible for students to communicate with each other. Thirdly, in the early stages of schooling, this is a convenient way to overcome the fear related to verbal difficulties. Fourthly, the process of drawing as a multidimensional factor expresses students' views, understanding and attitude. Drawing confirms objectivity in the projection of individual beliefs. Also, the method of drawing is more objective and easier for the purposes of quantitative analysis than the majority of others (Kubiatko et al. 2012).

Aim of the Study

If drawings are to be used for learning about students' conceptual knowledge, we must know how they represent their conceptions in drawings. As the drawing skills in Biology underlie the ability to communicate results in terms of observations and inferences, it is therefore necessary to examine the extent to which secondary school students use the drawing skills to communicate their scientific knowledge in Biology. The investigators were interested to explore how the secondary students represent their conceptions in drawing. Students' drawing will be seen as contextualised in pictorial conventions and students' conceptions will be seen as contextualised in conceptual framework with a focus on the human digestive system. The main question to be considered was the use of which teaching aid like LCD projector or charts or hand drawing by the teacher on the board improves the drawing skills of students. Secondly, is monitoring by the teacher essential for the assessment of students' understanding?

Material and Methods

The study was conducted in Bhubaneswar, Khurdha district of Odisha. Six sample schools were selected using simple random sampling technique. Out of these, three were CBSE-affiliated schools, two were Odisha State Board schools and one was West Bengal State Board affiliated school. All the CBSE-affiliated schools follow English as the language of instruction, the Odisha State Board schools follow Odiya as the medium of instruction while the West Bengal Board affiliated school employs Bengali as the medium of teaching and learning. The six selected sample schools had a population of 478 students in Class X, of which 226 were boys and 252 were girls.

For the study, a chapter—'Nutrition' (which includes the human digestive system and digestion) from Class X was selected. Since this study was conducted during August–September 2016, all the schools had already covered the chapter 'Nutrition' as it is the first chapter under the first unit in Biology—that is, 'Life Processes'.

The dates for the study were fixed in consultation with the principals of the respective schools. Two days before the study dates in different schools, the investigators interacted with students. The students were asked to go through the chapters which have been covered recently in Biology.

On the study day, each student received an A4-sized drawing paper and was told to use crayons to draw. At the same time, the students were given the following instructions—'we would like each of you to draw the human digestive system and label it properly. You will be given 35 minutes that is, one period, and we believe that it is enough for completing the drawing. This is not an examination but is part of a research study which involves many students of your age'.

In addition to the above, to collect data, the study employed a close-ended questionnaire. The questionnaire was used to investigate the problems that students encounter when making biological drawings. The questionnaire aimed at investigating the source from which students were asked to draw, whether the drawings are monitored by the teachers or not for the correct position, proportion, labelling and shading. The items were structured in a simple form requiring the respondents to tick either 'Yes' or 'No'.

Results

The drawings of the human digestive system of secondary students were examined as per scientific authenticity. These drawings were analysed under the following eight different categories.

A. Location, structure and colour correctness
B. Location correctness, structure incorrectness and colour correctness
C. Location correctness, structure correctness and colour incorrectness
D. Location correctness, structure incorrectness and colour incorrectness
E. Location incorrectness, structure correctness and colour correctness
F. Location incorrectness, structure incorrectness and colour correctness
G. Location incorrectness, structure correctness and colour incorrectness
H. Location incorrectness, structure incorrectness and colour incorrectness

The letters A to H for various categories are used for different data presentation. The investigators chose these features because they are all important for evaluating not only the drawing skills of students but also to explore the conceptual understanding of the human digestive system. The results were analysed by using the standard statistical method that is, percentage distribution.

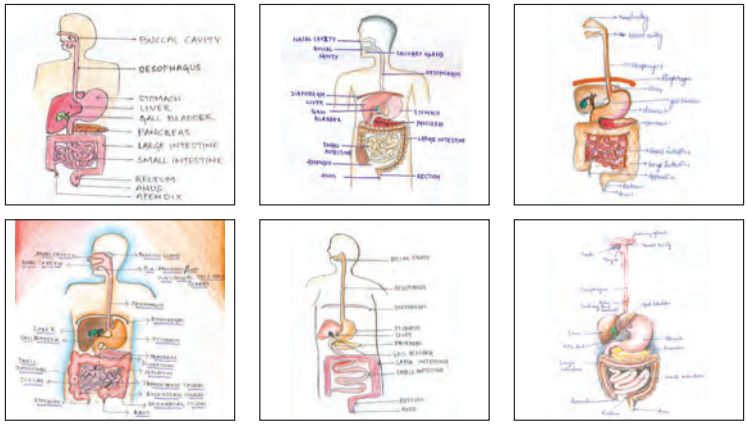

Plate 1. Students' drawing showing the correct structure, location and colour of the different parts of the human digestive system

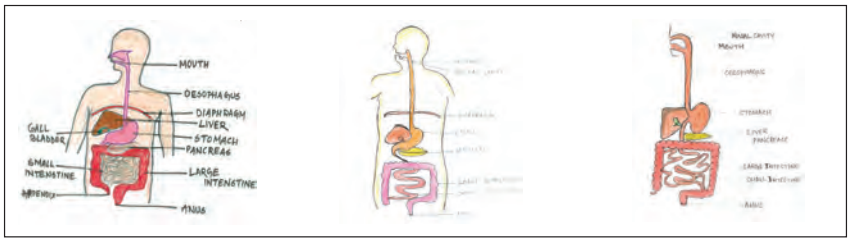

Plate 2. Students' drawing showing the correct location and colour but incorrect structure of the different parts of the human digestive system

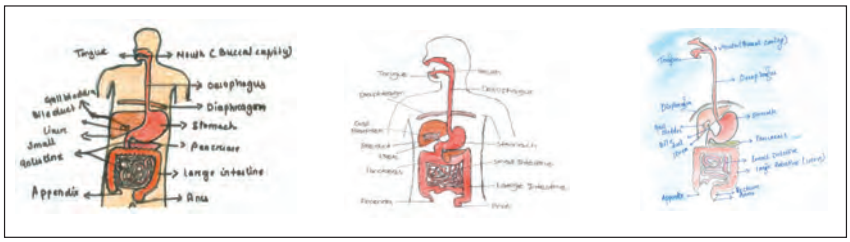

Plate 3. Students' drawing showing the correct location and structure but incorrect colour of the different parts of the human digestive system

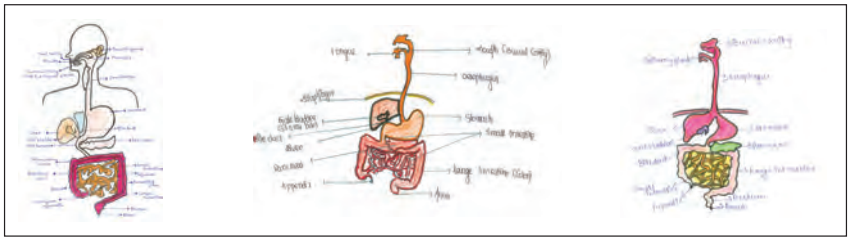

Plate 4. Students' drawing showing the correct location but incorrect structure and colour of the different parts of the human digestive system

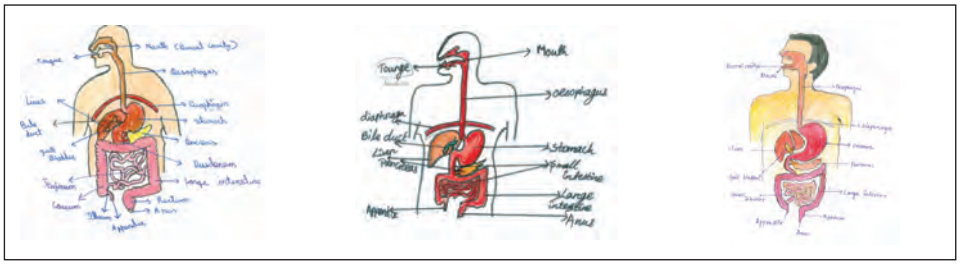

Plate 5. Students' drawing showing the incorrect location but correct structure and colour of the different parts of human digestive system

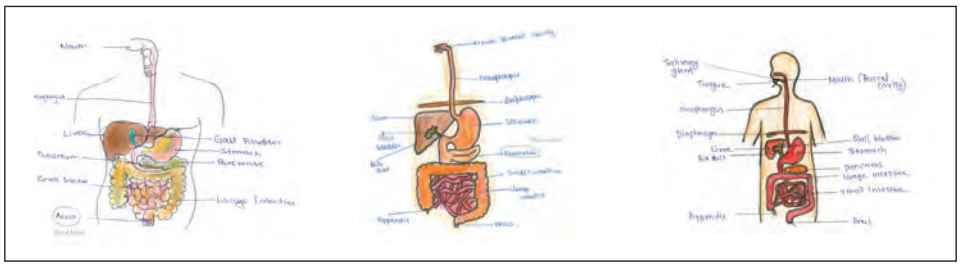

Plate 6: Students' drawing showing the incorrect location and structure and correct colour of the different parts of the human digestive system

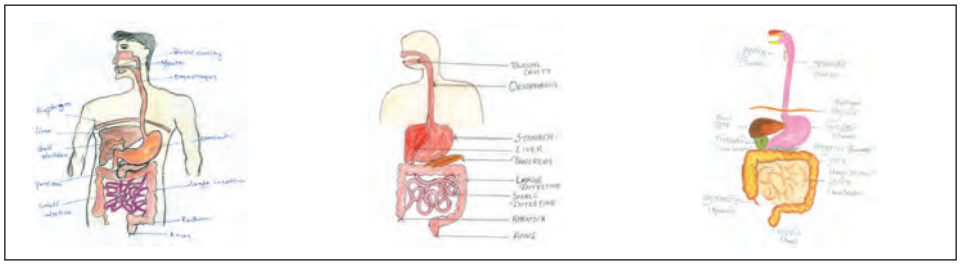

Plate 7. Students' drawing showing the incorrect location and colour but correct structure of the different parts of the human digestive system

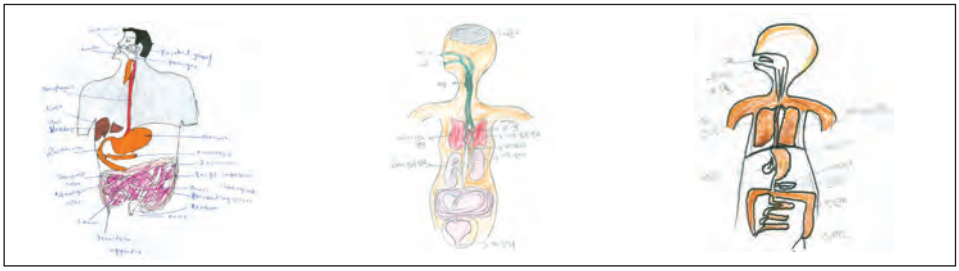

Plate 8: Students' drawing showing the incorrect structure, location and colour of the different parts of the human digestive system

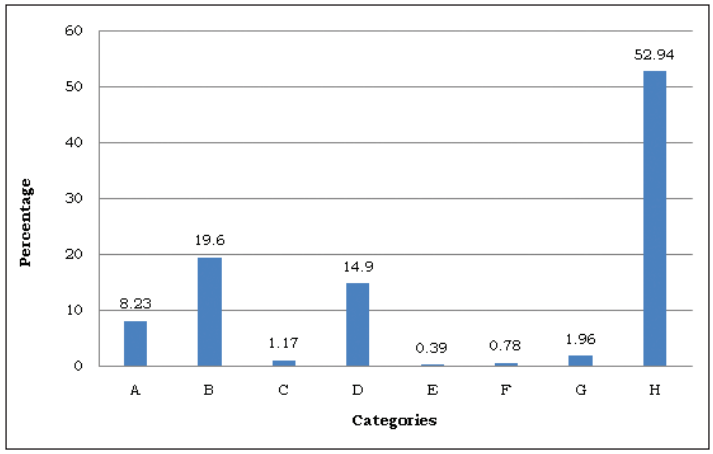

Figure 1. Results of the analysis of drawing on the human digestive system

The analysis of students' drawing showed that about half of the students (52.94 per cent) have a poor understanding of the correct position, shape, size and colour of various organs of the human digestive system (Figure 1, Plate 8). Only 8.23 per cent of students have a correct knowledge of the location, structure and colour of various organs (Plate 1). About one-fifth of the students have knowledge of position and colour of organs but not the shape and size (Plate 2) while 1.17 per cent of students are quite aware of the location and structure but not the colour of organs (Plate 3). Majority of students are not sure about the correct position of the various digestive organs (Figure 1, Plates 5 to 8).

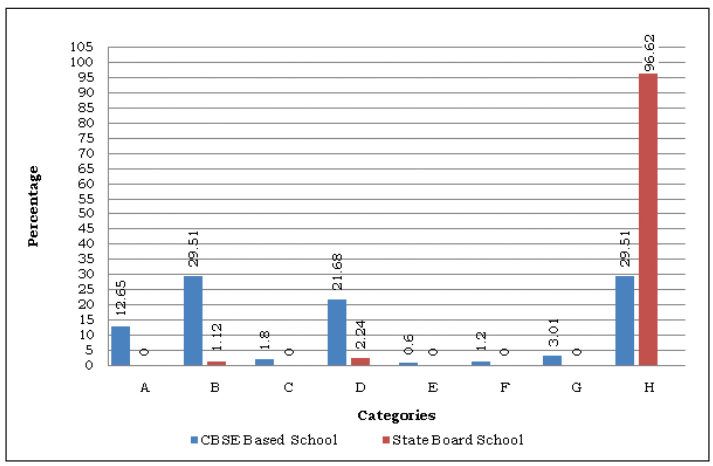

Figure 2. A comparison between the students of two different boards

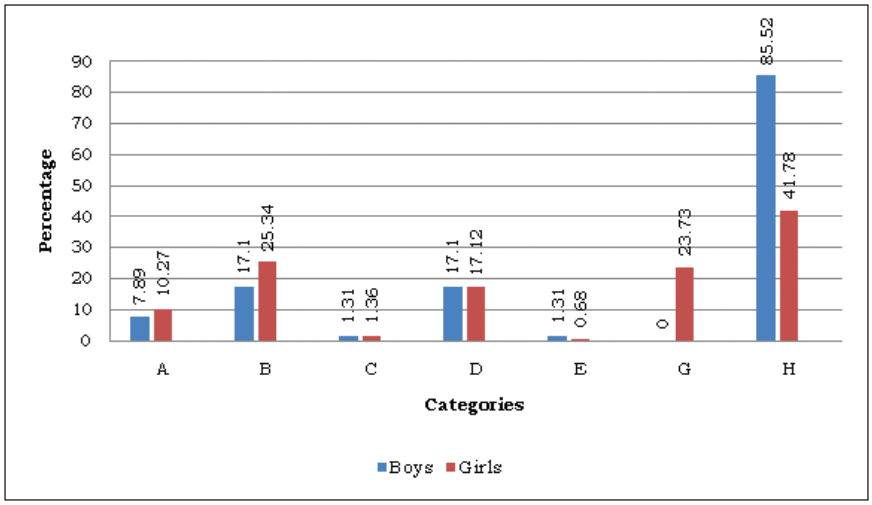

Figure 3. A comparison between boys and girls on drawing skills

The analysis of the students' drawings revealed that 96.62 per cent students of the State Board schools have poor information about the position, structure and colour of the digestive organs in comparison to only 29.51 per cent of students of the CBSE-affiliated schools (Figure 2). The results of the present study clearly show that girls have a much better idea than boys about the digestive system. In comparison to 41.78 per cent girls, 85.52 per cent of boys have a misconception about the position, structure and colour of the various digestive organs (Figure 3).

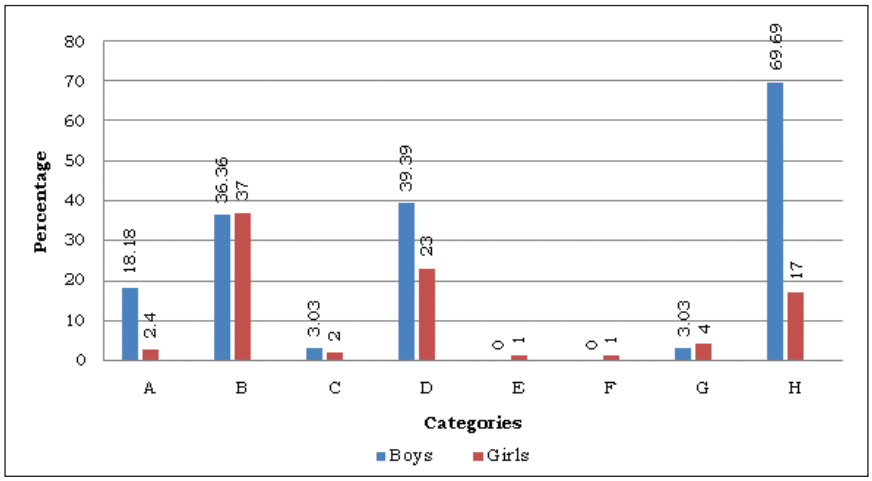

Figure 4. A comparison between boys and girls of CBSE-affiliated schools on drawing skills

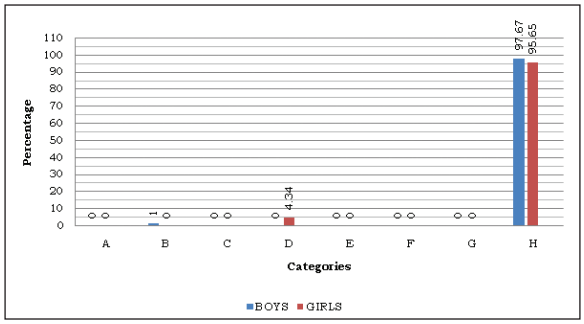

Figure 5. A comparison between boys and girls of State Board-affiliated schools on drawing skills schools on drawing skills

The investigators observed that boys (69.69 per cent) have poor information about the digestive system in comparison to girls (17 per cent) of CBSE-affiliated schools (Figure 4) while boys (97.67 per cent) and girls (95.65 per cent) of State Board-affiliated schools are equally poor in drawing skills and conceptual understanding of the digestive system (Figure 5).

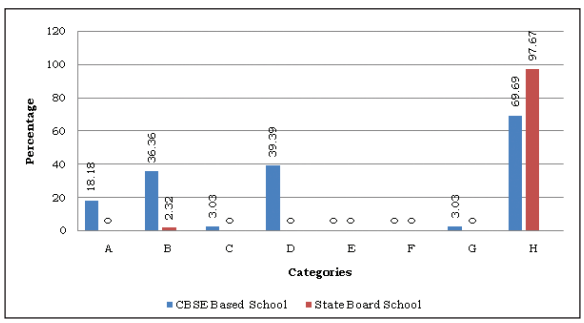

Figure 6. A comparison between boys of CBSE- and State Board-affiliated schools on drawing skills

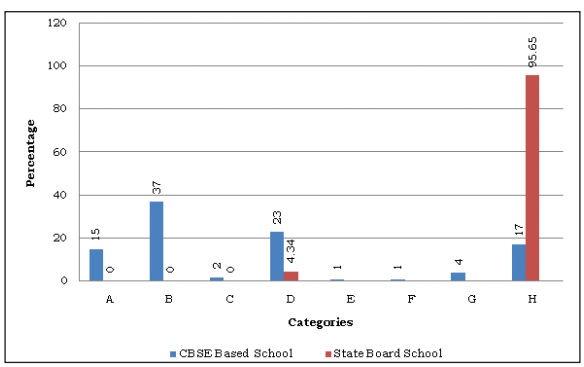

Figure 7. A comparison between girls of CBSE- and State Board-affiliated schools on drawing skills

The results of the present study (Figure 6) showed that boys of the State Board-affiliated schools (97.67 per cent) have more misconceptions about the digestive system than the boys of CBSE-affiliated schools (69.69 per cent). A similar trend has been observed in case of girl students (Figure 7).

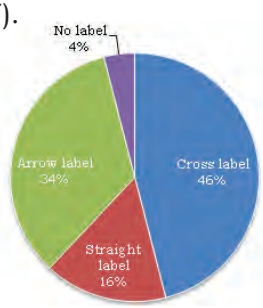

Figure 8. Different methods of labelling by students

While labelling the various components of the digestive system, it was observed that 46 per cent of students cross label lines, 34 per cent arrow labelling lines, 16 per cent straight lines and 4 per cent did not label their diagrams (Figure 8).

The analysis of responses to the close-ended questionnaire revealed the following problems faced by students when making biological drawings.

- ***LCD projector, charts and drawing on board***
  The results in Figure 9 indicate that 43 per cent of the students agreed that an LCD projector is used to show the biological figures and that they draw by observing. 38 per cent of the students mentioned that their teachers use commercial charts (that is, charts bought or purchased from outside) in the class and about one-fifth of students (19 per cent) mentioned that their teacher draws diagrams on the board.
- ***Monitoring of drawing***
  A large number of students (87 per cent) clearly mentioned that there was no monitoring by teachers while they were drawing (Figure 9). It indicates that teachers only show the figures and ask students to draw without any guidance.
- ***Instruction by teacher***
  The students' response (94 per cent) demonstrates that there were no instructions given by teachers such as labelling, shading and shape of organs. This is clearly reflected in students' drawings (Plates 2–8).

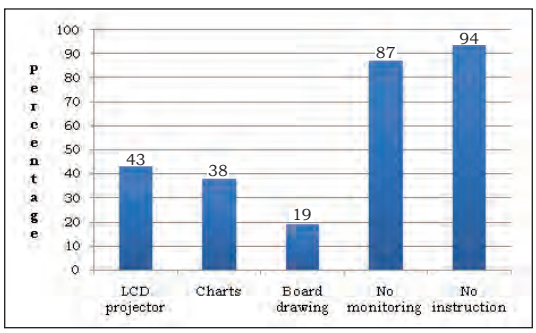

Figure 9. Responses of students to the close-ended questionnaire

Discussion

Biology is the most visual of all sciences, and has a long history of the use of drawing for defining and linking concepts in the living system. Drawing improves conceptual understanding. It helps students to have a better perception of the essential content that is considered (Göçmençelebi and Tappan 2010). Investigators of the present study are of the view that if a scientific text is supported by a drawing of the text, the students exhibit greater knowledge. Studies have shown that students who draw while considering a text, acquired greater knowledge than those who considered the same text without drawing (Schmeck et al. 2014).

The analysis of the drawings clearly demonstrates that about half of the respondents (52.94 per cent) have no correct knowledge about the position, structure and colour of various digestive organs. This may be due to several factors such as poor quality of charts shown to students, not showing scientifically correct figures through LCD projector or the absence of clear diagrams drawn on the board by the teachers. It is also evident from the responses of students (87 per cent) that there was no monitoring and no instructions were given by the teachers. Teachers' demonstration is very important in the sense that students will learn how to draw, how to label and make a proportional drawing. A large number of students could not draw straight labelling (Figure 9). This made the drawings untidy. Crossing the labelling lines and ones which do not touch the structures being labelled confuse the labels. Arrows normally show directions of flow; hence, they are not used as labelling lines. The labelling of biological drawings is an important component which reflects the understanding of students about the concepts. The results of the present study agreed with the findings of Wekesa (2013) and Dimitrijevic (2016).

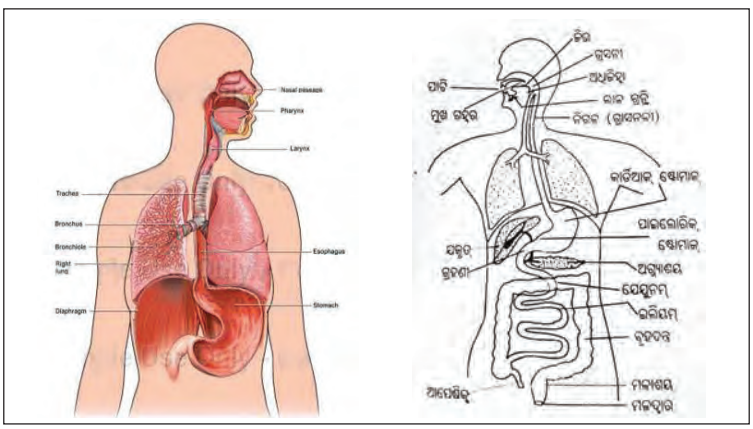

Figure 10. Chart (a) used in class and diagram (b) given in textbook

About one-fifth of the students mentioned that teachers ask them to draw from books. Though this strategy is very effective, without proper guidance and monitoring, it can be misused. The main objective of learning drawing skills may not be achieved. Students with basic understanding of a visual concept may reproduce a drawing in the same style as they have observed in the textbooks. Figure 10 shows the chart (a) and diagram (b) taken from the textbook of the State Board schools. This will surely develop misconceptions about various organs of digestive system. Teachers need to verify that the figures given in the textbooks are scientifically correct or not. To avoid this, teachers should closely monitor the students' drawing and give appropriate instructions.

The use of charts by teachers in the teaching of biology was indicated by 38 per cent of the respondents. Charts can be drawn by teachers or can be obtained from the market. Teachers rarely draw charts for Biology teaching at the secondary level (Figure 9). This may be due to the lack of information on the importance of charts in teaching-learning. It could also be attributed to the use of ICT (Information and Communication Technology) in many schools. While using commercial charts, care should be taken to ensure that the charts purchased are scientifically correct.

Several researchers describe drawing as a constructive learning process in which students' integrate information from the available representations in order to portray their understanding (Chang 2012; Cox 2005; Danish and Enyedy 2007; Van Meter and Garner 2005). While studying the students drawing the human digestive system, a number of misconceptions prevailing in the mind of students were observed. Many students have drawn the lungs in the digestive system (Plate 8). Maximum students are not aware of the position of diaphragm as they have shown it in the upper part of the chest or near the shoulder (Plates 2, 3, 5); some have shown that liver and pancreas arise from the oesophagus (Plate 4), and show the opening of the small intestine into the terminal part of the large intestine (Plates 6, 8). Some of the students are of the view that kidneys open into the intestines and many students are not aware of the shape of various digestive organs. The students' drawing reveals that the students of the State Board schools have a large number of misconceptions than the students of the CBSE-affiliated schools. Several researchers (Bell 2014; Chin and Teou 2010; Dempster and Stears 2014; Göçmençelebi and Tappan 2010; Malchiodi 2012) have opined that children's drawings reflect their knowledge and a very successful method in monitoring students' understanding. The misconception prevailing among students on the human digestive system demonstrates that neither the teachers have taken interest in monitoring the drawings

nor have they evaluated them to identify the alternative ideas that students have in the chapter.

Conclusion

Our findings strongly support the use of drawing as an epistemic practice not only in biology but also in other branches of science, and as an epistemological activity for the synthesis of understanding in addition to other forms of communication and assessment. Drawing as an additional form of assessment is needed to gauge students' understanding of the concepts of science alongside a more traditional mode, such as writing. With the goals for drawing-to-learn in mind, the next step is to consider how to scaffold drawing skills to meet those goals that is, how can instructors provide a sequence of support that helps the students to eventually achieve mastery of the skill on their own. It is beyond the scope of this study to propose teaching practices to support all of the diverse goals for drawing-to-learn. We recognise the need for drawing as a scientific practice to be taught in order for students to maximise their understanding of science.

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