Educational Research and Reviews Vol. 6(2), pp. 197-200, February 2011
Available online at http://www.academicjournals.org/ERR
ISSN 1990-3839 ©2011 Academic Journals

Full Length Research Paper

Prospective primary school teachers' misconceptions about states of matter

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Accepted 11th January, 2011

The purpose of this study was to identify prospective primary school teachers' misconceptions about the states of matter. The sample of the study was 227 fourth-year prospective primary school teachers in a Department of Primary Education in Turkey. Researcher asked from every participant to write **a response to an open ended question about differences among solid, liquid and gaseous states of matter. In analyzing the research data, the researcher used descriptive analysis techniques. The findings of the research indicated that prospective primary school teachers have some misconceptions such as: The shape of solids do not change, there is no space between the particles of solids, since gases are not affected by gravity they do not fall down like the solids and liquids, the size of the particles of solids is bigger than the particles of liquids, and the particles of liquids are bigger than the ones of gases.**

Key words: States of matter, misconception, prospective primary school teacher, chemistry education

INTRODUCTION

In the last forty years, the findings of the studies carried out in science education have determined that students come to the science lessons although they have some prior science knowledge. However, these researches indicated that the views and explanations that students had in relation to the natural world were different from the views of scientists (Osborne, 1982). According to Ausubel (1968), students determined that some unwanted teaching results occurred while they were trying to digest the new information they encountered via the current knowledge structures. In this respect, it is vitally important to determine students' views and prior knowledge in relation to the subject in helping them create their scientific understanding (Talanquer, 2006).

In the literature of science education, preconceptions (Hashweh,1988), alternative conceptions (Driver and Easley, 1978; Gilbert and Swift, 1985; Schoon and Boone, 1998), alternative frameworks (Driver and Erickson, 1983; Kuiper, 1994), children's science (Gilbert et al., 1982) and misconceptions (Helm, 1980; Lawson and Thompson, 1988; Treagust, 1988; Chou, 2002; Özmen and Ayas, 2003) have been used commonly. In this study, it is preferred to using misconceptions term.

Constructivist learning theory emphasizes the importance of social interaction in learning. According to this theory, students come to classes with the misconceptions they give about the shape as a result of their interaction with the world. These misconceptions are affected by students' way of interpreting and constructing new concepts (Boo and Watson, 2001). On the other hand, Taber suggests that most of the misconceptions in chemistry do not result from the experiences had out of the school. According to Taber, the misconceptions in chemistry result from the situations occurring in formal learning environment such as students' misconceptions in previous science educations, the limitation of the models in science, mistakes in model applications and misleading expressions in the language used (Taber, 2001).

Primary education teachers have an important role in their students' understanding of science concepts. Because, they are also science teachers in primary education. This study is about the misconceptions of elementary education teacher candidates about the states of matter. In science education literature, there are a lot of studies in relation to the misconceptions about the states of matter (Osborne and Cosgrove, 1983; Jones, 1984; Stavy, 1988; Jones and Lynch, 1989; Stavy, 1990; Andersson, 1990; Bar and Travis, 1991; Lee et al., 1993; Tsai, 1999; Çalık and Ayas, 2005). The findings of these studies provide us with evidence in relation to different misconceptions of science teachers about the states of matter. They help us to better understand the source and possible reasons of the problems faced by students in learning and their misconceptions (Chou, 2002).

In addition to this, the number of studies focusing on the differences between the states of matter is limited among the above mentioned studies. In this study, it was aimed at determining the misconceptions of primary education teacher candidates considering the differences between solid, liquid and gaseous states of matter.

MATERIALS AND METHODS

Sample

The sample of the study was 227 fourth-year prospective primary school teachers in the Department of Primary Education in a Turkish state University. The Department has seven or eight classes at each level. Eight classes in fourth-year took part in the study.

Process

Every participant was given a sheet of A4 paper and they were asked to write differences among solid, liquid and gaseous states of matter on it. In order to further probe the participants' understandings, also they were asked to write a response to the following question: "If you are a primary school teacher now, will you plan activities to teach your students the differences among states of matter?" Participants were allowed a 60 min time period to complete their responses.

Analyzing

In analysis of the data, descriptive analysis techniques were used (Mcmillan and Schumacher, 2001). For validity, two chemistry education experts worked analyzing and identifying the misconceptions. Initially, the data obtained from the answer sheets were read and analyzed in detail and participants' misconceptions about the states of matter were identified by two experts separately. Then, similar categories were combined and final categorization was made with its frequencies. Results were tabulated in terms of percentages.

RESULTS AND DISCUSSION

In this study, we aimed to identify prospective primary school teachers' misconceptions about the states of matter. In the end of the descriptive analysis of the data obtained from the answer sheets, participants' misconceptions were identified. Then a categorization was done. Results are presented under six main headings: weight, shape, particle, flowing, volume and others. Table 1 shows participants' misconceptions and its percentages.

The results of the study indicate that some participants have misconceptions about the weight of solids, liquids and gases. Some participants think that a solid is heavier than a liquid. They think that the gaseous state of matter is the lightest than others. Some participants in their responses stated that gases are not affected by gravity, they do not have weight and can fly. These result is similar to the findings of Ramsden (1997), Barker and Millar (1999) and Özmen and Ayas (2003).Their studies attribute this to the fact that solids are taught to be heavier than liquids. Özmen and Ayas (2003) state that

> *"These students use a naive model of matter dependent on the sensory perception of expecting solids to be heavier than liquids*".

Another similar research was made by Stavy (1990). He examined children's (ages 9 to 15) conception of changes in the state of matter. He determined that some students believed that the gaseous state of matter is lighter than its liquid and solid forms, and some students even believed that gases had no weight.

This misconception may originate from the lack of participants' understandings about properties of solid, liquid and gaseous states of matters. Considering their experiences in their daily lives, they make a wrong comparison between the macro sizes of matters (in which matters can be observed with naked eye) and the micro sizes of matters (particle size). They observe that although they have the same volume in daily life, solids are heavier than liquids and liquids are heavier than gases. These observations arouse the image that there is this weight relationship between the states of matter in micro dimension. This misconception results from their understanding of the states of matter insufficiently in terms of the frequency of particles.

This study indicates that some participants have misconceptions about the shape of solids, liquids and gases. These participants think that all solid matters have a definite shape and are hard matters. This misconception may arise from participants thought that solids are only hard objects in their environment. In a similar study, Stavy and Stachel (1985) examined the conceptions children (between the ages of 5 to 12) have of solid and liquid. Children think that substances which are not hard and rigid cannot be solids. According to them, the easier it is to change the shape of the solid, the less likely it is to be a solid.

This study also revealed another misconception related to the particles of matter. The participants state that the particles of solids cannot move, there is no space between the particles of solids and solids are completely made up of particles, but liquids and gases are not completely made up particles (contain another things).

Also they think that the size (dimension) of the particles

Table 1. Participants' misconceptions and its percentages.

Misconceptions identified	%
Weight	
Solids have more particles than liquids and liquids have more particles than gases.	15
Gases flies.	12
Since gases are not affected by gravity they do not fall down like the solids and liquids.	12
Gases do not have weight.	10
Gases are light, liquids are heavier than gases and solids are the heaviest.	5
Shape	
All solids have a definite shape.	90%
Solids are hard matters.	35%
The shape of solids does not change.	15%
Particle	
There is no space between the particles of solids.	18%
The size (dimension) of the particles of solids is bigger than the particles of liquids and the particles of liquids are bigger than the ones of gases.	15%
The particles of solids can not move.	12%
Solids are made up of the particles completely, but liquids and gases are made up the particles not completely (contain another things).	5%
Flowing	
Matters that can be poured from one container to the other are liquids.	25%
When solids are put into a container they cannot be transformed.	25%
Volume	
Although solids have volume liquids and gases do not.	28%
The volume of gases only changes when the temperature is changed, but the volume of solids and liquids not change.	7%

of solids is bigger than the particles of liquids and the particles of liquids are bigger than the ones of gases. These misconceptions stem from the lack of participants' understandings about properties of solid, liquid and gaseous states of matters. They do not know that the particles of solid matter can vibrate and have a kinetic energy.

Also these misconceptions may originate from particles drawings related to solids, liquids and gases in the texts. Because solids' molecules have been packed together and usually are seen in a regular pattern in drawings. According to the participants, since the particles of solids are bigger in comparison to others, they seem entrapped in comparison to liquids and gases with the same volume. Since the gaps between solid particles are small, the particles cannot take any substances between themselves and move in any way.

Another misconception is about the flowing of solids, liquids and gases. The participants state that matters that can be poured from one container to the other are liquids and when solids are put into a container they cannot be transformed. This misconception may originate from the fact that participants do not think some matter such as sand and sugar as solids. According to them, solids are hard matter and do not flow easily its particles cannot move.

The results of the study also indicate that some participants have misconceptions about the volume of solids, liquids and gases. Some participants think that solids have volume liquids and gases do not. And some participants think that the volume of only gases changes when the temperature is changed, but the volume of solids and liquids do not change. These misconceptions may stem from the lack of participants' understandings about volume concept. The participants think of the volume of the matter as the shape of the matter.

This research indicated that participants' misconceptions originated from the lack of understanding about states of matter. Participants' views might be affected by these preconceptions in their life due to their inadequate understanding in class. One reason of misconceptions in pupils is that their teachers (primary school teachers) also have misconceptions. Therefore it is important that prospective primary school teachers have correct the misunderstanding about science concepts. Although the “States of Matter” is considered as a simple and well-known topic, it is found that participants have misconceptions about this idea. Since “States of Matter” is an important topic that concerns our daily life, participants’ mistakes in conception can have detrimental influence on the scientific comprehension of the other concepts. In future studies related to the teaching of this topic is necessary to focus on the misunderstood points discussed above. Therefore, we concluded that it would be beneficial to carry out more studies on methods to reduce or eliminate such misconceptions.

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