How do high school students know diffusion and osmosis?
High school students’ difficulties in understanding diffusion & osmosis

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Abstract

The previous researches results seem to suggest that some aspects of learning of diffusion and osmosis concepts such as membranes, kinetic energy of matter, and elements of the particulate and random nature of matter could lead to misconceptions. The concept of diffusion is very common in science instruction, and understanding the concept is an important precursor to instruction in life science and physical science. The learning of concentration and tonicity processes of diffusion and osmosis, life forces influence on diffusion and osmosis, and random nature of matter were difficult learning for students. It appears that misconceptions may play a larger role students learn diffusion and osmosis concepts. What could be take place the active role of the student learning without misconceptions of diffusion and osmosis. It is possible suggest, students should actively engaged in constructing knowledge. During each phase of the learning, students should actively manipulating materials, recording data, or analyzing results. Students should encourage to discuss findings in groups and with the class. The teacher acts as a facilitator via making connections between concepts. Students may debate and argue a relationship between concepts and their contents this may provides paying their attention experiences with the concepts. Because of its importance of diffusion and osmosis, it may be beneficial to investigate misconceptions of high school students. The purpose of this study was to investigate students’ understanding about scientifically acceptable content knowledge by exploring the relationship between knowledge of diffusion and osmosis and a student’s confidence in their content knowledge following instruction.

Keywords: Osmosis, diffusion, High school, cell membrane

1. Introduction

Both students’ content knowledge and confidence are important in determining students’ level of understanding about science concepts. Although researchers have reported difficulties with teaching diffusion and osmosis, the concepts remain very important to the understanding of basic biology concepts. It was strongly advice that students should develop an understanding of transport of materials across cell membranes. Diffusion is the primary method of short-distance transport in cells and cellular systems. Osmosis is used to explain water uptake by plants, turgor pressure in plants, water balance in aquatic creatures, and transport in living organisms. Unfortunately, many students find these topics very difficult to understand (Friedler, Amir & Tamir 1987, Oztas & Bozkurt, 2010).
several biology education researchers have reported student misconceptions regarding these two topics (Marek, 1986; Zuckerman, 1998; Odom & Barrow, 1995; Oztas & Oztas, 2012). One reason why students may have difficulty with the concepts of diffusion and osmosis is because these concepts require students to visualize and think about chemical processes at the molecular level. Sanger et al. (2001) reported that students are unfamiliar with particulate drawings, they may misinterpret these drawings. Most of the concepts in diffusion and osmosis are closely related to concepts present both in chemistry and in physics, such as solutions, particulate nature of matter, and permeability. Therefore, understanding of these concepts requires the understanding and application of knowledge in physics and chemistry as well as biology. Johnstone & Mahmoud (1980) observed that osmosis and water potential were regarded by students and teachers as being among the most difficult biological concepts to understand. Zuckerman (1993) reported that two misconceptions about osmosis especially important. These were that the rate of osmosis is constant; the concentrations of water across the membrane must be equal at osmotic equilibrium. In order to construct meaning of diffusion and osmosis, one must make sense of technical concepts (e.g., solution, solute, solvent, molecular movement, net movement, and direction of movement); many of which are difficult to detect or simulate in laboratory situations. Odom (1995) administered the Diffusion and Osmosis Diagnostic Test (DODT) to secondary biology students, and misconceptions were detected in related conceptual areas.

According to Ausubel (1968), progressive differentiation refers to the learning process in which learners differentiate between concepts as they learn more about them. During the process of integrative reconciliation, the learner recognizes relationships between concepts and does not compartmentalize them (Novak, 1990). For this purpose of this study has been designated as to identify high school biology students’ knowledge and certainty about diffusion and osmosis concepts.

2. Material and methods

The DODT is a validated two-tier diagnostic test designed to assess understanding of diffusion and osmosis concepts. Each item on the DODT has two tiers. The first tier consists of a content question with two choices. The second tier consists of four possible reasons for the first part: three alternative reasons and one scientifically accepted reason. The DODT has 10 items that assess understanding corresponding to the particulate and random nature of matter on diffusion and osmosis. Items were scored correct on the DODT if both the desired first tier answer and second tier reason were selected. If an undesired answer was selected in either tier the item was scored as incorrect (Odom & Barrow, 1995). Adjacent to each DODT item was a statement in which students were asked to indicate the level of their confidence such as I am sure --------, 100% 80% 60% 40% 20% 0% (please circle one). Initially, selecting 80% or above on the confidence statement was defined as being confident in an answer, and selecting 60% or below on the confidence statement was defined as being not confident in an answer. However, following data collected we transformed confidence responses to the Certainty of Response (CRI) scale to simplify analysis. It has been reported that (Hasan, Bagayoko, & Kelly, 1999) reported using a six point CRI scale in conjunction with answers to multiple choice questions to identify misconceptions. A zero on the CRI scale implied no confidence in their answer on the corresponding multiple choice item, and 5 implied complete confidence in their answer. Both the confidence scale and CRI had six values making a one-to-one conversion simple. For example, a confidence scale of 0-19% was converted to a 0 CRI.

3. Results

The particulate nature and random motion of matter was examined through items 2 and 3 of the DODT. These items assessed students’ understandings of the movement of matter at the molecular level. Students observed demonstrations of diffusion, such as the diffusion of blue ink in water. The desired response to item was “during the process of diffusion, particles will generally move from high to low concentrations” because “particles in areas of greater concentration are more likely toward to lower areas.” The group had an average score of 60% for this item 2 and 40% percent points item 3. The obtained scores were below 75% on this item, suggesting an unsatisfactory understanding. Of particulate nature and random motions in solution. It is possible that these students had a partial understanding of diffusion, because an end result of the process of diffusion is a uniform distribution of particles.
In item 5, students were to determine what would happen to a spoon of sugar molecules after they had been evenly distributed throughout a cup of clear water. The desired response was “that molecules of sugar continue to move around randomly not sedimentation even not stir it” because “molecules are always moving up to saturation”. The average score was 20%, not suggesting any satisfactory understanding.

The students have been selected that “if sugar stirred, could stop moving and it would settle to the bottom of the cup.” This may be because students believed that movement is necessary to oppose gravity.

Students have interpreted item 7 such as stop moving as equivalent to no net movement, thereby demonstrating a partial understanding of kinetic theory of matter. The average score was 40%. Another common alternative selection for item 6 was that “crowded particulars in an area into one area and therefore they move to an area with more room.” This selection could represent an anthropomorphic view of matter; that is, the need for molecules to move into another area. The mean score was 80% and an unsatisfactory understanding of this item.

In item 4, students were asked to determine the rate of diffusion as a result of a concentration gradient. The desired response was that “as the difference in concentration between two areas increases, the rate of diffusion increases,” because of “the greater likelihood of random motion into other regions.” The average score was 40%, it was scored above 75.0% on this item, suggesting an unsatisfactory understanding. The view of students about diffusion and osmosis activities with both nonliving and living systems examined through items 1, 8 & 9. In this item, if a plant cell was placed in 25% salt water, then whether diffusion and osmosis would continue in vacuoles. The desired response combination was “diffusion and osmosis would continue,” because “the cell does not have to be alive.”

The group had a score, 60%, suggesting unsatisfactory understanding. The most common alternative response was diffusion and osmosis would stop after a plant cell was killed because the cell was no longer functioning. It is reasonable that students would compare a cell with a living organism such as a person.

4. Discussion

None of the average scores was below 75%, suggesting an unsatisfactory understanding. Scientifically understanding of diffusion and osmosis conceptions did not occur for the large majority of students. Odom (1995) reported that even following instruction continued to have misconceptions about diffusion and osmosis. Westbrook and Marek (1991) noted that none of the secondary and college level science students in their study had a complete or sound understanding of diffusion. Because of the tenacity of students’ misconceptions and the formal nature of diffusion and osmosis, teachers need to carefully select content material that is based on empirical phenomena and provide students ample time and opportunity to collect data, and discuss and debate their observations.

We believe that osmosis and diffusion are important to understanding many biological processes, but that great caution should be taken when the concept of tonicity is introduced to high school biology students until effective instructional approaches can be identified by researchers. In order to understand diffusion and osmosis, students must have a working knowledge of concepts such as solute, concentration, solubility, and dilution (Johnstone & Mahmoud, 1980). To suggest that diffusion and osmosis are simple concepts because they are so basic is inaccurate.

References


