The Visual and Verbal as Modes to Express Understanding of the Human Body

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Abstract. In this study, students' expression of understanding of structure and function in three systems of the body through visual (drawn) and verbal (written and spoken) modes was probed. Those with good comprehension had high scores in both modes. Pedagogical practices must emphasise explicit use of drawings and words to link structure and function concepts. This can help students of lower ability to form an integrated mental model which will aid understanding and expression.

The study of living beings encompasses two unique but interconnected aspects, structure and function. The work reported here probed how students express understanding of structure and function in three systems of the human body through words and drawings. Understanding was inferred from expression through these two modes. We tested the following hypotheses:

- Structure-function scores are likely to be correlated among good students.
- More concepts are likely to be expressed through a verbal mode.
- More function than structure concepts are likely to be communicated.

Twelve mixed-ability students (5 girls, 7 boys) of Stds. 6, 7 and 8 (ages 10 to 13) from an English medium school in Mumbai, India were the subjects. They were asked to respond to three questionnaires on the digestive, respiratory and circulatory systems through drawings and words. The questionnaires required them to perform two tasks. The first was to draw the organs of that particular system (this question probed understanding of structure). The second required visualisation of the processes of digestion, respiration and circulation by forming a visual mental image (probed understanding of function) such as tracing the path of a favourite food through the body for the digestive system. This was followed by clinical interviews with each student.

Textual responses (written and spoken, broken into simple propositions) and drawings (schematic diagrams and exact depictions) were analysed for comprehension of structure and function. The scheme of analysis is shown (Table 1).

'Order' is a criterion for understanding both structure (location of organs) and function (order of action of organs in a system). 'Segmentation', specific to drawn responses, refers to the basic units in a drawing, in this case the organs. Hierarchy inherent in *understanding* function is 'functional hierarchy'. For the digestive system, there are two levels of hierarchy: passage of food through

D. Barker-Plummer et al. (Eds.): Diagrams 2006, LNAI 4045, pp. 173–175, 2006.

Table 1. Scheme of data analysis

Text/verbal responses				Drawings			
Comprehension of structure		Comprehension of function		Comprehension of structure		Comprehension of function	
1	Organs of the system (names)	1	Order of action	1	Segmentation (organs drawn)	1	Order of action
2	Order (location in the system)	2	Hierarchy			2	Hierarchy

the alimentary canal and action of the liver and pancreas. Standard propositions from school textbooks provided guidelines to evaluate propositions from students' verbal responses. For every system a student was assigned four scores between 0 and 1 (for understanding of structure and function from verbal and drawn responses). Pearson's correlation coefficient was determined for verbal-drawing and structure-function scores across all systems (Table 2). Wilcoxon's signed ranks test was used to check if structure-function and verbal-drawing scores were significantly different.

Table 2. Pearson's correlation coefficient (r) for various scores

System of the body	Pearson's correlation co-efficient	
	Verbal with drawing	Structure with function
Digestive	0.24	-0.05
Respiratory	0.79**	0.82**
Circulatory	0.67*	0.39
Across all systems	0.62*	0.67*
*Significant correlation at $p<0.05$ level **Significant correlation at $p<0.01$ level		

For the digestive system it was found that there was no correlation between structure-function and verbal-drawing scores. Most students were at roughly the same level of understanding with scores at the higher end of the scale. A lack of correlation could be attributed to the 'functional hierarchy' inherent in the system. This led students to think that food goes into the liver and pancreas just as it passes through organs of the alimentary canal. Another difficulty concerned the structural connection between the small and large intestine though its functional connection was understood. This was perhaps a result of textbook drawings which portray the small intestine as a separate organ enclosed by the large intestine. Diagrams and content are presented separately with no clear linkages in the textbook and therefore learnt that way by students. For the respiratory system there is a direction in the structure of the system itself which helps in understanding function. Hence structure-function and verbal-drawing scores are correlated across written and drawn responses. The structural order of organs: nostrils-pharynx-trachea-bronchi-bronchioles-alveoli-bloodstream-body organs is also its functional order. The circulatory system has been treated quite cursorily in textbooks at this level, and therefore there is no structure-function

correlation. Many students erroneously understood the capillary to be another term for arteries and veins.

Wilcoxon's test showed a greater expression of structure concepts through drawings. However, overall across both text and drawings, more function concepts were expressed through the familiar verbal mode. Since the working of a system is what is easily remembered and emphasised, function is spontaneously communicated. Also since there is no direct correspondence (at a macroscopic level) between structure and function in the human body, correlation of the two aspects becomes difficult. Expression through drawings, particularly *schematic diagrams* is not emphasised in schools. It is a common myth that exact depictions are indicators of good drawing and are the privilege of a few talented students. Diagrams in biology therefore are often used to convey structure alone, with function (which is represented schematically such as through arrows) to be inferred from it.

Subjects with high drawing scores were found to have high verbal scores too. Previous research has documented similar findings. Piaget (1966) emphasised the use of both imaginal abilities and logical reasoning to perform conservation tasks. Heiser and Tversky (in press) found that high ability students formed a 'unitary' mental model which incorporated both structure and function. This may have been the case for good students in this study, who made linkages despite an unfavourable learning environment. For the large majority of students, pedagogical practices must emphasise dual coding of content by explicitly linking text with drawings and structure with function. Mayer (2003) put forth certain principles to design effective multimedia explanations making use of both pictures and words. However, diagrams are open to interpretation and can reveal as well as conceal. Therefore, it is finally the teacher in a classroom environment open to receiving and asking questions, who should play an important role in facilitating picture-text and structure-function linkages.

References

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