Students Learn About Their Own Bodies as Part of Their Biological and Citizenship Deduction. How do they learn? What do they learn first? From whom do they learn?

Subject

Students construct their ideas from formal or informal environments within an individual prospective or a social prospective (Scott, Asoko, and Leach, 2006). Scott, Asoko, and Leach (2006) state, "There are strong commonalities in how individuals appear to think about the natural world" (p. 38). The results from several studies in UK and US suggest students have commonalities about the order of organs of the digestive system and how the digestive system functions. In addition to commonalities, studies by Reiss and Tunnicliffe (2001, 2002) revealed that students' understanding of the human organs and organ systems increases with age but remains incomplete.

When teachers or researchers ask subjects about their understandings of anything, subjects respond by presenting 'representations.' These representations may be words or mathematical symbols, drawings, physical constructions or even gestures or, in the language of Buckley *et al.* (1997) and Gilbert *et al.* (2000), expressed models – that is, representations of phenomena placed in a public domain. These expressed students' models are presumed to be generated from mental models, i.e. the personal cognitive representations held by individual subjects. The only way for a researcher to understand a subject's mental model of a particular phenomenon is by eliciting one or more of their expressed models of that phenomenon.

Procedure

1. Students answer questions posted on the Diagnoser website (www.Diagnoser.com). The questions are intended to elicit "facets of understanding" that students use to describe the respiratory system, circulatory system, and digestive system.

In the United States, the 751 students answered human biology questions posted on the Diagnoser website www.Diagnoser.com, developed by Jim Minstrell and his group Facet Innovation, Seattle, WA. The questions pertain to the respiratory system, circulatory system, and digestive system. Results presented are from the analysis of students' answers to digestive system questions. The questions are intended to elicit "facets of understanding" that students use to describe the physical world. The program provides student feedback to either reinforce their thinking or encourage revision of their thinking. A class summary report is provided to teachers and a report on how each student answered the questions. The questions presented to students are intended to elicit the ideas (conceptions, misconceptions, facets of understanding) that the student uses to describe the physical world. Diagnoser is aligned with the National Science Education Science Standards (NAP, 1996) and Benchmarks (AAAS, 1993) for middle and high school students. Along with the questions, the program provides some feedback to students to either reinforce their thinking or encourage them to revise their thinking. The program also provides reports to teachers that show how each student answered the questions along with a class summary.

A*nalyses and Findings*

Results from Diagnoser showed students have alternative understandings of anatomy and physiology after instruction. Unfortunately, instructors take it for granted that all students would know the order of digestive organs after instruction. This is not true. Almost 50% of the students in grades 5, 7, 8, 9, and 10 either thought the large intestine came before the small intestine or

the bladder came after the large intestine, or the lungs came between the esophagus and stomach. Fifty eight percent of students wrongly answered the question: most of the products of the digestive system are transported into the rest of the body in which part of the digestive system: (a) mouth 11%; (b) large intestine 20%; (c) stomach 24%; (d) small intestine 42%; (e) esophagus 3%.

Students had difficulty with abstract physiological concepts (theoretical conception) such as the function of micro-villi. Forty five percent of students answered the following question "In some diseases the tiny bumps (micro-villi) of the digestive system are destroyed. How would that affect the functioning of the digestive system?; (a) It would limit movement of stuff along the digestive tract (It would limit movement of stuff along the digestive tract, 45%; (b) It would limit absorption of stuff from the digestive tract, 51% (correct answer); (c) It would limit the mixing of stuff within the digestive tract, 4%."

Language can be confusing to students such as the "break down" of food, chemical (break-down of molecule) and mechanical (break-down of large pieces to smaller pieces, no change in molecular structure). The digestive system breaks the food you ate into smaller pieces of that food and the smaller pieces get transported into the body; (a) true 53%; (b) false 47%, indicates students are confused.

Conclusions

Students' exposure to information about human biology before beginning school can be from other sources of knowledge outside a formal learning environment. For example, Hannah (8yrs) describes asthma because her friend had kit and shows an understanding of respiratory system and mentions funny bone from personal experience. Several times students hear repeated phrases " if you didn't have bone you'd be jelly on the floor' blood made in thighs (influence of particular teacher year 4)."

It appears that there is the comfort level at which students' knowledge suffices and there is from anecdotal evidence the same leveling off of knowledge about phenomena and artifacts in many areas. A sufficiency but not a proficiency of knowledge is the norm.

Implications for Teachers

Instruction should start from learning organ and organ location but at the same time instruction should include a description about how the organ works within the organ system and it functions with all the systems, a holistic instructional approach. For example, the diaphragm is the muscle most often indicated on drawings, because it is taught with the respiratory system and the classic longitudinal section of the upper torso is the one studied and recalled, with the diaphragm as its lowered boundary. Diaphragm function provides the perfect opportunity for discussion of flow, specifically air flow, influenced by volume and pressure. Flow, volume, and pressure relationships are similar in other systems. Therefore, when students learn about the diaphragm they need to learn the functions of the diaphragm.

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