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DETERMINATION OF THE UNIVERSITY STUDENTS' MISCONCEPTIONS ABOUT THE TOPIC "PASSAGE OF SUBSTANCES THROUGH CELL MEMBRANE" BY TWO-TIER TEST[1]

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ABSTRACT

Information that is contrary to the scientific reality is called misconceptions, and students gain them as a result of their past experiences. Learning new and correct information becomes more difficult or even hamper due to misconceptions. This study was conducted to determine the misconceptions of the health-care technician students related with the passage of substance through cell membrane. It was performed with 335 students. The research subject was explained to the students in a two-hour course by a researcher in the human physiology course. One week later, a two-tier diagnostic test consisting of seven questions was applied.

It was seen that diffusion was the most known subject by the students and the correct answer rate was 77.9% (n:261). On the other hand, the least known subject was the calculation of the amount and the direction of the passage matter's (plasmolysis and deplasmolysis events) depending on ambient density (number of correct answer: 9.3%, n:31). Some misconceptions that were identified are the following: 1- 33.7% of students thought that the active substance transport occurred only from low density medium towards high density medium. 2- 36.1%of students thought that pure water was isotonic. 3-53.7% of the students thought that the large molecules such as starch could pass through the membrane until the density to equal in both side.

The data were compared in SPSS 15.0 program depending on whether students participated in the training programs that was given as a research subject or not. The correct response rate for questions was significantly different between participating and nonparticipating groups ($p = .01$ for multiple choice questions and $p = .003$ for open ended questions), and most successful training program was physiotherapy.

Key Words: health technician, misconceptions, passage of substances through cell membrane, two-tier diagnostic test

INTRODUCTION

To be able to make sense of abstract concepts and correct understanding of how the incident of the students occurred is the most important fact to learn a lot of topics in science training. The topic, the passage of substances through cell membrane, is also one of these abstract concepts for students. This topic is a subject related to all of science courses, primarily of the biology. All metabolic activities such as nutrition, respiration, filtration and re-absorption in the kidneys, passage of substances in capillaries, nervous transmission or nutrient/water transport in plants in the biology course occur as to rules of the active and passive substance transportations, and these rules are the same for all living creatures. That's why correct/good learning of this subject has great importance especially in learning and understanding of physiological events which occur in living beings (Odom & Barrow, 1995). If students do not learn substance transmission correctly, they will also have difficulty in understanding / learning other physiological events or they will not learn them correctly. It was reported by Ausubel (1968) that in order to provide successful teaching, the most important psychological principle was to measure the knowledge of the students and to design the methods of teaching according to this data. Likewise, in the constructivist teaching model,

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the learning a new knowledge and the developing a new understanding can only occur in the direction of the knowledge and the experiences the students have (Bransford, Brown & Cocking, 2000).

The misconception can be defined as the information which is known significantly different from the scientifically meaning (Yagbasan & Gülçiçek, 2003). Learning is the product of the interaction between the concepts existing in the mind of the individual and the newly learned ones. For this reason, in a new learning environment, the previous knowledge can facilitate the learning or can prevent it. Misconceptions are closer and more valuable for students because they are developed in a long process resulting in their own observations. If the misconceptions can't be resolved, the learning process can be seriously hampered (Yagbasan & Gülçiçek, 2003). Many researches were carried out on the passage of substances through the cell membrane, but a great majority of these were only on passive transport (osmosis and diffusion phenomena) (Odom & Borrow, 1995; Odom &Borrow, 2007; Odom & Kelly, 2001; Christianson & Fisher, 1999; Hasni, Roy & Dumais, 2016; Artun & Coştu, 2011; Çinici & Demir, 2013; Tarakçı et al., 1999; Tekkaya, Şen & Özden, 1999; Yıldırım, Nakiboğlu & Sinan, 2016; Oztas, 2014).

Aim of study: This study was designed to identify the misconceptions of the health technician students about the transportation of substances through the cell membrane.

Importance of study: This study has two superior features to the previously done ones.

1. The content validity of this study is broader because the two-tier diagnostic test contains questions about both active and passive transport. In the vast majority of similar previous studies, only osmosis and diffusion concepts were dealt with. But, the issue of transporting active substances was not studied much. Whereas particularly metabolic events, such as neural transmission, the recovery of organic molecules in the kidneys, and the transport of nutrients in the plants' vascular tissues, occur along with the active substances transporting way. Therefore, it is necessary to determine the students' knowledge level and whether they have the misconceptions with regard to of active transport or not. This will help teachers in preparing their teaching methods and programs appropriately.

2. In previous studies conducted with two-tier test method. In the previous studies conducted with two-tier test method, the multiple-choice questions given by the researcher were usually for both stages of the questions. However, in this study at the second stage of the questions, open-ended questions were used (*Briefly explain why you are marking this option in the above question*.), and so it allowed students to express their own thoughts. The first stage of the questions contained five-options, and one of these was correct, the other four were for distracters. Thus, the answers that might come from students were not limited and it was allowed to identify new conceptual mistakes that couldn't be predicted.

METHOD

Samples: A total of 335 university students, who took human physiology course enrolled in six different programs of Aydın Vocational School of Health Services (AVSHS) in 2016-2017 academic year, participated in to the study. Distribution of the students who according education programs are as follows: *Anesthesia (AN) n:52 (15.5%), Dialyses (DY) n:46 (13.7%),Medical Imagine (MI) n:32 (9.6%), Medical Laboratory Techniques (MLT) n:44 (13.1%), Physiotherapy (PHT) n:49 (14.6%), Paramedic (PMD) n:104 (31.0%),* n:8 (2.4%) of the participants didn't answer this question. These eight participants were not included in to the calculations, while their scores were compared with statistically.

The same teacher taught the research subject to the students in six classes as a two-hour course. After a week, a two-tier diagnostic test prepared by the researcher was applied to them. 286 (85.4%) of the students attended the course, but 39 (11.6%) of them didn't and 10 (3.0%) of them did not answer this question.

Instrumentation: A Two-Tier Diagnostic Test was used. There was an instruction about questions and about how they would be solved at the beginning of the test. The test contained seven two-tier questions. Six of them were multiple choice questions (MCQ) in first stage, and in second stage they were open-ended (OEQ) "Why did you chose this option, please explain with a few sentences". In question 7, both stages were open-ended, and also students had to do mathematical calculations in order to find the answers. The questions were shown to the field experts and got their opinions before the application. The study was done after the proposed corrections were made.

Table 1: Measured subject areas and area information for active and passive substance transport with two-tier test.

No	Subjects	The knowledge intended to be measured.
1	Osmosis	Having knowledge about osmosis or not.
2	Intra cellular concentration	Having knowledge about the concepts "ISOTONIC, HIPOTONIC and HIPERTONIC" or not.
3	Diffusion	Having knowledge about diffusion or not?
4, 5	Active transport (energy-requiring)	Having knowledge about active substances transport and requirements for this event?
6	Plasmolysis, Deplasmolysis	Having knowledge about plasmolysis/deplasmolysis or not?
7	Osmotic pressure, Turgor pressure	Having knowledge about osmotic/turgor pressure or not?

Evaluation: Every question was examined and evaluated one by one, then the data were entered in to SPSS 15.0 program and were analyzed. It's Cronbach $\alpha = .74$.

Item discrimination index was calculated by 27% Lower - Upper Group Method.

In order to calculate the item difficulty index [**Pi = n(d)/N**] formula was used.

Table 2: Item difficulty index (Pi), and item discrimination index (Rjx) of questions in the test.

Q	1	2	3	4	5	6	7	*7 C-I*	*7 C-II*	*7 C-III*
$\mathbf{P_i}$	0.35	0.25	0.77*	0.27	0.20	0.25	0.09**	*0.08***	*0.08***	*0.41*
$\mathbf{R_{jx}}$	0.72	0.35	0.26!!	0.54	0.51	0.40	0.24!!	*0.12!*	*0.12!*	*0.29!!*

**Difficult question, * Simple question, !! A moderate item should be developed, !Discrimination is a weak item

According to these results, question 3 was simple and its discrimination feature was weak. This question was related to diffusion, and this event was the best known situation among the other physiological happenings. Thus this situation could be the reason of the negative/weak analysis results of the third question.

When the question 7th was evaluated it was thought that the question was a bit hard. But it was also seen that most of the students made mathematical calculations for this question wrongly. This was the reason for the weakness of the seventh question's discrimination index. When looked at option-III of the same question, it was seen that P_i and R_{jx} values were sufficient. Since the Ops were equal in the both sides of the cell membrane, the calculation was very easy, even wasn't necessary to be an option in the question.

Evaluation of the questions: The questions were classified according to the method used by Karataş, Köse & Coştu (2003). 2 points were given every correct multiple choice

question (MCQ). If open-ended question (OEQ) was completely true, 3 points were given. If it had got insufficient knowledge or partly true 2 points were given. Incorrect answers weren't scored. Each pair of correct answers corresponded to a total of 5 points. The student who answered all of questions correctly could get a total of 35 points.

FINDINGS

Question 1: This question was related to osmosis, and they were going to answered it like this: "Starch is a big molecule, so it cannot pass through semipermeable membrane, so water passes to the other side until the two sides are equalized by osmosis". MCQ part of the question was answered correctly by 117 (35.8%) students, but the correct answer rate in OEQ was 93 (28.4%).A statistically significant difference was found in favor of the PHT program (p=.000) when the response rates depending on the training programwere compared (table 3).

Total 44 wrong expression sentences were identified related to the first question, and totally 20 different misconceptions were determined. When these misconceptions were evaluated and combined, it was seen that these misconceptions arose due to three basic incorrect information the students had:

1. Students didn't know that starch was a big molecule could not pass through a semipermeable membrane (n:170; 53.7%).

2. They were confused about osmosis and diffusion concepts (n:114; 34.0%).

3. They thought that the starch was solvable in water (n:14; 4.2%).

Question 2: In this question, the internal concentration of a Protista that adapted to freshwater habitat was given as 0.5%. As to this information, different aquatic media such as tap water, sea water and lake water were asked "*How to be named*." Here, they had to state that pure water would be hypotonic, sea water hypertonic and tap water, freshwater or lake water would be isotonic. MCQ part of question was answered by 84 (25.7%) students correctly, but correct answer rate in OEQ was 61 (18.7%).A statistically significant difference was found in favor of the MI program as to FAE and MLT programs (p=.000) when the response rates depending on the training program were compared (table 3).

Total 116 wrong phrases were identified. When they were evaluated and combined, 26 different misstatements were identified as misconceptions. The misinformation that cause misconceptions in students were as follows:

1. The most important misconception was that the pure water was known as isotonic medium (n: 38; 32.8%) or hypertonic medium (n:13; 11.2%).

2. It was expressed by the students that the tap water was hypotonic medium (n: 27; 23.3%).

3. The meanings of hypotonic, isotonic and hypertonic concepts were not known correctly (n:49; 14.6%). It was observed that students confused hypotonic and hypertonic concepts.

Question 3: The definition of diffusion was given in this question, and students were asked to find the concept between alternatives. MCQ part of question was answered correctly by 259 (78.3%)students, but correct answer rate in OEQ was 207 (63.3%).A statistically significant difference was found in favor of the PHT program (p=.006 in MCQ, p=.017 in OEQ)when the response rates depending on the training program were compared (table 3).

Although diffusion was the most well-known subject by the students, 45 misunderstood sentences were identified related to the third question. There were totally 21

different wrong expressions. When they were evaluated it was speculated that these misconceptions could have arisen from two basic misinformation points:

1. The most frequent misconception was the confusing with diffusion and osmosis concepts since option e (osmosis) was marked by 37 (11.3%) participants.

2. Another remarkable misconception was that plasmolysis is known an active substance transport type like phagocytosis and exocytosis (n: 12; 3.6%).

Question 4: This question was prepared to measure the knowledge level in students related to active substance transports, and it had been assumed that students knew under what conditions this event started and occurred. In the question Cell A e had 2 Na^+ ions and cell B had 20 Na^+ ions and they were in a medium that contains 20 Na^+ ions, and substance transport direction was from inside to outside. Cell C had 5 Cl^- ions, and it was in a medium containing 20 Cl^- ions and the transport direction was from outside to inside. (These conditions apply to both question four and five.)

When the answers given to these questions were evaluated, it was seen that students didn't have adequate knowledge on this topic.MCQ part of question was answered correctly by 92 (28.1%) students, but the correct answer number in OEQ was 66 (20.2%).A statistically significant difference was found in favor of the DY program (p=.003 in MCQ, p=.000 in OEQ) when the response rates depending on the training program were compared (table 3).

Total 32 different misconceptions were identified. While it was determined 148 incorrect knowledge sentences related to the fourth question. The lacking points that lead to misconception are given below:

1. Active transport occurs only from less dense medium to high dense medium./ Active transport is the transition of small molecules from less dense medium to high dense medium by using energy (n: 75; 22.4%).

2. Some of the students (n:28; 8.6%) wrote that: "It is the transition of small molecules from very dense medium to the low dense medium by using energy." The reason why they did it so must be that they confused the concepts which are passive substance passage with active substance transport.

3. The substance transition does not occur in equal conditions (n: 8; 2.4%).

4. Some of the students think that it is an exergonic reaction. So they wrote that the energy-releasing occurred as a result of the substance transportation (n: 3; 0.9%).Some of them (n:4; 1.2%) written meaningless expressions, such as "*This event happened as an electrical load*".

Question 5: the environment in this question was quite similar to the question 4, namely, the same cells and environmental conditions were given. However, there was one different point, which was the fact that cell A and B were alive but cell C was died. The students were warned to take active substance transport and passive substance passage into account and asked in which cells matter passage would happen in the directions given in question four. MCQ part of question was answered correctly by 67 (20.5%) students, but correct answer rate in OEQ was 45 (13.8%). A statistically significant difference was found in favor of the PHT program (p=.012 in MCQ) when the response rates depending on the training program were compared (table 3).

Totally 90 wrong expressions and 10 different misconceptions were determined related to the fifth question. The students' misinformation that led to misconceptions are given below:

1. Students think that substance transport does not occur in dead cells or they don't need to the substances (n: 44; 13.1%).

2. If the amount of the substances is equal in two sides, they think that substance transition does not occur or passive substance passageoccurs (n:24; 7.2%). Passive transport takes place if the quantity of the substance in the two sides is equal (n: 10; 3.0%).

Question 6: In the question sixth, an animal cell which was placed in a 10% salt solution was given, and it was asked which kind of situations could happen. MCQ part of question was answered correctly by 87 (26.6%) students, but the correct answer rate in OEQ was 45 (13.8%).A statistically significant difference was found in favor of the AN and PHT programs (p=.032 in MCQ, p=.001 in OEQ) when the response rates depending on the training program were compared (table 3).

61 wrong expressions 30 different misconceptions were identified related to the sixth question. When these incorrect expressions evaluated, it was presumed that students confused plasmolysis and deplasmolysis events and that they didn't have sufficient knowledge about this topic. According to our evaluation:

1. They think that salt (Sodium-chlorine, $NaCl^-$) penetrates, and then passes into the cell or salt is soluble and it has transition into the cell (n:15; 4.5%).

2. Depending on the salt passing into cell, the cell takes water and it swells, so plasmolysis occurs (n:19; 2.7%).

4. The cell takes liquid from more concentrate medium than own (n:5; 1.5%).

5. Plasmolysis is the desire to get water and when water is taken, the osmotic pressure increases (n:8; 2.4%).

Table 3: The correct answer rates of questions.

No	MCQ – N(%)	OEQ – N (%)	P (with One –Way ANOVA)
1	117 (35.8)	93 (28.4)	p=.000 (PHT> the others; in two stages).
2	84 (25.7)	61 (18.7)	p=.000 (MI> FAE and MLT; in OEQ).
3	259 (78.3)	207 (63.3)	p=.006 (PHT> the others in MCQ), p=.017 (MI, PHT> MLT and FAE in OEQ).
4	92 (28.1)	66 (20.2)	p=.003 (DY> the others in MCQ), p=.000 (DY, PHT> the others in OEQ).
5	67 (20.5)	45 (13.8)	p=.012 (PHT> the others in MCQ)
6	87 (26.6)	45 (13.8)	p=.032 (AN> MI, MLT in MCQ), p=.001 (PHT> FAE, MI, MLT in OEQ).
7	31 (9.3)	29(8.7) / 28(8.4) / 137(41.9)	p>.05

Question 7: This question was open ended and osmotic pressure (OP) and turgor pressure (TP) values of three cells were given. OP and TP conditions of cells were respectively: Cell-I 12 mmHg/ 5mmHg, cell-II 7mmHg/0.7mmHg and for cell-III 10 mmHg/10 mmHg. In the first stage of the problem, it was asked which of them water extraction would happen depending on these conditions in the cell. In the second stage, they were asked to calculate the amount and the direction of the water flow in these cells.

It was seen that first stage of this question was answered correctly by very few students n:31 (9.3%), and also most of the students n:122 (%36.4) never responded this question. Cell-III was correctly answered by 138 students (41.2%), while the correct answer rate for Cell-I was 8.7% (n:29) and for Cell-II was 8.4% (n:28). It was determined that 178 (53.1%) students did not answer this question. Similarly, in the second part, where the students were asked to explain the reason for the answer they gave, the explanation was

written by few students n:10 (2.9%). There was no statistically significant difference between training programs (p>.05) (table 3).

Question seven was related to the sixth question, since plasmolysis or deplasmolysis events occur depending on the osmotic pressure and turgor pressure conditions of the cell. If students had known these events, they would have answered this question correctly. It was seen that most of students did not answer OEQ part. The answers were examined and 10 incorrect expressions/misconception sentences were identified.

Too few students answered this question. When the given answers were evaluated students didn't know confused about osmosis and turgor concepts have reached. It can be claimed that the students didn't have the necessary knowledge about osmosis and turgor concepts of they were startled about them.

Table 4: Distributions of the number of misconceptions according to training programs.

Programs	Q -1st N (%)	Q – 2nd N (%)	Q – 3rd N (%)	Q – 4th N (%)	Q -5th N (%)	Q – 6th N (%)	Q – 7th N (%)	Total N (%)
AN (n:52)	9 (17.3)	24 (46.1)	4 (7.6)	28 (53.8)	18 (34.6)	6 (11.5)	0 (0)	89 (17.3)
DY (n:46)	4 (10.6)	19 (41.3)	8 (17.3)	19 (41.3)	9 (19.5)	10 (21.7)	5 (10.8)	74 (14.4)
FAE(n:104)	12 (11.5)	26 (25.0)	16 (15.3)	36 (34.6)	27 (25.9)	28 (26.9)	0 (0)	145 (28.2)
PHT (n:49)	5 (10.2)	24 (48.9)	7 (14.2)	21 (42.8)	14 (28.5)	7 (14.2)	4 (8.1)	82 (16.0)
MI (n:32)	5 (15.6)	9 (28.1)	3 (9.3)	22 (68.7)	8 (25.0)	5 (15.6)	0 (0)	52 (10.1)
MLT (n:44)	9 (20.4)	14 (31.8)	7 (15.9)	22 (50.0)	14 (31.8)	5 (11.3)	1 (2.2)	72 (14.0)
Total(n:327)	**44 (8.6)**	**116(22.6)**	**45 (8.7)**	**148(28.8)**	**90 (17.5)**	**61 (11.9)**	**10 (1.9)**	**514 (100)**

Totally 514 misconceptions were found when the answers given to the open-ended part of the questions in the questionnaire were examined. Distributions of the misconceptions according to learning programs and question numbers were given in table 4.

Table 5: Distribution of the students' total scores according to their learning programs.

Scores: Programs	0 N (%)	1 N (%)	2 N (%)	3 N (%)	4 N (%)	Succeed N (%)
AN (n:52)	18 (34.6)	25 (48.1)	8 (15.4)	1 (1.9)	0	9 (17.3)
DY (n:46)	21 (45.7)	17 (37.0)	5 (10.9)	3 (6.5)	0	8 (17.4)
FAE (n:104)	58 (55.8)	29 (27.9)	16 (15.4)	1 (1.0)	0	17 (16.4)
PHT (n:49)	18 (36.7)	16 (32.7)	8 (16.3)	4 (8.2)	3 (6.1)*	15 (30.6)*
MI (n:32)	16 (50.0)	12 (37.5)	4 (12.5)	0	0	none
MLT (n:44)	35 (79.5)	9 (20.5)	0	0	0	none
Total (n:327)	**166 (50.8)**	**108 (33.0)**	**41 (12.5)**	**9 (2.8)**	**3 (0.9)**	**49 (15.3)**

*p<.05

Most of misconceptions about the active substance transport related to the fourth question was determined to be n:148 (28.8%) this question. The least misconception sentences were related to the seventh question n:10 (1.9%) were. Since the students didn't know the osmosis and turgor events well, they did these mistakes. Essentially the reason was that the rate of answers by students was quite low (table 3).

In Table 5 the frequency and percentage of the correct answers of the questions, and their comparing results according to learning programs with One - way ANOVA tests were given.

According to these results, the third was answered the most correctly while the question seven was the least (table 4). Correct answers of the health technician students to the

first six questions differed statistically depending on the learning programs, while the seventh question did not show statistical significance. When the data evaluated on the basis of the program, it was seen that the most successful group was the group of students of physiotherapy technicians (PHT) program (table 3, 5).

RESULTS AND DISCUSSION

As a result of the evaluation of the two-tier test, it was determined that health technician students had too many misconceptions about the transport of substances. This situation was taken under report to support the results of similar studies that were conducted with students or candidate teachers at different levels in abroad and in Turkey (Odom, 1993; Odom & Kelly, 2001; Artun & Coştu, 2011; Harman, 2014).

Although the research concepts, active and passive substances transport, were tried to be taught to the students in a two hours course a week before, it was observed that they could not learn enough when the answers given to the test were examined. Hasni et al. (2016) also reported a similar situation. In addition, it was identified that the students had many misconceptions and also a big part of students such as 85.1% (n:278) were not able to get a successful score. Selvi and Yakışan (2014) conducted a study in which open-ended questions was used in the second stage of questions with education faculty students like our study. They reported that 83.7% of first grade university students had misconceptions about the enzyme topic. Their results and ours are very close and these two studies was also support each other.

The diffusion was the best known topic by the students. But it was also seen that diffusion and osmosis concepts were confused by some students. Yıldırım et al. (2016), Çinici and Demir (2013) and Tarakçı et al. (1999) performed similar studies related to diffusion and osmosis, and they reported similar results to ours.

As a matter of fact, if the density difference makes up too large molecules, such as starch that can't pass through the membrane in a medium that is separated by a selective-permeable or semi-permeable membrane, water passage occurs until the densities of the two sides are equalized. Namely, osmosis occurs. When looked at the question about osmosis, it was identified that students thought starch could pass the other side for equalization. If the two mediums are separated by a semipermeable or selective permeable membrane, some of students expressed that polymers such as starch could pass through. Some students with misconception did not know that starch was too large molecule to pass through the membrane. Some even e thought the starch would be solved in water. In previous studies, both stage questions were generally prepared multiple-choice question, and distracter of crossing of the large molecules wasn't given in alternatives. It was determined that biology candidate teachers wrote statements about the transport of substances in osmosis event in Kurt and Ekici (2013)'s work. Some researchers argue that the misconceptions in this subject are due to the definition of osmosis in the literature as "fluid flow from a very dense environment to a less dense environment" (Odom & Borrow, 1995; Harman, 2014, Artun & Coştu, 2011).

When the answers given to second question were evaluated, it was seen that the density concept was thought the students like the following ways:

- Hypotonic medium contains water more than substance.
- Isotonic medium contains equal quantity water and substance.
- 0.9% salt solution is isotonic in every condition.
- Hypertonic medium contains substance more than water.

Isotonic, hypotonic and hypertonic concepts were not known adequately by the students. Students did not know that isotonic, hypotonic or hypertonic conditions don't change depending on the density difference between the cell and its environment. They wrote

expressions as these situations changed depending on the rate/quantity of the soluble and solvent in medium. Christensen and Fisher (1999) reported that some concepts such as isotonic, hypotonic and hypertonic could be better understood and learned in laboratory/discussion courses in their work.

Students knew correctly the active transport types of the phagocytosis and exocytosis. But they misunderstood plasmolysis because they thought that it was an active transport type. In order to teach the abstract concepts requiring complex reasoning skills such as plasmolysis, deplasmolysis efficiently lecture courses aren't sufficient. These kinds of abstract concepts can be learned better in laboratory and in active learning lessons such as discussion (Christensen & Fisher, 1999).

Defining of the active substance transport is expressed as "*Transition from less dense medium to high dense medium*" or "*In contrast to passive transport*". These definitions have been used in books, web-pages and by teachers in Turkey and in other countries in the world. It might be concluded that the most important reason for the misconceptions of the students are the fact that it was defined wrongly. The most misunderstood concept was identified as the active substance transport (n:148+90=238; 46.3%). The most important reason of the misconceptions was that they did not know what happened in equal conditions. The biggest problem in this regard is the definition of the transport of active substance in the written sources and students can only reach faulty textbooks, and in the written sources and in the teachers' definition at every stage of the education or on web pages the topic is expressed as follows: "*The active substance transport is called as the move of the molecules to a very dense medium/environment from a less dense medium/environment with energy use.*" (Dimitrov et al., 2004 p.211;Yel et al. 2009 p.275; Boynukara et al. 2008 p.62; Balım et al. 2003 p.55; Khan academy, 2018; Chegg Study, 2018; cK-12, 2018).

Although it is said that the active substance transport starts when each side of the cell is equal, it was seen that most of the students could not decide what would happen if the two sides were equal. When the responses given to 4^{th} and 5^{th} questions related to active transport in comparison with t-test were compared, a statistically significant difference in favor of the students attended the course was determined in OEQ (p=.007) and in MCQ (p=04). Based on these findings, it could be claimed that the misconceptions that students had in this subject should have originated from their previous learning.

Last two questions were about the concepts osmotic pressure and turgor pressure, and indirectly about plasmolysis and deplasmolysis events. The sixth and especially the seventh questions were mostly unanswered by students. However, a small number of the answers given were correct. It was seen that they confused plasmolysis with hemolysis, and also the concepts of osmotic pressure and turgor pressure. When the answers of the seventh question examined, it was seen that the most of the students did not have sufficient math knowledge, since they could not calculate the result correctly using the substance transport formula (OP – TP = amount of solvent transport).There were also very few expressions in the OEQ part, and most of them were incorrect. On the other hand, remarkably, in the seventh question, the cell-III (two sides are equal OP=10mmHg, TP= 10mmHg) was correctly answered by half of the students n:137 (41.9%). It can be said that the most important reason for this result was that any mathematical subtraction calculation was not necessary or it was very easy.

Another remarkable misconception is that pure water is considered as an isotonic medium by the students (n: 38; 32.8%). Moreover, some of students (n:13; 11.2%) believe that it is hypertonic medium.

Harman (2014) reported that some of the students incorrectly stated the direction of the passage, the electrical load, or used meaningless expressions. Similar statements were also

found in this study. A few examples of these are as follows:"*The substance transport occurs only until the two medium are equalized*." "*There cannot be any substance transport in dead cells*." "*Active transport happens because the opposite poles attract each other, and the same poles are pushed.*"

One of the professional responsibilities of health technicians (dialysis, anesthesia and ambulance technicians, especially laboratory technicians) is involved in preparing, injecting and analyzing many fluids that are vital for patients. For this reason, it is very important to know the mentioned concepts accurately.

Suggestions

The definition of active transport should be changed as "*Substance transport using energy in live cells can only happen when the inside and outside concentrations are equal or the transport is from les concentration medium towards high concentration medium*." in textbook.

Since the duration of the two-hour course is not sufficient to learn the passage of substances through the cell membrane, it is necessary to teach these points in a wider period of time. Also laboratory practice for better understanding of conflicting/abstract issues such as osmosis - diffusion, isotonic - hypotonic - hypertonic, plasmolysis - deplazmolysis, turgor - osmotic pressure and active transport is a must.

Active and passive transport types and some other event terms, such as plasmolysis, hemolysis, hypotonic, isotonic, etc., are quite similar to each other in spelling and in pronunciation. Therefore, these terms should be taught more precisely using distinctive examples to facilitate learning.

Next studies should be done with a control group in order to compare the results more accurately. Determining whether the misconceptions are due to previous learning by applying pre-test/post-test related to similar topic will guide the educators in organizing the curriculum.

REFERENCES

Artun, H. &Coştu, B. (2011). Sınıf öğretmen adaylarının difüzyon ve osmoz kavramları ile ilgili yanılgılarının belirlenmesi. *Journal of Turkish Science Education, 8 (4),* 117-127.

Ausubel, D. (1968). Educational psychology: A cognitive view. New York: Holt, Rinehart & Winston.

Balım, A. G., Yenice, N. & Oluk, S. (2003). *Canlılar Bilimi*, (p.55), Anı Yayıncılık, Ankara.

Boynukara, Z., Başar, A., Bozkurt, O., Cansaran, A., Darçın, E. S., …Yıldırım, C. (2008). *Genel Biyoloji*, (p.62), 1. Baskı, Pegem Yayınevi, Ankara.

Bransford, J. D., Brown, A. L.& Cocking, R. R. (2000). *How people learn* (Expanded ed.). Washington, DC: National Academy.

Chegg study (2018, September 15) Retrieved from https://www.chegg.com/homework-help/definitions/active-transport-systems-14

Christianson, R. G.& Fisher, K. M. (1999). Comparison of student learning about diffusion and osmosis in constructivist and traditional classrooms.*International Journal of Science Education, 21(6),* 687-698.

cK-12 (2018, January 10) Retrieved from https://www.ck12.org/search/?q=active%20transport&referrer=top_nav&autoComplete=false

Çakır M. &Aldemir B. (2011). İki aşamalı genetik kavramlar tanı testi geliştirme ve geçerlilik çalışması. *Mustafa Kemal University Journal of Social Sciences Institute, 8 (16),* 335-353.

Çinici, A.&Demir, Y. (2013). Difüzyon ve ozmos kavramlarına yönelik tanı testi geliştirilmesi ve uygulanması. *Adıyaman Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, (13).*

Dimitrov, O., Kozhuharova, M., Argirova, T., Bogoev, V., Minkov, I., Kimenov, G., Slavova, M. (2004). *Biology and Health Education, 10th grade Textbook*, (p. 119-122), Bulvest Pub., Sofia.

Hasni, A., Roy, P. & Dumais, N. (2016). The teaching and learning of diffusion and osmosis: What can we learn from analysis of classroom practices? A case study.*Eurasia Journal of Mathematics, Science & Technology Education, 12(6).*

Harman, G. (2014). Hücre zarından madde geçişi ile ilgili kavram yanılgılarının tahmin-gözlem-açıklama yöntemiyle belirlenmesi. *Turkish Science Education, 11(4),* 81-106.

Karataş, F. Ö., Köse, S. & Coştu, B. (2003). Öğrenci yanılgılarını ve anlama düzeylerini belirlemede kullanılan iki aşamalı testler. *Pamukkale Üniversitesi Eğitim Fakültesi Dergisi, 1 (13),* 54-69.

Khan Academy (2018, September 15) Retrievedfrom https://www.khanacademy.org/science/high-school-biology/hs-energy-and-transport/hs-passive-and-active-transport/a/hs-active-transport-review

Kurt, H. & Ekici, G. (2013). Biyoloji öğretmen daylarının bağımsız kelime ilişkilendirme testi ve çizme-yazma tekniğiyle "ozmos" kavramı konusundaki bilişsel yapılarının belirlenmesi. *Turkish Studies-International Periodical forthe Languages, Literature and History of Turkish or Turkic, 8(12),* 809-829.

Odom, A. L. (1993). Action potentials & biology textbooks: accurate, misconceptions or avoidance?. *The American biology teacher,* 468-472.

Odom, A. L. & Barrow, L. H. (1995).Development and application of a two-tier diagnostic test measuring college biology students' understanding of diffusion and osmosis after a course of instruction.*Journal of Research in Science Teaching, 32 (1),* 45-61.

Odom, A. L. & Kelly, P. V. (2001). Integrating concept mapping and the learning cycle to teach diffusion and osmosis concepts to high school biology students.*Science Education, 85(6),* 615-635.

Odom, A.L. & Barrow, L.H. (2007).High school biology students' knowledge and certainty about diffusion and osmosis concepts.*School science and mathematics, 107 (3),* 94-101. Wiley Online Library, Retrieved fromhttp://onlinelibrary.wiley.com/doi/10.1111/j.1949-8594.2007.tb17775.x/full

Oztas, F. (2014). How do high school students know diffusion and osmosis? High school students' difficulties in understanding diffusion & osmosis. Procedia - Social and Behavioral Sciences *116,* 3679 – 3682.

Selvi, M. &Yakışan, M. (2014). Üniversite birinci sınıf öğrencilerinin enzimler konusu ile ilgili kavram yanılgıları. *Gazi Üniversitesi Gazi Eğitim Fakültesi Dergisi, 24(2).*

Tarakçı, M., Hatipoğlu, S., Tekkaya, C.&Özden, M. Y. (1999). A cross-age study of high school students' understanding of diffusion and osmosis. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, 15(15).*

Tekkaya, C., Şen, B. & Özden, M. Y. (1999). University students' misconceptions concerning osmosis and diffusion. *Eğitim ve Bilim, 23 (113),* 28-34.

Yağbasan, R. & Gülçiçek, Ç. (2003). Fen öğretiminde kavram yanılgılarının karakteristiklerinin tanımlanması. *Pamukkale Üniversitesi Eğitim Fakültesi Dergisi, 1 (13),* 102-120.

Yel, M., Bahçeci, Z. & Yılmaz, M. (2009). *Genel Biyoloji,* 2. Baskı, (p. 274-276), Gündüz Eğitim ve Yayıncılık, Ankara.

Yıldırım, O., Nakiboğlu, C. & Sinan, O. (2016). Fen bilgisi öğretmen adaylarının difüzyon ile ilgili kavram yanılgıları. *Balıkesir Üniversitesi Fen Bilimleri Enstitüsü Dergisi, 6(1),* 79-99.