STUDENTS' PRECONCEPTIONS AND MISCONCEPTIONS ABOUT GASES*

Nursen AZIZOĞLU[1,2] and Ömer GEBAN[1]

[1]Middle East Technical University, Faculty of Education, Department of SSME, 06531 Ankara
[2]Balıkesir University, Necatibey Faculty of Education, Department of SSME, 10100 Balıkesir

ABSTRACT

The aim of this study was to investigate tenth grade students' preconceptions and misconceptions about gases concepts. One hundred tenth grade students from two classes in a public high school were enrolled in the study. The instrument used to determine students' preconceptions and misconceptions was Gases Concept Test which consisted of 40 multiple-choice questions. Gases Concept Test was administered to all students as pre- and post-test. The results showed that students have incorrect conceptions about gases before and even after instruction.

Keywords: Gases, Misconceptions, Preconceptions.

ÖZET

Bu çalışmanın amacı onuncu sınıf öğrencilerinin gazlar konusundaki önkavrama ve kavram yanılgılarını incelemektir. Çalışmaya bir devlet okulundaki iki ayrı onuncu sınıftaki yüz öğrenci katılmıştır. Gazlar Kavram Testi öğrencilerin gazlarla ilgili önkavramaları ile kavram yanılgılarını belirlemek için ön- ve son-test olarak bütün öğrencilere uygulanmıştır. Sonuçlar öğrencilerin öğretimden önce ve sonra doğru olmayan kavramsallaştırmalara sahip olduklarını göstermiştir.

Anahtar Kelimeler: Gazlar, Kavram Yanılgısı, Önkavrama.

1. INTRODUCTION

Learning scientific concepts meaningfully is the main goal of science education. Research studies on students' conceptions about scientific phenomena propose that students develop some informal ideas which make sense of the world around them. Students' incorrect conceptions prior to instruction were called as preconceptions, while misconceptions refer to ideas formed as a result of incorrectly assimilation of formal models or theories (1). In chemistry, the major obstacle in learning the concepts is their abstract nature. Particularly gases cause difficulty for students because they are invisible. "Seeing is believing" principle deeply affects students' beliefs about gases. 'Gases have no mass' or 'Gases are not matter' are incorrect conceptions probably developed as a result of experiences in which students could not apply this principle. Stavy (2) emphasizes that this invisibility prevents children from forming a concept of gas spontaneously. Students have well-established notions and interpretations about gas phenomena. The research literature that identifies the students' informal ideas about concepts related to gases is extensive. Novick and Nussbaum (3) revealed that students have difficulties in understanding the random motion of particles. When asked, "why do not the particles fall to the bottom?" only around half of the students were able to

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Dr. Nursen Azizoğlu: nursen@balikesir.edu.tr

explain that the particles are in constant motion. Students have also considerable difficulties on the notion that empty space exists between particles. Students think that there is something between the particles such as other gases (oxygen, nitrogen, or air), dirt, germs, unknown vapors,…(3,4). Sometimes those students who successfully understand that matter consists of particles assign bulk properties to particles themselves. For example, students argue, "water molecules from the gaseous phase are the largest" (5). Various studies revealed that students also develop incorrect conceptions while concepts of different topics for example, conservation of mass in reactions with gaseous products or reactants, or air related phenomena, require the use of concepts related to gases. "The weight does not change after release of gas" (2) or "hot air rises" (6) are examples of such misconceptions. The views that children bring with them to science classes are to them logical and coherent but these views influence how and what children learn in their classrooms.

Incorrect conceptions have many common features. The most important one is that the misconceptions are strongly resistant to traditional teaching. These student views may remain uninfluenced, or be influenced in unexpected ways, by science teaching (7).

In the present study students' understanding of concepts related to gases was investigated. Students' incorrect conceptions prior to instruction were determined and called as preconceptions. Students' incorrect conceptions determined after detailed instruction of gases topic were classified as misconceptions.

2. METHOD

2.1 Sample

The subjects of this study included 100 tenth grade students from two science classes, taught by the same chemistry teacher, in a public high school.

2.2 Instruments

In this study the instrument used to gather data was Gases Concept Test (GCT). The test consisted of 40 five-alternative multiple-choice questions. Twenty-nine of 40 were qualitative questions that tested students' conceptions with respect to a concept about gases. Questions have one correct answer, while distracters were misconceptions revealed in previous research studies. Eleven of 40 were quantitative questions that required arithmetical calculations based on gas laws formula. All students received GCT as pre- and post-test. The Cronbach alpha reliability of the test was found to be 0.78. An example of a question in GCT is shown in Figure 1.

2.3 Treatment

Treatment duration was six weeks and instruction was three 45-minute sessions per week. During the treatment, the gases topic was covered as part of the regular classroom curriculum in the chemistry course. All students in both classes were instructed about the same concepts related to gases.

2.4 Data Analysis

Pre-test results of GCT were used to determine students' preconceptions while post-test results were used to identify students' misconceptions about gases.

Question 6: A rubber balloon is filled with hydrogen gas and the opening is tightly tied. Few days later the balloon deflates. Which of the following explain why the balloon deflated?

Alternative A
The energy of molecules gradually died and the molecules stopped moving.
Alternative B*
Balloon had a pore.
* Correct alternative
Alternative C
Weather became colder and molecules clustered.
Alternative D
Molecules got smaller as a result of collisions.
Alternative E
The atmospheric pressure rose and made balloon small.

Figure 1. A question included in the Gases Concept Test

3. RESULTS

Table 1 lists the important preconceptions and misconceptions about concepts related to gases revealed through analysis of pre- and post-GCT results.

Pre-GCT results were analyzed and students' preconceptions were determined. Analyzing post-GCT results misconceptions about gases were identified. At the end of the analyses it was seen that the incorrect conceptions identified before instruction persist to survive even after instruction. The difference was found in the percentages of students' holding the given conception; there was decrease in percentages of holding conceptions after instruction.

Table 1. List of Students' Preconceptions and Misconceptions.

Preconceptions/Misconceptions
Conservation of matter applies to solids and liquids, but may be ignored for gaseous reactants and products.
Molecules increase in size with change of state from solid to liquid to gas.
Gases have no mass.
The decrease in volume as a gas cools is due to increased attractive forces between particles, rather than decreased molecular motion.
The energy gradually dies, so the gas motion stops and balloon deflates.
Matter exists between gas atoms.
Collisions may result in a change of atomic size.
The particles in a gas are unevenly scattered in any enclosed space.
Heated air weighs more than cold air.
Hot air weighs less than cold air.
Air neither has mass nor can it occupy space.
An evacuated can or deflated balloon has less pressure inside than out.
Pressure acts downward only.
In compressed air the particles are compacted like a solid and do not move.
When heated the molecules expand, when cooled they shrink.
When the air is compressed, the particles stick together.
When the air is compressed, the air particles are all pushed to the end of the syringe.
Gas behavior is similar to liquid behavior.

4. DISCUSSIONS and CONCLUSION

The purpose of this study was to determine students' understanding of concepts related to gases. Students' ideas about concepts related to gases were identified prior to and after instruction. Preconceptions and misconceptions revealed in this study were found to be similar with those found in the literature related to students' conceptions about gases. It is not surprising because as explained previously the GCT consisted of questions which distracters included the misconceptions found in the literature about students' ideas about gases. This result also supports the findings of the previous research studies that students' conceptions show remarkable consistency across diverse populations. On the other hand, although students received detailed instruction post-test results of GCT showed that students still hold incorrect conceptions. The reason may be the nature of the misconception. Some misconceptions are deeply rooted in students' minds and they persist to survive despite of instruction (1,8). Type of instruction is also important factor affecting the way and quality of the acquisition of the concepts. Traditionally designed instruction is delineated as less effective, in improving students' understanding of scientific concepts, because does not aim conceptual change (9,10). On the other hand, instructional approaches aimed at providing conceptual change are pointed as successful in improving students' understanding of scientific concepts because of the continuous process of exchange and differentiation of the existing concepts and the integration of new conceptions with existing conceptions (9-12).

Identifying students' conceptions have some consequences for science teaching and learning. Determining students' preconceptions is important because incorrect conceptions interfere with subsequent learning. Teachers are frequently unaware of the existence of such ideas. The teachers need to be sensitive to and value students' ideas that students' bring with them to classes (13). The teachers should give students opportunities to express their ideas, share them with peers and teacher. The teachers knowing that students possess invalid ideas may change their teaching strategies to lead students from their preconceptions to scientific conceptions. Changing the old and useless conceptions to new and plausible conceptions would be the matter of a well-designed instruction that aims conceptual change and eliciting meaningful understanding of scientific conceptions.

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