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Research Paper

Misconceptions in the Concepts of Volume and Capacity among Sixth Grade Teachers

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Abstract

Aim: The purpose of this study was to investigate the misconceptions in the concepts of volume and capacity among sixth grade school teachers of Tabriz Education Office, District 3 during 2019-2020 academic year. Given the nature of the subject and the mentioned objective, mixed method (quantitative-qualitative) was used. The statistical sample consisted of 140 sixth grade teachers selected by cluster sampling from among the population of sixth grade school teachers in Tabriz Education Office. The data was collected using volume and capacity misconception assessment questionnaire and semi-structured interviews. The results indicated that although many teachers showed a clear understanding of the concepts of volume and capacity, 20 teachers were identified with misconceptions of these concepts. The interview results with the selected teachers indicated the need for retraining sixth grade teachers in terms of the concepts of volume and capacity.

Keywords*: Misconceptions, Volume, Capacity, Sixth grade teachers*

Introduction

Misconception is known as a barrier to knowledge acquisition among students (Soeharto, Csapó, et al, 2019). Research on misconception of the concepts of volume and capacity has shown that many students have difficulty understanding these concepts (Ho et al., 2019). However, in

elementary schools, it is difficult to determine whether the main cause of students' problems is due to their lack of knowledge or lack of logical structure (Klopfer, et al., 1992). Everyone believes that it is necessary to have sufficient knowledge in the field of teaching mathematics and science, and these teachers need to take technical courses to succeed in their educational career (Manasia, et al., 2020).

If the teacher has difficulty understanding the concepts, the problem gets even more complicated. A study by Qian, et al. (2019) shows that in many cases teachers have little knowledge of students' understanding. A study in the United States found that teachers lacked the content knowledge on teaching mathematics. Although knowing and mastering the subject and basic knowledge will turn them into successful and effective teachers in teaching mathematics, only few teachers feel they need help (Ruane, 2010). The results of Shahuneeza (2016) studies showed that despite teachers' assumptions that they have sufficient knowledge about the subject and the pedagogical content of algebra both of which are necessary for effective teaching, they lacked the knowledge of both areas. Teachers may make mistakes in teaching topics that lead to misconceptions in students (Bektas, 2017; Moodley, et al., 2019). It has also been shown that teachers' misconceptions in scientific subjects affect their professional performance (Wilhelm, et al, 2016). Accordingly, teachers themselves sometimes seem to have misconceptions regarding their curricula. In this line, the present study intends to examine the misconceptions of the two concepts of volume and capacity among sixth grade teachers.

Methodology

The present study is a mixed method study with a quantitative and a qualitative phase. In the quantitative phase, single stage cluster sampling was used to select 140 participants from among the total population of sixth grade teachers of Tabriz, Iran during the academic year of 2019-2020. In the qualitative phase, 20 teachers with misconceptions were selected through purposive sampling, and later they were interviewed using theoretical saturation criterion.

Diagnostic tests and semi-structured interviews were used to collect data for the study. Teachers were asked to answer ten questions about the concepts of volume and capacity. Then, 20 of them who had misunderstandings were interviewed.

Research questions focused on five issues, each with two questions: one examining the teachers’ understanding of the concept of volume and the other investigating their understanding of the concept of capacity. The obtained responses were classified into four levels of complete comprehension, partial comprehension, misunderstanding, and lack of

comprehension. The questionnaire was especially designed for the elementary teachers of educational sciences, mathematics, and experimental sciences; its face and content validity were originally confirmed. It is necessary to understand that despite the changes in the appearance of solids, the dimensions of objects, the appearance of liquids, the nature of the units of measurement, and the materials, in fact, volume is defined as the space occupied by the mass of the body, while capacity refers to the empty space in which liquids (e.g., water) or anything else can occupy. An interview protocol was developed with the advice of professors in the field of educational sciences and teaching for conducting the interviews properly.

Abraham, et al.'s (1992) conceptual evaluation method was used to analyze teachers' understanding. In this method, the options selected by the teachers and their responses to the explanatory questions were divided into four levels: complete comprehension, partial comprehension, misunderstanding and lack of understanding.

Results

Table 1 shows the frequency and the percentage of comprehension levels in questions related to volume and capacity. Odd numbers indicate the responses to the questions about the concept of volume and even numbers are related to the questions on the concept of capacity. As Table 1 shows, in most cases, for both concepts of volume and capacity, a high percentage of teachers had partial comprehension, misunderstanding, or lack of comprehension.

Table 1. Frequency and percentage of comprehension levels in questions related to volume and capacity

Question	subject	Lack of comprehension		Misunderstanding		Partial comprehension		Full comprehension	
		F	P	F	P	F	P	F	P
1	The effect of the nature of physical deformation on solid objects	0	0	22	55	7	17.5	11	27.5
2		0	0	12	30	13	32.5	15	37.5
3	The nature of changing the dimensions of objects	2	5	13	47	5	12.5	14	35
4		3	7.5	18	45	9	22.5	10	25
5	The effect of	3	7.5	21	52.5	8	20	8	20

6	fluid deformation	1	2.5	11	27.5	9	22.5	19	47.5
7	The nature	2	5	22	55	6	15	10	25
8	of units of measurement	3	7.5	22	55	7	17.5	8	20
9	The nature	3	7.5	8	20	14	35	15	37.5
10	of matter	4	10	19	47.5	5	5	11	27.5

Qualitative interviews with sixth grade teachers who had misconceptions about volume and capacity yielded some interesting explanations, some of which are mentioned here:

A) The effect of the nature of physical deformation on solid objects

- "Figure 1 is thicker, so it is larger."
- "The capacity is the same as volume; because the volume of both of them is the same, their capacity is the same too."

B) The nature of changing the dimensions of objects and its effect on the object volume and capacity

- "It is not possible to calculate the volume of different shapes; as cardboard is made of paper, it is not possible to calculate volume by floating new objects in the water inside a graduated cylinder and calculating the rising height of the water in it."
- "The capacity of these two shapes is not related to each other, since in any case, the space inside the shapes is closed, and therefore, the capacity of the shapes cannot be calculated."

C) The effect of fluid deformation and its effect on volume and capacity of the fluid

- "The volume of the glass and the cube container are the same because they both hold the same amount of water."
- "The capacity of the two containers cannot be compared because the shape of the glass and the cube container are not the same."

D) The nature of units of measurement and their effect on volume and capacity of the object

- "The volume of the classroom is larger than that of 12 cans because in addition to the internal volume, volume depends on the thickness of classroom walls."
- "Comparing the capacity of these two containers is meaningless because we cannot calculate the capacity of the cans; the reason is the fact that the concept of capacity is not the same as the concept of volume."

E) The nature of matter and its effect on volume and capacity of the object

- "It is not logically right to compare the volume of two objects made of different matters because volume also depends on the matter."

– "Since a piece of wood has lower density, it will logically have a larger capacity."

Discussion and conclusion

The results obtained from teachers' responses to the questions as well as semi-structured interview results showed that many sixth-grade teachers do not have a proper understanding of the concepts of volume and capacity. These results are consistent with the findings of Özerem (2012), Al-Khatib (2016), and Sisman, et al. (2015).

The results of this study indicate the need for in-service training on the concepts of volume and capacity for elementary school teachers. It is suggested that the education departments of the Education Office develop a special training program to teach the mentioned concepts to tackle the probable misconceptions on the part of teachers as well as the students. It is suggested that these issues be addressed more in educating students in the field of teacher training. It is also suggested to conduct similar studies on other concepts of mathematics and science to solve other relevant problems if any.

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