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How Do Biology Teacher Candidates Know Particulate Movements & Random Nature of Matter and Their Effects to Diffusion

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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 leaening 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. İt 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 difussion and osmosis? İt 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 discussing findings in groups and with the class. The teacher acts as a facilitator via making connections betvveen concepts. Students may debate and argue relationships betvveen concepts and their contens this may provides paying their attention experiences with the concepts. Because of its importance of diffusion and osmosis, it may be benefial to investigate misconceptions of high school students. The purpose of this study vvas to investigate students' understanding about scientifically acceptable content knowledge by exploring the relationship betvveen knowledge of diffusion and osmosis and a student's confidence in their content knowledge following instruction.

Keywords: Diffusion, concentration, membranes, random nature of matter.

1. Introduction

The purpose of this study vvas to identify high school biology students' knovvledge and certainty about diffusion and osmosis concepts. More specifically, it has been examined students' knowledge and certainty about concentration and tonicity, influence of life forces on diffusion and osmosis, membranes, particulate and random nature of matter, the process of diffusion, and the process of osmosis. It has been reported that a group of pre-service teachers had a significant correlation in their confidence and knowledge, as confidence decreased their content knovvledge decreased (Oztas & Dilmaç, 2009). Pallieret al. (Pallıer et al.,2002) found that individual differences provided a source of overconfidence. Similarly, Lundeberg (1994) assessed individual's degree of confidence in their ability to ansvver test questions.

Wandersee et al. (1994) summarized a large body of research on science misconceptions (alternative conceptions) providing a comprehensive revievv of the literature. They subsequently reported evidence of eight emergent knovvledge claims. They claimed that all learners have a diverse explanation of scientific phenomena which are often at variance vvith accepted scientific vievvs. Both students' content knowledge and confidence are important in determining students' level of understanding about science concepts. Although researchers have reported difficulties vvith teaching diffusion and osmosis, the concepts remain very important to the understanding of basic biology concepts. It was strongly adviced 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 et al. (1987), and several biology education researchers have reported student misconceptions regarding with these two topics (Marek, 1986; Zuckerman, 1988; Odom, & Barrow, 1995).

One reason why students may have difficulty vvith 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 vvith particulate dravvings, they may misinterpret these dravvings. 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 knovvledge in physics and chemistry as well as biology. Johnstone & Mahmoud (1980) observed that osmosis and water potential vvere regarded by students and teachers as being among the most difficult biological concepts to understand. Zuckerman (1998) reported that two misconceptions about osmosis especially important. These were rate of osmosis is constant; the concentrations of water across the membrane must be equal at osmotic equilibrium. İn 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 vvhich are difficult to detect or simulate in laboratory situation. Odom & Barrovv (1994) 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 betvveen 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).

2. Materials 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, three or four choices. The second tier consisted of four possible reasons for the first part: three alternative reasons and one scientifically accepted reason *(Table 1).*

If concertration level betvveen two area increases, how could change diffusion rate; *a. İncreases b.Decreases*	*/ am sure about my ansvver (100%, 80%, 60%,* *40%, 20%,0%)*
Because, *a. There is less space for particules move* *b. If concentration is high enough, the concantration* *rate vvill be less* *c. The molecules vvant to spread* *d. The random motion of particules vvill increase*	*1 am sure about my ansvver (100%, 80%, 60%,* *40%, 20%,0%)*

Table 1. A sample of applied two-tier diagnostic test item

The DODT has 9 items that assess understanding corresponding to the particulate and random nature of matter and influence of life forces on diffusion and osmosis the process of diffusion. *Items vvere 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 & Borrow, 1995).* Adjacent to each DODT item vvas a statement in vvhich students vvere asked to indicate the level of their confidence in their selection for each tier of the DODT with the following statement: "*/ am sure about my answer-100% 80% 60% 40% 20% 0% (please tick one)."* Initially, selecting 80% or above on the confidence statement was defined as being confident in an ansvver, and selecting 60% or below on the confidence statement was defined as being not confident in an answer. However, following data collected and transformed confidence responses to the Certainty of Response (CRI) scale to simplify analysis. Hasan et al. (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 *(Table 2).*

I am sure about my ansvvers (100%, 80%, 60	***Certainity of Response lndex (CRI)***
%, 40%, 20%, 0%).	
a.% 100, b.% 80,c. % 40, d.% 20, e.% 0	
0-19	*0 Totally guess*
20-39	*1 Almost guess*
40-59	*2 Not sure*
60-79	*3 Sure*
80-99	*4 Almost certain*
100	*5 Certain*

***Table** 2.Certainity of Responces Scale*

Concept, and with incorrect DODT ansvver suggested a misconception about the content. Our reasoning was hat students who have low certainty in their answer combinations were possibly guessing; and, therefore had no understanding, or was confused about their understanding. However, students who had high confidence n incorrect answers on the DODT indicated their tenacious misconceptions about diffusion and osmosis concepts. Data was collected from 30 biology teacher candidates in grade 2 with the Diffusion and Osmosis Diagnostic Test (DODT) vvho education in N. Erbakan University, Ahmet Keleşoglu Education Faculty, Konya-Turkey. The one of researchers is lecturer in the same Department. The questionnaire has been seen and appreciated by three senior lecturer of Department of Biology Education and amended by Ethic Commision of Ahmet Keleşoğlu Education Faculity (N. Erbakan University) that *"this research project information did not obtain from the next of kin, caretakers, or guardians on the behalfof the minors/children participants."* The students received a combination of text question, focused on movement of particles, concentration gradients, the process of diffusion, and osmosis.

The students filled these questionnaire forms under supervision and importance of the subject was described before application in order to prevent students to answer questions without reading. Moreover, it was determined that it was not an examination and sufficient time was given for students to fil out these questionnaires. This test was controlled by three academic members vvho are expert in biology education field. Evaluation of the data obtained via questionnaire forms was carried out with ready statistical packaged softvvare SPSS 10.00. The results of the DODT were sorted into correct and incorrect ansvers. The frequences and % percentage of answers sorted out statically. High certainty in incorrect answers on DODT indicated tenacious misconceptions about diffusion and osmosis. Most students were either guessing or had misconceptions about every item related to the concepts. Low certainty in incorrect correct answers on the DODT indicated possible guessing.

II.Findings

Concentration, influence of life forces on diffusion and osmosis, membranes and diffusion the particulate nature and random motion of matter was examined through *items–9* 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 a spoon of sucrose in water.

The desired response to *item 5* vvas *"during the process of diffusion, particles will generally move from high to low concentrations"* because *"particles in areas of greater concentration are more likely to bounce toward other areas."* The group had an average score of 80 % for this items' certainity. Mean value scored below75 % on this item (60 %), suggesting an unsatisfactory understanding.

A common alternative response may have been due to a misunderstanding of terminology. For example, many students selected *"particles generally move from high to low concentration because particles tend to move until the two areas are isotonic and then the particles stop moving."* These students may have accept *"homogenite"* means *as"the same"* and interpreted this item to mean that particles vvould continue to move until they are *"the* *same"* concentration throughout *(İtem, 4, 5, 6).*

*In i*tem *4,* students were asked to determine the rate of diffusion as a result of a concentration gradient. The desired response vvas 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 60 %, none of the treatment groups scored above 75.0% on this item, suggesting an unsatisfactory understanding.

*I*n *İtem 5,* students were to determine vvhat would happen to sucrose molecules after they had been evenly distributed throughout a cup of vvater. The desired response was *"that molecules of sugar continue to move around randomly"* (rather than stop moving), because *"molecules are always moving."* The average score vvas 40 %, suggesting a unsatisfactory understanding. Most of students have been selected that *"if sugar particuls did not stir by a mixer they stopped moving and settle to the bottom of the cup."* The most common alternative responses were *"the sugar molecules will be more concentrated on the bottom of the cup,"* because "the sugar is heavier than vvater and vvill sink," and "there vvill be more time for settling." This may be because students believed that movement is necessary to oppose gravity. Possible students integrated gravity concepts into chemistry. Students can see sugar granules sink to the bottom of the container. If students ignored the condition (that the sugar was allowed to set for a very long period of time), their response vvould describe what happens when sugar granules are first placed in the container.

Students may have interpreted *"stop moving"* as equivalent to *"no net movement,"* thereby demonstrating a partial understanding of *"particulate and random nature of matter (Item 2 & 7).* A common alternative selection for *İtem 7* was that *"there are too many particles crowded into one area and therefore they move to an area with more room."* This selection could represent an anthropomorphic vievv of matter; that is, the need for molecules to move into another area. The group had an average score of 60 % for *İtem 2* and 80 % for *İtem 7* certainity. Mean value scored below 75 % for item 2 (60 %), suggesting an unsatisfactory understanding. But a beter understanding for item 7 (80 %). The most common alternative response for *item* was *"the rate of diffusion will decrease because if the concentration is high enough, the particles will spread less and the rate will be slowed."* It is reasonable that students had no accepting the random motion of molecules.

Item 8, assessed the process of osmosis in a plant cell. This item shows a picture of a plant cell that lives in freshvvater, the cell was then placed in 25% salt water and students were asked what happened to the size of the central vacuole. The desired response was *"the central vacuole would decrease in size"* because *"water vvill move from the vacuole to the saltwater solution."* A minority of students determined the correct direction of water flow and the desired reason (60 %), suggesting unsatisfactory understanding (under % 75). The most common alternative response was "salt absorbsvvater from the central vacuole." The meaning of *"absorb"* may be different in a science context than in a nonscientific context. Common everyday experiences in a nonscience context are sponges absorb water and paper towels absorb water. if *"absorb"* is viewed as the "taking avvay" of water, then students may have believed that the saltwater solution absorbs the freshwater. In a scientific context, absorption is capillary action caused by adhesion. Salt solutions do not cause capillaryaction.

Students observed or participated in diffusion and osmosis activities vvith both nonliving and living systems. This concept was examined through *İtem 9.* İn this item, cell was killed the question was whether diffusion and osmosis would continue. The desired response combination was *"diffusion and osmosis would continue,"* because"t/he *cell does not have to be al ive."*

The group had a score, 60%, suggesting unsatisfactory understanding. The most common alternative response was diffusion and osmosis would stop after a 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. At the macro-level, when an organism dies it stops functioning; but at the micro-level, processes may continue for hours or days.

III.Discussion

Construction of scientifically acceptable understanding of diffusion and osmosis conceptions did not occur for the large majority of students. Strong misconceptions vvere detected about concentration, influence of life forces on diffusion and osmosis, membranes, particulate and random nature of matter *(Marek, 1986; Zuckerman, 1988; Odom, & Barrow, 1995).* Christianson & Fisher (1999) reported that college students in a "*constructivist"* course learned significantly more diffusion and osmosis concepts than students in a more traditional biology course. It was suggested that motivation and learning in biology could be enhanced by allowing teacher-student, student-student discussion.

It becomes obvious that high levels of certainty in incorrect content suggest that misconceptions will be difficult to change. Traditional teacher-centered instruction provides poor learning opportunities. According to Ausubel (1968) there are difficulties associated with rote learning that rote learning may cause interference with previous learning. This may result in difficulties with patterns of recall, including mis-associations. It has been stated that development of declarative and procedural knovvledge occurs as a consequence of accommodation (Piaget, 1970); alternative mental structures are selected or constructed, driven by disequilibrium, until a good match betvveen expected and actual outcomes occurs to restore equilibrium (Lavson, 1995).

This process of constructing knowledge usually vvill begin vvith an observation and question. The ability to generate declarative knowledge depends on procedural knowledge, which is dependent on the ability to generate and test hypotheses. We believe that osmosis and diffusion are important to understanding many biological processes. As it has been shown in study large majority of students were either guessing or had misconceptions about every item related to the concentration, influence of life forces on diffusion and osmosis, membranes, particulate and random nature of matter concepts. We believe that these concepts are important to understanding many biological processes, but that great caution should be taken when these concepts introduced to students until effective teaching approaches can be identified by researchers.

It seems that the relationship betvveen self-efficacy (Oztas & Dilmac, 2009) and confidence (Oztas, 2010; Oztas & Oztas, 2012) in content knowledge, and student understanding these concepts are vital for biology education. It could strongly accept that understanding of the particulate and random nature of matter is important to understanding of diffusion and osmosis. Also explore the exact means of scientific terminology on learning should be consider. This study's results may help a science teacher address the question: "what can I do to increase the likelihood that my students vvill understand diffusion and osmosis?"

In this study a modified form of The Diffusion and Osmosis Diagnostic Test, (Odom & Borrow, 1995) partly used in this study assessed the particulate and random nature of matter. Each methodology has its strengths and has contributed significantly to improving science achievement, the promotion of the active role of the learner, and the promotion of the facilitative role of the teacher. Hovvever, using of a single methodology as teaching difusion and osmosis not good enough.

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