Misconceptions about the particulate structure of science teacher candidates

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Abstract. The aim of this study is to determine preservice science teachers' misconceptions related particulate nature of matter. For this purpose misconceptions evaluation tool about particulate nature of matter was prepared 118 preservice science teachers who 48 of them first grade and 70 of them fourth grade was applied. The findings show that preservice science teachers' misconceptions about the atomic structure is more than the other concepts. Misconception related to the concept of element is minimum. Also there is no significant differences between the first and fourth grade in the misconceptions measurement tool about particulate nature of matter.

Keywords: Misconceptions, Particulate Nature of the Substance, Misconceptions Evaluation Tool

1 Introduction

Scientific developments, and depending on them, the technologies produced, play important roles in the development of countries. For this reason, the importance of science and its education is growing with each passing day. For this reason, countries want to raise individuals who have the requirements of future ages by providing them with quality education-training services [1].

When the literature is reviewed, it is observed that misconception is defined in different ways. According to Bilgin and Geban[2], it is defined as the thinking method of students on any topic different than the specialists of that specific topic. On the other hand, Tekkaya, Çapa and Yılmaz [3] defined misconception as the concept developed by students as an alternative to the concepts accepted scientifically. Misconceptions are the ones acquired by students as a result of their experiences. These alternative concepts make it difficult to understand new topics and affect meaningful learning in a negative way.

The abstract structure of physical science misconceptions in this field pose a difficult situation for students and teachers. When the reasons of misconceptions are considered, it is

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seen that they stem from the prejudices, ideas, perceptions, and life experiences of the students when they are at pre-learning stage. For this reason, before the science classes start, the pre-learnt concepts of students must be checked, and if there are any misconceptions, these must be corrected to facilitate future learning [4, 6].

When the literature is reviewed, it is observed that there are many reasons for misconceptions in the science field. In order to determine and eliminate these factors, firstly, it is necessary that science teachers have the scientific process skills and they require knowledge and experience on conceptual change. One of the ways to ensure this is to share the results of studies conducted in this field with teachers and make them acquire some pedagogical skills with in-service trainings [4].

Misconceptions must be resolved within the teaching and learning process. Students need to understand the contents of science classes in order to understand the natural world. Contributions may be made to the understanding of the students about the natural world by eliminating their misconceptions [6].

Obtaining information on misconceptions and their possible causes is extremely important for teaching concepts and to eliminate misconceptions. Because this information makes use of at a maximum level in the stage where the teaching material on concepts are prepared [7].

In the study of Akgün, Gönen and Yılmaz [4] it was reported that science teachers had misconceptions on the structure of the mixtures and their conductivity. Ayas and Özmen[1] conducted a study and reported that there were misconceptions on 5 topics related with to the particulate structure of matter in daily life (vaporization, the change of pressure with temperature in a closed medium, condensation, diffusion and the states of matter). Aydoğan, Güneş and Gülçiçek[5], Kaptan and Korkmaz[8] also conducted studies and showed that students had misconceptions about the topics.

Bilgin and Geban[2] conducted another study on chemical balance and determined that students had misconceptions about the topic. Demircioğlu, Demircioğlu and Yadigaroğlu[9] reported in their study that worksheets were influential in teaching the oxidation and reduction concepts. Erdem, Yılmaz and Morgil[10] conducted another study and determined that students had misconceptions on topics like mol-molecule, atom mass-mass number and oxidizing-oxidized agents. In the study of Sökmen and Bayram[11] which was conducted on eight different concepts, including chemical change and physical change, it was revealed that students could not learn these concepts in a due manner during their educations, and therefore, they were having misconceptions. In their study conducted of the structure of the atom, Tezcan and Salmaz[12] reported that although there were differences between the control group and the study group in terms of academic success levels in favor of the study group, according to the data obtained in the study, misconceptions continued in both groups. Yılmaz, Erdem and Morgil[13] showed in their studies that the question type was influential in the emergence of misconceptions. The purpose of the present study is to determine the existing misconceptions of science teacher candidates on the particulate structure of matter, and to recommend solutions.

2 Method

The literature survey method, which is among quantitative research designs, was used in this study in which the aim was to determine the misconceptions on the particulate structure of matter, and to make recommendations in this context. The survey method is defined as collecting data to determine certain characteristics of a group [14]. The sampling of the study consisted of 118 Science teacher candidates 48 of whom were 1st Graders and 70 of whom were 4th Graders.

In the context of the study, “the Scale to Measure the Misconceptions of the Particulate Structure of Matter” was used to determine the misconceptions of teacher candidates. Six

different particulate models were given in the scale to show the particulate structure of matter. Teacher candidates were asked to classify the particle models in terms of being in atomic, molecular, elementary or compound structure by stating the reasons. They were then asked to define the concepts of atomic structure, molecular structure and element and compound. Based on the definitions made by the teacher candidates, their definitions of the concepts in question were examined, and scores were given according to the answers given in the scale by the teacher candidates.

3 Findings

The misconceptions of the science teacher candidates in the particulate structure of matter were examined in the context of their answers given to the questions in the scale, and the definitions of them on atomic structure, molecular structure, element and compound were analyzed. When all the sampling was examined (Table 1), it was observed that teacher candidates, especially have problems in defining the concepts like atomic structure and molecular structure. The rate of answering accurately in atomic structure concept was 10,3%; and the rate of answering accurately in molecular structure concept was 16,2%. On the other hand, the rate of answering accurately in element and compound concept definitions were 76,6%and 65%, respectively.

Table 1. Rates of the answers based on the sampling

Concept	Atomic structure		Molecular structure		Element		Compound	
Definition	N	%	N	%	N	%	N	%
Wrong Answer	105	89,7	98	83,8	27	23,1	41	35,0
True Answer	12	10,3	19	16,2	90	76,9	76	65,0
Total	117	100	117	100,0	117	100,0	117	100,0

Similarly, when the sampling was examined in terms of the grades (Table 2), it was observed that aside from the element concept, the rate of the true answers given by the teacher candidates at the 1st grade in all other concepts was higher than those of the 4th grade teacher candidates.

Table 2. Rates of the answers based on the grades

	Concept	Atomic		Molecular		Element		Compound	
Grade	Definition	N	%	N	%	N	%	N	%
1	Wrong Answer	41	85,4	38	79,2	13	27,1	16	33,3
	True Answer	7	14,6	10	20,8	35	72,9	32	66,7
	Total	48	100,0	48	100,0	48	100,0	48	100,0
4	Wrong Answer	64	92,8	60	87,0	14	20,3	25	36,2
	True Answer	5	7,2	9	13,0	55	79,7	44	63,8
	Total	69	100,0	69	100,0	69	100,0	69	100,0

3.1 Atomic structure concept

When the answers of the science teacher candidates given to the questions in the scale to measure the misconceptions of the particulate structure of matter were examined it was observed that 7 teacher candidates from the 1st grade gave true answers to the question on Atomic Concept (Success $Rate_1$=0,14); and 5 teacher candidates gave true answers at the 4thGrade (Success $Rate_4$=0,07). The Success average comparison (The *z*-Test) was made to

determine whether the difference between the success rates was significant or not (Table 3), and no significant differences were detected between the groups (z=1,287, p>0,05).

Table 3. The Z-Test on the atomic structure concept

Grade	n	N	n/N	z	P
1	7	48	0,14	1,287	0,19
4	5	69	0,07		

(p<0,05)

3.2 Molecular structure concept

On the scale to measure the misconceptions of the particulate structure of matter, 10 teacher candidates gave true answers at the 1stGrade on Molecular Concept (Success $Rate_1$=0,208); 9 teacher candidates gave true answers at the 4th Grade (Success $Rate_4$=0,13). The Success average comparison (The *z*-Test) was made to determine whether the difference between the success rates was significant or not (Table 4), no significant difference was detected between the groups (z=1,124, p>0,05).

Table 4. The z-Test on molecular structure concept

Grade	n	N	n/N	z	p
1	10	48	0,208	1,124	0,21
4	9	69	0,13		

(p<0,05)

3.3 Element concept

On the scale to measure the misconceptions of the particulate structure of matter,35 teacher candidates gave true answers on the element concept at the 1stGrade (Success $Rate_1$=0,729); and 5 teacher candidates gave true answers at the 4th Grade (Success $Rate_4$=0,797). The Success average comparison (The *z*-Test) was made to determine whether the difference between the success rates was significant or not (Table 5), no significant difference was detected between the groups (z=0,858, p>0,05).

Table 5. The *z*-Test on element concept

Grade	n	N	n/N	z	p
1	35	48	0,729	0,858	0,39
4	55	69	0,797		

(p<0,05)

3.4 Compound concept

On "the Scale to Measure the Misconceptions of the Particulate Structure of Matter", 32 teacher candidates at the 1st Grade gave true answers on the Compound Concept (Success $Rate_1$=0,667); 9 teacher candidates gave true answers at the 4th Grade (Success $Rate_4$=0,638). The Success average comparison (The *z*-Test) was made to determine whether the difference between the success rates was significant or not (Table 6), no significant difference was detected between the groups (z=0,323, p>0,05).

Table 6. The z-test on compound concept

Grade	n	N	n/N	z	p
1	32	48	0,667	0,323	0,75
4	44	69	0,638		

(p<0,05)

3.5 The t-Test results

When the data obtained as a result of scoring the answers given to the questions in the scale to measure the misconceptions of the particulate structure of matter were analyzed, it was observed that the arithmetic average, median and peak value, which are the central inclination measurements, were close to each other. In the equality of the variances test that was conducted in the dataset, it was observed that the variance between the grades were equal to each other. The *t*-test was also conducted on the dataset.

The results of the independent groups t-test conducted to determine whether there were any significant differences between the grades are given in table 7.

Table 7. The result of the t-test

Groups	N	$\overline{X}$	SS	sd	t	p
1stGrade	48	48,56	16,03	115	,311	,757
4thGrade	69	47,74	12,64			

(p<0,05)

When Table 7 is analyzed, it is observed that the arithmetic averages of both groups were low and close to each other. According to the *t*-test result, it was determined that there was no significant difference between the 1stGrade ($\overline{X}$ =46,56) and 4thGrade ($\overline{X}$ =47,74) [$t_{(115)}$=,311 p>,005].

4 Discussion

The Scale to Measure the Misconceptions of the Particulate Structure of Matter was applied to 118 teacher candidates studying at 1st and 4thGrades of science teachers department in order to determine the misconceptions in the Science Teacher Candidates on the Particulate Structure of Matter subject; and the answers given by the teacher candidates were analyzed. When Table 1 is examined, it is observed that misconceptions exist mostly on the atomic structure concept. The misconceptions were at the lowest level in element concept. Similarly, when the answers of the teacher candidates are examined in terms of the grades (Table 2), it is observed that the true answers given by the teacher candidates except for the element concept are more than the true answers given by the 4th Graders. In addition, when Table 2 is examined, it is also observed that the number of the teacher candidates who gave true answers to the atomic and molecular Concept at both grades was close to each other and at low levels. Based on this situation, it might be claimed that the misconceptions of science teacher candidates on the basic concept that constitute the basic structure of the atom do not change throughout the educational process of the teacher candidates. Among the reasons of this, it is possible to consider the education being performed in a traditional method in the educational process. Parallel to this result, the t-test was conducted between the points received in the scale to measure the misconceptions of the particulate structure of matter to see whether there was significant differences (Table 7) and it was observed that there were no significant differences between the 1stGrade ($\overline{X}$ =48,56) and 4thGrade ($\overline{X}$ =47,74) [$t_{(117)}$=0,311, p<,005].

When the literature is reviewed, it was observed that there were no direct studies on the atom, molecule, element and compound concepts in particulate structure of matter subject. However, in the study conducted by Ayas and Özmen [1], misconceptions were detected in particulate structure of matter subject in the concepts like vaporization, the change of pressure with temperature in a closed medium, condensation, diffusion and the states of matter. Similarly, in the study conducted by Tezcan and Salmaz [12], it was determined those misconceptions continued on subjects like the structure, movement style, size, weight, lifespan and the composition of matter. It is possible to claim that the results reported in the

literature are parallel to the ones determined in the present study. The structure of the atom may be considered as one of the basic subjects in science. Without knowing the structure of the atom, it is difficult to learn some other subjects like the structure of the matter, chemical reactions, chemical bonds, etc. For this reason, when the results obtained in this study and the ones reported in the literature are analyzed together, it is possible to claim that the basis of the difficulty in understanding the structure of the matter and the misconceptions in further subjects is the misconceptions that exist in the particulate structure of matter.

5 Result and recommendations

The scale to measure the misconceptions of the particulate structure of matter was applied to 118 teacher candidates studying at 1st and 4thGrades of science teacher's department in order to determine the misconceptions in the science teacher candidates on the particulate structure of matter subject; and the answers given by the teacher candidates were analyzed. When the answers given by the teacher candidates were examined in terms of the sampling (Table 1) it was observed that the rate of the wrong answers given in atomic structure (% 89,7) and molecular structure (% 83,8) concepts were more than those of the element and compound concepts. The concept in which the wrong answer rate was the lowest was the concept element (23,1%). When the analysis results were examined in terms of grades (Table 2) it as observed that the rate of true answers of 1st Grade students was higher than those of the 4th Graders. The *z*-Test was made to determine whether there was a significant difference between the grades according to the true answers given to the concepts, and it was observed that there was no difference in any concept. In addition, the t test was applied again to determine whether there was a significant difference between the points received in the scale and it was observed that there were no significant differences between the 1stGrade ($\overline{X}$ =48,56) and 4thGrade ($\overline{X}$ =47,74) [$t_{(117)}$=0,311, p<,005].

The misconception in the teacher candidates will influence the conceptual development in the students in a negative manner. For this reason, the misconceptions must be determined in teacher candidates and eliminated [4]. Questions with long answers may be asked in order to reveal the misconceptions in students. Because such questions require that students revise and reorganize their knowledge to explain what they understand from the subject. Questions with long answers which enable students to show their reasoning, must be emphasized in homework assignments to help students define misconceptions [6]. Yılmaz, Erdem and Morgil [13] conducted a study and showed that the question type used in the study was influential in detecting misconceptions.

The bilateral communication between the student and the teacher must be increased in order to eliminate misconceptions. By doing so, it may be ensured that students become aware of the concepts they are going to develop. In addition, it must be considered that preparing the course books in such a way that will lead to misconceptions will deteriorate the situation [6].

In order to succeed in science education, student-centered methods must be preferred rather than traditional methods. When the literature is reviewed, it is observed that student-centered methods are replacing traditional methods in science education. According to Yağbasan and Gülçiçek [6], science education is a complex process and hosts may components. In order to have a more influential science education, it has been claimed that methods that are different from the traditional methods should be used such as cooperation-based science education, concept mapping method, asking questions techniques, reflective thoughts skills, and computer-assisted science teaching.

In the study conducted by Polat [15], a positive result was reported in favor of the study group in which argumentation method was applied ad the control group in which traditional method was applied, which shows that argumentation method may also be used as an influential method on the subject the structure of the atom.

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