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Assessment of Middle School Science Teachers' Perceptions Using Two-Tier Diagnostic Test about the Material Behavior and Properties: A Case Study of Iran

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ABSTRACT

This study aimed to develop two-tier diagnostic tools and assess middle school science teachers' perceptions of substance states. A two-tier questionnaire with 11 items was designed to assess middle school science teachers'perception and was completed by 109 teachers. A semi-structured telephone interview with eight middle school science teachers was conducted to prove two-tier test findings. The results of this study showed that some teachers, despite their teaching experience, have misunderstandings about some concepts related to the subject. Even some of these misunderstandings are shared with students' misunderstandings in the mentioned scientific sources. The reason for this may be attributed to issues such as the lack of need for teachers to learn more during the teaching speriod after graduation, the lack of adequate and specialized educational courses for teachers by the Ministry of Education of Iran, and also lack of educational facilities during the academic education of teacher

1. Introduction

Perusing science and chemistry includes observing and explaining the behavior of matter in its diverse forms. Particle theory concepts are a particular component of middle school science lesson teaching (Martin et al., 2004). For example, chemistry is one of the most significant areas of science and has been viewed as a complicated subject matter for high school learners by chemistry teachers, researchers, and educators (Clough & Driver, 1985; Pinarbasi et al., 2009; Allen, 2010).

As a result, most articles on science and chemistry education have been written to define the misunderstandings regarding the topics on which student teachers and students encounter difficulties while learning, the reasons for these misunderstandings, and the investigation of preventive and corrective methods. (Schoon & Boone, 1998; Yabasan & Gülçiçek, 2003; Özmen, 2004). Consistent research findings indicate that misunderstandings are profoundly ingrained and frequently persist even after teaching (Eryilmaz, 2002). On the other hand, misconceptions are more than misunderstandings about a topic. Misconceptions are a subset of a more extensive knowledge system that encompasses a plethora of interconnected ideas (Southerland et al., 2001).

It is a well-known fact that the education process has significant importance in the pedagogy of new generations in the world. Forasmuch as the lack of data and misunderstandings that students have in the process of learning affect the achievements of the new topics negatively (Gopal et al., 2004; Garnett et al., 1995), it is very significant for the teachers who have a crucial status in the process to be well prepared in each way and to be devoid of misunderstandings (Schoon & Boone, 1998; Özmen, 2004).

In this way, Hashweh (1987) discovered that teachers sometimes had similar misunderstandings about their students. Most of these misunderstandings become visible in their curriculum and training, which results in the amplification of students' misunderstandings instead of correcting them with chemistry facts. Also, articles show that student teachers in many countries have misunderstandings about science and chemistry (Valanides, 2000; Kikas, 2004; Håland, 2010; Tatar, 2011; Larkin, 2012; Lemma, 2013; Aydeniz et al., 2017; Sopandi et al., 2017; Jager & Keinonen, 2017).

Thus, student teachers should be provided with numerous learning opportunities to reflect on diverse ideas concerning science and contribute to understanding chemistry concepts (Abd-El-Khalick et al., 2008). These activities could include observations, inquiries, and research on chemical, social, and cultural aspects. In

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general, the methods used to assess participants' misconceptions are multiple-choice tests, interviews, concept maps, etc. These methods can also be used to examine teachers' misunderstandings. Over the past few decades, multiple-choice diagnostic tests have been preferred. They are economical, easily applied, and allow greater generalizability of findings, except for probing participant responses (Beichner, 1994; Wuttiprom et al., 2009).

Despite their ease of use, multiple-choice surveys might result in erroneous findings due to their restricted alternatives (Taslidere, 2016). To address the limitations of multiple-choice exams, researchers devised two-tier diagnostic tools (Lin, 2004; Wang, 2004; Chandrasegaran et al., 2007). Multiple-choice items with a two-tier structure consisting of a first tier that demands a response to specified material and a second tier that requires an explanation for that response. While two-tier examinations are more efficient than single-tier multiple-choice tests, they have certain drawbacks. Put another way, and there is always the chance of predicting the outcomes (Taslidere, 2016).

As mentioned above, there are some chemistry issues that students have trouble comprehending. One of these problems is the substance and its properties, which are necessary for understanding different fields of chemistry (Alpaydin, 2017). So, this study aims to evaluate the level of comprehension and explore misunderstandings of middle school science teachers (MSST) about concepts of material and its properties based on two-tier multiple-choice diagnostic instruments.

2. Theoretical framework

Several articles have been written about the state of matter; for example, a study was conducted by Tatar (2011). The purpose of this study was to identify the misunderstandings of futuristic elementary school teachers in the field of the state of substances by the Department of Science and Mathematics, Education Faculty, Mustafa Kemal University. This study showed that prospective elementary school teachers had misconceptions about substance states. Misconceptions such as: the shape of solids does not change; there is no space between the particles of solids since gases are not affected by gravity; they do not fall like solids and liquids; the size of the particles of solids is more significant than the particles of liquids; and the particles of liquids are more significant than the ones of gases (Tatar, 2011).

Among other articles that have been researched, the state of materials using multiple-choice tests can be mentioned in the research written at Middle East Technical University, Turkey by Kirbulut and Geben. In this research, finally, 20 misunderstandings were discovered in this research (Kirbulut & Geban, 2014).

Also in this regard, another article has been written by Alpaydin (2017). This study was carried out to determine the level of understanding and misconceptions of science teacher candidates about some concepts related to materials and their properties. It was determined that teacher candidates had misconceptions about some concepts related to materials and their properties, and some suggestions were made to eliminate these misconceptions.

A study was conducted in 2009 using a two-tier test by the Department of Primary Education at Hatay Mustafa Kemal University in Turkey. In this study, using the development of a two-tier test about the separation of materials in the ninth grade, the effectiveness of the two-tier test has been proven (Tüysüz, 2009). The results of this research are in line with the results obtained from the present study, and both studies confirm the two-tier test's effectiveness.

Additionally, another study focused on developing the two-tier multiple-choice diagnostic instrument, which was designed and then progressively modified and implemented to assess students' understanding of solution chemistry concepts by Addan and Savasci (2011). Also, results indicated that a substantial number of students held an inadequate understanding of solution chemistry concepts.

To the best of our knowledge, no research has been reported on misunderstandings about matter-related concepts using two-tier multiple-choice diagnostic tools between middle school teachers. For this purpose, this study was conducted to detect misunderstandings between middle school teachers.

3. Materials and methods

For administering this study, first, the content boundary of the research was defined, and the propositions and concept maps were compiled based on the chemistry education program of the junior high school, and then it was collected in the form of a two-tier diagnostic tool. This type of test was used because a two-tier test is helpful for instructors to have a deep understanding of misconceptions because there is a chance to identify why they have such misconceptions (Chou et al., 2007).

Then, Semi-structured interviews were conducted with eight science teachers to obtain in-depth information. In the interviews, teachers were asked the same questions as on the test but were asked for further explanation about their responses to confirm the appropriate interpretation of their written responses.

3.1 The Material behavior and properties misconceptions test (MBPMT)

The two-tier diagnostic test was prepared and compiled in the Persian language. The research questions consisted of two parts, the first tier of each test item was related to the content, and the second tier of each test item was a question that teachers were asked to give a reason for their answer in the first tier. Each tier was multiple-choice and followed a concept (Tsui & Treagust, 2010; Karadeniz Bayrak, 2013; Kim, 2014).

Different sources such as articles and gifted tests were used to prepare the first tier of each item. (Primary School Leaving Examinations (Grade 6), which is a national examination conducted in the final year of primary school education and is used to determine the type of secondary education and school that the students will go to for their next level of education (Loh, 2014). The second tier of the items included reasons for the last part, written based on the researchers' scientific knowledge.

The questionnaire consisted of eleven two-tier questions; a university professor analyzed the questions with a Ph.D. in chemistry and some experienced teachers in terms of content. Finally, item 12 included general information about the paper-making process, was eventually dropped due to low statistics in the data and teachers' responses were categorized, and their frequency was calculated to identify misunderstanding factors in material behavior and properties.

3.2 Interview

The interview collects answers or information by giving respondents direct questions related to the problems (Norman & Yvonna, 2000). To increase accuracy and reduce restrictions of two-tier questions, an interview was conducted with eight head science teachers of middle schools of Mazandaran province. Due to the covid-19 epidemic, the interview was conducted by telephone. Participants first answered the content tier of the open-ended questions, and then they were asked to explain their reasoning; if necessary, more related questions were asked, requesting an additional explanation for their justifications.

This work has been tried to be used the textbook to choose the open-ended question and extract a similar conception to the two-tier questionnaire. The first question of the interview is given in the seventh science book. This question concerns the structure of atoms. As with all elements, metals are composed of atoms. The shape of the atoms does not change with a with mechanical shocks such as hammer blows, and only the atomic layers slide on top of each other.

The purpose of the second question was to assess teachers' perceptions of density and their relative comparison. Then we asked questions complementary to this question to know their views on this concept, including changing one of the quantities and changing the type of liquid in the container.

The third question of the first tier its purpose is to understand the teachers' misunderstanding about how molecules are distributed in a closed container. The first part refers to the dispersion of molecules. The second part of the question also deals with teachers' views on the effect of heat on the structure and dispersion of gas molecules. All questions were administered to understand the teachers' perceptions and misunderstandings of the concepts and related topics.

3.3 The pilot study

This questionnaire was first piloted on 106 elementary school teachers from the first to the sixth grade; this sample included 15 men and 91 women teaching in the Iranian education system. The questions were not answered correctly, and the level of some questions was higher than the knowledge and awareness of these teachers. Therefore, it was decided that the MSST will do this questionnaire and test with a slight chance that these teachers were 39 men and 70 women. After completing the questionnaire by these teachers, surveys showed that the level of questions was commensurate with the level of MSST.

3.4 Participants

This research was administered for the whole sample in summer 2021, and the participants of this study are divided into two categories: interview and two-tier diagnostic test. The number of MSST in Mazandaran province is close to 300 teachers, 36% of whom were contacted. These teachers were randomly included in this study. The telephone numbers of these people were received from the Telegram of Science groups, and because it was online teaching, the questionnaire was sent to them as a link, and due to lack of trust in an unknown person and cyber thefts, only 109 of them completed the questionnaire in two weeks.

Thus, about 64% of them were female, and 36% were male. Among them, their university degree mainly was bachelor's and master's degrees, and their diploma degree mostly belonged to the experimental field (84.40%), and the teaching experience of these people has varied, but most participants have taught in different schools for 25 to 30 years (about 38%) (see Appendix 1), Also eight MSST participated in the interview, who were the head of their city's educational department. 75% of these participants were men and 25% of them were women.

4. Data collection

This research was administered in summer 2021. Due to the COVID-19 epidemic, the questionnaire was distributed among MSST in WhatsApp and Telegram messaging groups via the link in the google form. Virtual communication also has problems, such as non-response, late response, etc. Since the research questionnaire was sent randomly to the groups of science teachers, some student teachers also performed the questionnaire that the data related to the student-teacher were not removed from the research and analyzed because the statistical population of this research was teachers.

At the beginning of the questionnaire, there was information such as gender, diploma, university degree, teaching history, and type of school required to be answered, and they could not access the MBPMT questions until teachers answered them. Before taking the MBPMT, participants made sure that their information was not disclosed and did not need to write their name but was used as research objectives for the test results to comply with research ethics and increase teachers' participation in the research. The time allotted for 12 multiple-choice items was 30 minutes; finally, 109 teachers completed the questionnaire in two weeks. Then, interviews were administered for reliability estimation purposes.

Nearly 7% of the participants (8 teachers) were interviewed four weeks after they took that MBPMT, on the assumption that teachers' clear memory would have a minor effect on their interview responses. According to the issue of determining the appropriate period between the performances of the two tests with common concepts for the same participants, McKelvie (1992) pointed to a minimum of three weeks to prevent the interference of participants' clear memory in their responses on the retest, and such a view was supported by Freeman (1962).

These eight teachers were selected from among those who were head science group (There is a private group that transmits educational policies to teachers, especially in the method of teaching and learning, guides them in content knowledge, and supervises their teaching in classrooms). They were asked for individual interviews that, Due to the Covid-19 epidemic, were conducted by telephone; to prepare the teachers mentally, the questions were sent to them on WhatsApp five minutes before the call. Each interview took about 15–20 min, and each teacher answered three open-ended questions related to the questionnaire.

5. Data analysis

For each item, both content answer and reasoning were evaluated by sorting into the five categories provided by Çalik and Ayas (2005): sound understanding, partial understanding, partial understanding with specific alternative conception, specific alternative conception, and no understanding. The criteria were as follows:

- Sound understanding (SU): responses that provided correct answers and reasoning.

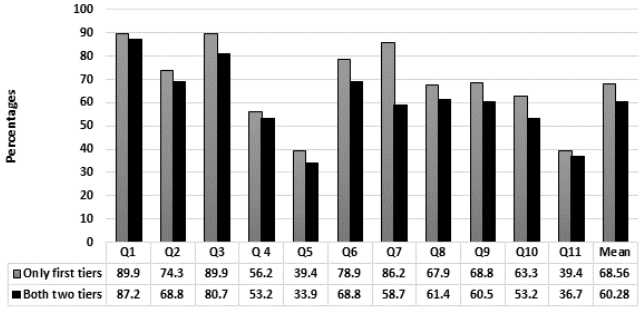
- Partial understanding (PU): responses that included correct answers or correct reasoning while leaving another tier unanswered.
- Partial understanding with specific alternative conception (PUSA): responses that included either correct answer with wrong reasoning or wrong answer with correct reasoning.
- Specific alternative conception (SA): responses that included wrong answers in both tiers.
- No understanding (NU): responses with blank or multiple responses in one test item (Artdej et al., 2010).

6. Results

As mentioned, the questionnaire of this research consisted of 11 two-tier sections (see Appendix 2), which according to the scores defined in Google Form, was considered 1 point for each tier, i.e., each section contained 2 points. The minimum score started from 0, and the maximum score that participants could earn was 24 points, which was calculated from 22 points due to eliminating 12 of these points. Two participants achieved total points, both of whom had the most work experience. The average score obtained by MSST is 14.13 percentage in the MBPMT.

One of the most important findings of this research is that the percentage of correct answers to both tiers is less than the percentage of correct answers to one tier, and this is a sign of insufficient knowledge of first-grade science teachers. Figure 1 shows the proportion of teachers who answered correctly only the first tier and both tiers of the MBPMT. For the first tier of test items, the correct answers ranged from 39.4 to 89.9, and the correct answers for both tiers dropped from 31.81 to 87.27. The lowest proportion of teachers to the concept of volume of solutions was 15 to 31.81 in both tiers, meaning that teachers had little understanding of the concepts mentioned.

The average proportion was 68.56% in the content tier and 59.79% in both tiers. Items 4, 5, 10 and 11 were lower than the average in the content tier, and the same cases plus 7 were lower than the average in both tiers. These findings are consistent with previous studies involving two-level diagnostic tools (Griffard & Wandersee, 2001; Chou et al., 2007; Loh et al., 2014; Taslidere, 2016) in which most participants performed better than both levels in the first tier of test cases.



	Q1	Q2	Q3	Q 4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Mean
Only first tiers	89.9	74.3	89.9	56.2	39.4	78.9	86.2	67.9	68.8	63.3	39.4	68.56
Both two tiers	87.2	68.8	80.7	53.2	33.9	68.8	58.7	61.4	60.5	53.2	36.7	60.28

Figure 1. Percentage of correct answers to the questionnaire.

In analyzing teachers' answers, we found that several important factors affect the percentage of correct responses, including gender, high school diploma, work experience, and type of school. Also, a high degree did not affect increasing the scores.

Table 1 shows the level of teachers' experience (by year) and its relationship with the average score that they were able to obtain in the questionnaire. Work experience has been measured with two types of components. These components are: gender (male and female) type of diploma (mathematical and experimental)**.** The lowest score was related to male teachers who had 25–30 years of work experience and had a diploma in mathematics, and the highest score was related to male teachers with 15–20 years of work experience and an experimental diploma.

In another comparison, the lowest scores for men were 5–1 for work experience and for women 5-10 for work experience. In general, the scoring process is zigzag and does not provide accurate information about the increase or decrease of teachers during the increase of work experience.

Table 1. Percentage of average scores of participants based on their information.

	1-5	5-10	10-15	15-20	20-25	25-30
Mean	14.2	12.4	13.2	14.7	14.4	15
Male	13	14	14.5	15.2	15.5	15.4
Female	15.8	10.8	12.9	14.5	14.2	14.6
Male-Diploma-Experimental	12.2	15.7	14.5	19	15.5	16
Male-Diploma-Mathematics	13	11.5	–	9.5	–	6

It should be noted that Artdej et al. (2010) concluded that due to the nature of multiple-choice tests, participants almost never respond to partial comprehension and lack of comprehension. Research by Gilbert (1977) and Tsai (2007) shows that if the percentage of students with specific alternative concepts is more than 10%, such issues should be discussed.

In this research, an attempt has been made to adapt the said research; percentages higher than 10% should be considered further. Table 2 shows the test data, which shows the ratio of the answers of the guides, including the SU, PU, PUSA, SA and NU based on each concept of questions. According to Gilbert (1977) and Tsai (2007) suggestion, Q5, Q6, Q8, Q9, Q10 and Q11 in the SA index are higher than 10% and are considered a special alternative concept. The highest percentage specific alternative concept is related to Q11 and the lowest percentage is related to Q7. This study has tried to pay more attention to these concepts and discuss some of them in the following:

Table 2. Percentage of responses of MSST in MBPMT.

Item	Concept	SU		PU		PUSA		SA		NU	
		n	%	n	%	n	%	n	%	n	%
Q1	Phase changes and mass of particles	95	87.2	–	–	5	4.6	9	8.2	–	–
Q2	Nature of solutions and dissolving	75	68.8	1	0.9	25	22.9	8	7.3	–	–
Q3	Intermolecular interaction or interatomic bonding	88	80.7	–	–	12	11	9	8.2	–	–
Q4	The effect of heat on gaseous molecules	58	53.2	–	–	42	38.5	9	8.2	–	–
Q5	Change the volume of solid solutions in the liquid	37	33.9	4	3.6	21	19.3	46	42.2	1	0.9
Q6	Density of gases	75	68.8	–	–	21	19.3	11	10.1	2	1.8
Q7	Characteristics of physical and chemical changes	64	58.7	3	2.7	35	32.1	5	4.6	2	1.8
Q8	Dissolution of gases/relationship between dissolution and pressure of gase	67	61.4	1	0.9	15	13.7	20	18.3	4	3.6
Q9	The relationship between dispersion and pressure of gases	66	60.5	–	–	12	11	27	24.8	4	3.6
Q10	Density of gases	58	53.2	–	–	19	17.4	28	25.7	4	3.6
Q11	The effect of temperature on the dispersion of gases	40	36.7	1	0.9	6	5.5	48	44	9	8.2

6.1 Phase changes and mass of particles (Question 1)

The particulate nature of matter (PNM) is a central concept to the teaching and learning of Science (Harrison and Treagust, 2002) and Researchers have shown that misconceptions about the small, unseen particles that comprise matter abound across the entire age spectrum (Litchtfeldt, 1996; Sanger, 2000; Bunce & Gabel, 2002).

Sometimes there is a misunderstanding among people that the mass of matter increases or decreases with the change of phase, and the probability of this misunderstanding is more about converting liquid to gas, especially solid to gas; Because some people think that all the gas molecules or some of the gas molecules disappear, and this shows their weakness in understanding the particle nature of matter.

6.2 Nature of solutions and dissolving (Question 2)

Solutions should contain particles that are evenly distributed throughout the container, with the two basic components of a solution being solvent and soluble. Solvent is the substance that has the highest amount, any substance that is more in the mixture is its solvent and solute is the substance that is in the least amount. Let's think for a minute that we want to make a glass of sugar water. Take a teaspoon of sugar and dissolve it in a cup of water. Since sugar has a lower amount, it becomes soluble and water is solvent because it has a higher amount in solution. For a mixture to be known as a solution, you have to distribute the very fine particles evenly throughout the container, so that the mixture has the same properties throughout (Silberberg, 2006).

6.3 Intermolecular interaction or interatomic bonding (Question 3)

Another important discussion of the particle nature of matter is the arrangement of molecules after phase change. Sometimes, people think that some or all of the bonds of liquid molecules are broken after evaporation, or that liquid molecules become their own constituents, hydrogen gas and oxygen gas. This misunderstanding stems from a misunderstanding of the particle nature of matter and their weakness in their microscopic view.

In other words, these people think that interatomic bonds are broken, while molecular interactions are weakened, not interatomic bonds, and of course it should be noted that this is true of materials that they have separate molecules, including water, but weakening of atomic bonds can be observed.

6.4 The effect of heat on gaseous molecules (Question 4)

The words heat and temperature are not used interchangeably and have different meanings. Increasing the temperature of a substance increases its thermal energy. In fact, heat is the same movement of thermal energy from a hotter body to a colder body. So, by giving heat to a container in a package, the gas particles move from the heat side to the other side of the container, which is colder, and are distributed evenly throughout the container, while most people think of the effect of increasing temperature on the size and number of gas particles (Silberberg, 2006).

6.5 Change the volume of solid solutions in the liquid (Question 5)

During the dissolution process, the soluble constituent particles are separated and dispersed in the solvent. Suppose we dissolve some sugar in water and mix another with a pinch of salt; It is not very difficult or possible to find the sugar grains and go back to the original state, but at the same time, the soluble or the same sugar has not lost its nature and, although small, has a mass (Allen, 2010).

Some people mistakenly think that by dissolving sugar (soluble) in water (solvent), its nature also disappears, while it is not only visible, but in reality, it increases the volume and mass of water (solvent).

6.6 Compressibility of gases (Question 6)

Compressibility is the measure of how much a given volume of matter decreases when placed under pressure. If we put pressure on a solid or a liquid, there is essentially no change in volume. The atoms, ions, or molecules that make up the solid or liquid are very close

together. There is no space between the individual particles, so they cannot pack together. When a gas is compressed, the particles are pushed closer together, resulting in a much smaller volume because the spacing between particles in a gas is much greater than in a liquid. The particles in a liquid cannot be pushed any closer together, so there is no change in volume (Tsaparlis & Sevian, 2013).

Compressibility is the measure of the amount of reduction of a certain volume of a substance when it is under pressure. If we apply pressure to a solid or liquid, there is essentially no change in volume. The atoms, ions, or molecules that make up a solid or liquid are very close together. There is no space between the individual particles, so they can not be closed together. When a gas is compressed, the particles get closer to each other, resulting in a much smaller volume because the distance between the particles in the gas is much larger than in the liquid. The particles in a liquid can not be brought closer together, so there is no change in volume (Tsaparlis & Sevian, 2013).

6.7 Characteristics of physical and chemical changes (Question 7)

In chemical change a material changes into something completely different, losing its chemical identity; otherwise known as a chemical reaction. New substances are formed due to the atoms reordering of the preexisting substances as bonds are broken and new bonds are formed. Emphasis on the idea of chemical change itself in terms of atoms reordering new substances are formed because structural characteristics of the atoms / ions of the substances change as bonds are broken, structures destroyed, and new bonds and structures are formed (Tsaparlis & Sevian, 2013).

6.8 Dissolution of gases/relationship between dissolution and pressure of gases (Question 8)

The solubility of carbon dioxide first increases rapidly and then decreases over time because it tends to escape water as the pressure decreases, while one of the students in the Adadan & Savasci (2013) study argued that because opening the beverage can, some of the gas escapes (into the air) and little gas remains in the water, so the water can dissolve more gas and then remain stable.

6.9 The Relationship between dispersion and pressure of gases (Question 9)

In dealing with gases, the word "full" has no meaning. Liquids may be part of a glass and can be measured with the naked eye, but a container containing a gaseous substance is always full (Silberberg, 2006). Gas molecules, regardless of their properties, such as size, molar mass, etc., are randomly dispersed in a closed container.

6.10 Density of gases (Question 10)

Does an inflated balloon weigh? A full balloon can be easily thrown around a room and when dropped, it is gently dropped to the ground. In contrast, an empty balloon behaves like a thin piece of rubber and falls to the ground quickly if dropped. A full balloon weighs more than a hollow balloon, but because the difference between the volume of a hollow balloon and a full balloon is significant, its density is higher than that of a full balloon because the density is the same as the mass-to-volume ratio. If we imagine the earth as a sea from the air, the higher density balloon will reach the ground sooner; then, the hollow balloon will reach the ground sooner due to its higher density (Allen, 2010).

6.11 The effect of temperature on the dispersion of gases (Question 11)

Gases consist of vast numbers of molecules traveling in all directions at speeds that are distributed randomly around an average determined by their temperature. Molecules are distributed randomly in space, colliding with one another and with the walls of their container, exerting pressure (Buekens, 2009).

6.12 Interview

For example, the following excerpts show the perspective and conceptual understanding of the two interviewed teachers about the answers to questions 3 and 10 (R: Researcher, T: Teacher):

Question 3

Part1

R: What is your explanation for question one?

T1: They are scattered all over the container. At constant temperature, we see a difference in density. Carbon dioxide particles are denser at the bottom of the container, and oxygen particles are more at the top of the container. The molecule of carbon dioxide is heavier than the molecule of oxygen.

T2: Gases do not have a specific volume and shape. They are placed in a square or circular container. The gases are dispersed throughout the container.

Part2

R: What is your explanation for question one?

T1: Deformation does not occur; only the particles move faster. The shape of the particle is not a function of ambient temperature conditions. Suppose we say that the velocity of the particle changes; it does not affect the shape of the particles. Particle motion changes and moves faster. Because we gave heat, as in the question above, we do not have the separation of carbon dioxide and oxygen, and they are spread all over the container.

T2: The volume of the particles does not change; the increase in heat affects the number of collisions. Their speed also increases.

Question 10

R: Explain this question if possible

T: Given that the pressure is ignored, we consider the environment a vacuum and reach the ground together.

R: That is, do we consider the air inside the balloon as a vacuum?

T: No; in a vacuum environment, if objects are released, they will reach the ground simultaneously with any mass, even if the balloon is full because its volume is more; in my opinion, they will not have much difference in density.

7.Discussion

In this study, misunderstandings of middle teachers have been identified. Based on the statistics and results obtained in Table 2, questions 5 and 11 had the most misunderstandings, with % 42.20 and 44.03%, respectively. The concept mentioned in question 5 is also related to the change in the volume of solid solutions in the liquid, and question 11 is related to the effect of temperature on the dispersion of gases. Then, questions 8, 9, and 10 with the percentages of 18.33%, 24.77%, and, 25.68% respectively, had the most misunderstandings after questions 5 and 11. Question 8 deals with the dissolution of gases, question 9 deals with the relationship between dispersion and pressure of gases, and also question 10 is about the density of gases. Finally, it can be noted that most of the above results are consistent with previous research on students' misunderstanding (Blosser, 1986; Westbrook, 1992; Chiu, 2007; Allen, 2010; Tsaparlis & Sevian, 2013; Kirbulut & Geban, 2014).

Also, from this information is obtained that the amount of misunderstanding of teachers has nothing to do with the amount of their work experience. In other words, the amount of misunderstanding does not decrease or increase with increasing work experience (according to Table 2). In this regard, in order to understand more deeply the reasons for teachers' misunderstandings, the Iranian educational system should be examined.

It can also be noted that the percentage of misunderstanding of other questions is 10% and less than the results of these questions did not correspond to the results of previous research about students. In other words, while teachers did not misunderstand these concepts in the present study, students in previous research had misconceptions (Driver et al., 1994; Mulford & Robinson, 2002; Chiu, 2007; Adadan & Savasci, 2013).

The findings also show that the lowest percentage of misunderstanding is 4.58%, related to question 7. This question examines chemical changes. In addition, according to the obtained results, the misunderstanding of middle school teachers is the highest percentage related to the concept of gases; in other words, teachers have a better understanding of the concept of chemical change than the concept of gases.

Several conclusions can be drawn from this study:

First, the questions of the present study were taken from books, articles, and tests of elementary, middle, and high school students, and in these sources, it is mentioned that children and adolescents have a misunderstanding in these issues and concepts (Blosser, 1986; Westbrook & Marek, 1992; Driver et al., 1994; Mulford & Robinson, 2002; Karen C, 2013; Allen, 2014; Cohen, Chiu, 2007; Adadan & Savasci, 2013; Kirbulut & Geban, 2014).

In evaluating these questions on teachers, it was found that teachers only suffer from some of these misunderstandings while children are dealing with more misconceptions. Therefore, it can be concluded that some misunderstandings among people are corrected and reduced over time. It is also found from this study that with increasing work experience, the level of teachers' misunderstanding does not change and does not decrease (according to Table 2). In this regard, in order to study this sentence more and better, the Iranian educational system must first be examined.

Iran's educational system is knowledge-based and in Iran's classrooms, Teachers pay more attention to students' memory of lessons and skills training in this educational system are marginalized, because the only goal of students is to pass the university entrance exam. According to Karimi et al. (2010), 1795 higher education institutes in Iran. There are 1200 public universities financed, controlled, and supported by the government. However, there are also 595 privates, often called "Islamic Azad University", and non-profit institutions providing training at undergraduate and graduate levels. Admission to state universities is based on completion of secondary school and successful placing in the competitive Iranian university entrance exam, simply known as Konkour, All the candidates are given a ranking. Their ranking decides what they study and their interest or ability.

Therefore, it can be said that despite the appropriate number of universities in Iran, the capacity of the labor market is limited. Hence, only a few very reputable universities meet the needs of the labor market. Therefore, students must take a difficult test (entrance exam) in order to be accepted in the universities of their choice, one of which is the Teacher Training University (Farhangian University) in Iran. Of course, it should be noted that, with the exception of some prestigious universities in big cities, other universities have many scientific and theoretical deficiencies, and thus students' learning will not be well.

Traced back to ineffective management of resources human as well as natural, increased enrollments, a shortage of technology, outmoded and traditional instructional methods largely based on memorization, and improper incentives for teachers and students. Today, with the increased speed of information and telecommunication technology, many changes have occurred in society. However, Iran's old and experienced higher educational system doesn't have the capacity to meet current societal needs. It faces numerous challenges and obstacles, and needs reform and transformation pretty quickly (Rasian, 2009). Teachers also enter schools from these universities, and despite all the courses and workshops that the Iranian Education Organization does to raise teachers' knowledge, several teachers still have misconceptions about the subject they teach.

Another weakness of this system is that teachers are not only recruited from teacher training universities (Farhangian University); in general, teachers are recruited in two ways:

A) Recruitment of teachers through recruitment tests among graduates of biology, chemistry, and physics of national universities. These people undergo intensive training in middle school for six months and then enter schools.

B) Recruitment of student teachers through the national entrance exam in physics, chemistry, and biology and their education. After four years of study, these student teachers enter schools in their field and work in middle schools as science teachers. In general, although the process of entering the country's cultural universities and top universities is complicated, the process of studying in undergraduate courses is straightforward, while in prosperous countries in the field of education, this process is two-way.

In addition, in Farhangian University despite the heavy competition of students to enter, there are no suitable and good professors for teaching students, and students suffer from a lack of efficient professors with a high level of science, and this case along with other shortcomings. It causes the scientific weakness of the student-teachers and they enter the schools with misconceptions and lack of knowledge and science.

Finally, according to the results of this work, it can be stated that the degree of teachers' misunderstanding does not change with increasing work experience for the following reasons:

1. As the work experience increases, teachers do not make the effort to learn more. In other words, they forget the phrase that it is lifelong learning and think that with the beginning of the teaching process, their learning stops and they do not feel the need to learn and they think that they are just teachers.

2. The educational system in the Ministry of Education of Iran does not hold educational classes related to the specialized field of teachers.

3. Lack of academic facilities such as lack of school facilities, lack of specialized teachers (due to attracting teachers from universities other than Farhangian University), lack of experienced professors in universities, etc.

Therefore, the weaknesses of these teachers in most cases are not eliminated despite all the training courses of the education organization. And they teach students the lack of knowledge of the subjects and pass on these misconceptions to them, as a result of this vicious cycle in the Iranian educational system, starting with learning in schools and ending with teaching in schools by today teachers, yesterday student.

8.Conclusions

Since the identification and discovery of misconceptions has an important role in the development of science, therefore, the study was conducted with the aim of developing two-level diagnostic tools and assessing the perception of middle school teachers of the states of matter. For this purpose, a two-layer questionnaire with 11 items was designed to assess the perception of middle school teachers and was completed by 109 teachers in the summer of 2021. These questions were taken from sources that included students' misconceptions. A semi-structured telephone interview was conducted with eight middle school teachers to substantiate the findings of the two-tier test. The results of this study showed that some teachers, despite their teaching background, have misunderstandings about some concepts related to the subject. Even some of these misunderstandings are common to the students' misunderstandings in the mentioned scientific sources. The reason for this can be attributed to such things as the lack of need for teachers to learn more in the postgraduate teaching course, the lack of adequate and specialized training courses for teachers by the Ministry of Education and also the lack of educational facilities during teachers' academic education. It was even found that the level of teachers' misunderstandings increases with the increase of their work experience.

9.Implications

In order to prevent the creation of misconceptions and correct them, the following items are suggested:

1. Pay attention to teachers' research articles in the subjects they teach. In this regard, senior officials of the educational system can consider special privileges such as career advancement, salary increase, etc., to encourage teachers to write scientific articles and, in turn, increase the knowledge and awareness of these teachers.

2. We are establishing relations with other prosperous countries to increase the quality of education.

3. Iran can communicate with other prosperous countries such as Japan and Finland to improve the knowledge and awareness of its teachers, In this regard, different educational ambassadors can be sent to these countries to gain experience, and after the return of these ambassadors, they can use their experiences and learnings in order to improve the quality of the structure of Iran's education system.

4. They hold scientific meetings, discussion, and debate sessions by student-teachers and professors of public and top universities to raise science awareness and reduce or eliminate teachers' misconceptions.

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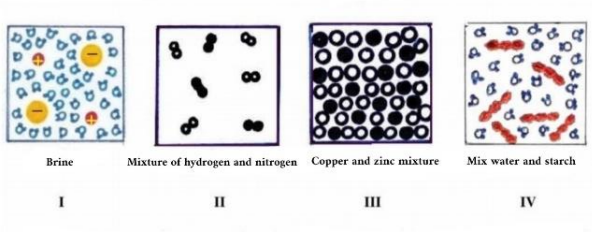
Appendix 1. Percentage of MBPMT participants' characteristics.

Characteristics of test participants	Participant statistics					
Gender	Female			Male		
	64.22			35.77		
Diploma certificate	Mathematics field		Experimental field		Other fields	
	14.67		84.40		0.91	
University degree	PhD		Master	Bachelor		Associate
	1.83		33.02	61.46		3.66
Teaching experience	1-5	5-10	10-15	15-20	20-25	25-30
	12.48	9.17	14.67	15.59	10.09	37.61

Appendix 2. Some the two-tier questions used in this work.

2.1- Based on the microscopic representations shown below, which of the following mixtures can be soluble? Select the best option. (Note: In the following illustrations, each circle shows an atom or ion).

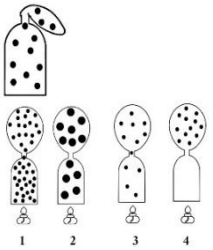


a) Just I
b) II, IIII
c) I, II, III
d) I, II, IV
e) I, IV

2.2- Which of the following expressions best describes your answer in part 1?

a) In a solution, the solvent should be a liquid.
b) Only salts dissolve in water.
c) Regardless of the physical state of the material, the particles that make up the solution dissolve uniformly in each other.
d) Under no circumstances do two solids form a solution.
e) Solutions are homogeneous mixtures that result from the mixing of at least two substances that have the same physical states.

4.1- According to the Fig. below, we close a balloon on the lid of the bottle and place it on the heat of the candle; The balloon expands. The change in gas particles during balloon expansion can be expressed by which of the following forms?



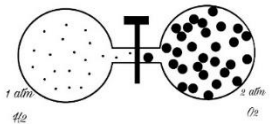
a) Fig. 1 b) Fig. 2 c)Fig. 3 d)Fig. 4

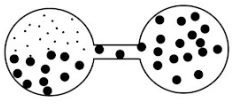
4.2- Which of the following expressions best describes your answer in part 1?

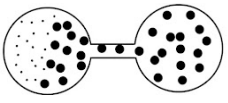
a) As a result of the heat, the particle size of the trapped gas becomes larger.
b) Due to the heat, most of the particles are distributed on top of the container and cause the balloon to expand.
c) The complete inflation of the balloon indicates that all the gas molecules have moved upwards.
d) Due to the heat, the number of gaseous particles trapped in the container increases.

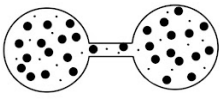
Appendix 2 (continued)

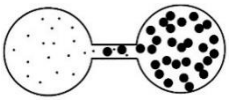
9.1- We put 1 atom hydrogen and 2 atoms oxygen into the two portion of the container which have the same volume and open the interface tap between them, as a result balance is achieved. What is the distribution of gases in the two side of the container?



a) 

b) 

c) 

d) 

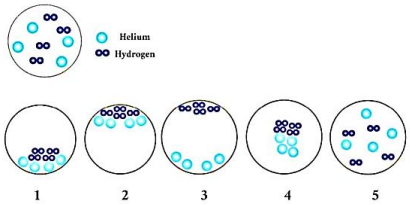
9.2- Which of the following statements best describes your answer in part 1?

a) Due to the higher pressure of oxygen, hydrogen is compressed by oxygen.
b) Most of the gas particles remain in the first container and only a small number of gas particles are mixed in the middle.
c) The gas particles are reciprocated, but the lighter gas particles are distributed at the top of the container.
d) The gas particles move randomly and are finally well distributed in the container.

11.1- Container A shows the mixture of two hydrogen and helium gasses at a given pressure in a sealed container. If at constant pressure

this gas mixture cools which of the following would result in containers 1 to 5?

a) Picture 1
b) Picture 2
c) Picture 3
d) Picture 4
e) Picture 5



11.2- Which of the following statements best describes your answer in part 1?

a) The kinetic energy of the gas particles is reduced but still spread throughout the container.
b) As it cools, the gas particles come closer together and concentrate in the middle of the container.
c) When gas particles cool, the energy of the particles decreases so they become lighter.
d) As the temperature decreases, the mass of gaseous particles increases and settles to the bottom of the container.
When the gas particles are cooled in the container, the heavier and lighter gas particles are placed at the bottom and top of the container, respectively