The effect of constructivist science teaching on 4th grade students' understanding of matter

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Abstract

In the last three decades, the constructivist approach has been the dominant ideology in the field of educational research. The aim of this study is to explore the effect of constructivist science teaching on the students' understanding about matter, and to compare the effectiveness of a constructivist approach over traditional teaching methods. The study was conducted with 33 fourth grade students at a state primary school in the Babaeski-Kirklareli district located in the Northwestern part of Turkey, during the autumn term of the 2007-2008 academic year. Students were randomly divided into two groups as control group (CG, n=17) and experimental group (EG, n=16). An achievement test consisting of 13 open-ended questions was developed through piloting. Initially, pre-tests were applied to both the CG and EG. Following the first four weeks, the EG was taught using the constructivist teaching practices, while the CG was taught using the traditional teaching practices based on direct speech and question-answer. Then, the post-tests were carried out in order to determine the effect of a constructivist teaching approach on student learning. Students' responses to the questions have been categorized mainly as scientific, partially scientific and non-scientific. Responses in the non-scientific category were further classified as either a misconception or nonsensical. A comparison of the responses between the CG and EG was made using a chi-square test. The results revealed that there was a significant increase in achievement within the EG students compared to the CG. In particular, the teaching based on the constructivist approach appears to be effective in eliminating the misconceptions the EG students had prior to the instruction.

Keywords: Constructivist approach, science teaching, matter, states of matter, primary education.

Introduction

Since the seventies, the change from behaviourism to cognitivism in educational psychology has placed an increasing responsibility upon the learners for their own learning, (Chen, 2002) and student-centered teaching has become the focus of many researches. The constructivist approach is based on the premise that science is a human construction. As far as learning is concerned, the constructivist approach accepts that children construct or change their representations about the environment in which they live, mainly through three processes: interaction with adults, interaction with their peers, and their personal experiences (Kokkotas and Vlachos, 1998). In brief, constructivism argues that learners actively construct meaning from existing knowledge structures, and highlights the importance of children's existing ideas in the teaching process.

Although constructivism is not a theory of teaching, it suggests taking a radically different approach to classroom teaching (Fosnot, 1996). The process of teaching requires children's existing ideas to be elicited, then challenged and altered, rather than developing a new idea (Osborne, 1996). As Osborne and Freyberg (1985, p.13) pointed out, "unless we know what children think and why they think that way, we have little chance of making any impact with our teaching no matter how skillfully we proceed." Therefore, the constructivist teaching process involves more student-centered, active learning experiences and more work with concrete materials. Richardson (1997, p.34) emphasis that teachers can facilitate "student-centered learning by providing various activities including demonstrations, diagrams, examples, and images." In Turkey, the new national curriculum, which has been in practice since 2004, emphasizes classroom teaching using a constructivist approach. The aim of this study is to highlight the importance of constructivist teaching practice in terms of student achievement in the classroom.

Why choose matter as a topic?

Matter and its states are among the fundamental topics to be learned by elementary children in science courses. However, the research literature indicates that this topic has always been confusing for these students. The study conducted by Stavy and Stachel (1985), regarding children's ideas about solids and liquids, revealed that children (aged 5 to 12) had difficulty classifying solids, which are not hard and rigid enough. They considered metals and wood as typical solids. However, around 50 percent of 12 and 13 year olds tended to classify solids, such as sponge and sand, separately from glass or coins. Most children (grades 1 to 7) experienced difficulty in classifying powders as solids. Children think that pourable powders have liquid properties. However, they do not lead to a sensation of wetness; hence they tended to classify these separately. Krnel, Watson and Glazar (2005) explored the development of the concept of matter by interviewing 84 children aged 3–13 in Slovenia. Children were asked to describe objects and substances placed in front of them. Children's responses were coded and explored for patterns indicating development with age. In their study, granular substances or powders were frequently described as a state of matter (e.g. "It is a powder," "It is crystals," "It is particles," "It is plastic"). This started at age 3. For the rigid solids, the shape was the dominant category of answers. The variety of shapes of solid objects seemed to lead children to focus on shape rather than the state of matter. These results support the research conducted by Mortimer (1998).

In a similar study, Babai and Amsterdamer (2008) investigated whether the naive concepts of solid and liquid persist in adolescence. They identified the accuracy of responses and reaction times, while 41 ninth graders classified different solids (rigid, non-rigid and powders) and different liquids (runny, dense) into solid or liquid. The results show that these naive conceptions affect adolescences' classifications in terms of both accuracy and reaction time. The rate of correct classifications of nonrigid solids and especially powders was significantly lower than that of rigid solids. A lower success rate was also found for classification of dense liquids compared with runny liquids. In addition, the reaction time results of correct classifications for non-rigid solids and powders were longer than those for rigid solids.

In another study, Liu and Lesniak (2006) explored students' conceptual progression pattern on understanding the concept of matter from elementary to high school. They found that students' conceptions of substances (i.e., water, baking soda, and vinegar) progress in general from their perceptual characteristics for all grades. These results concur with the views of Piaget and Inhelder (1997) and Kind (2004), in that children tend to use sensory reasoning or information when considering matter. This brief review of literature shows that students have common misconceptions about the matter, and this leads them to experience difficulty in their understanding and meaningful learning.

The purpose of the study

The purpose of this study was to determine the effect of a constructivist science teaching on the fourth grade students' understanding and meaningful learning of the unit on matter, and to compare the effectiveness of constructivist approach over traditional teaching methods.

Method

Research design

In this study, the pre-test post-test control group of quasi-experimental research design was used (Cohen & Manion, 2000). The design of the study can be represented as follows:

Experimental G.	O1 (Pre-Test)	X (Constructivist Science Teaching)	O2 (Post-Test)
Control G.	O3 (Pre-Test)	(Traditional Science Teaching)	O4 (Post-Test)

The experimental and control groups have not been equated by randomization. However, quasi-experimental designs are applied to "much educational research where the random selection of classrooms is quite impracticable" (Cohen & Manion, 2000, p.169).

Participants

This study was conducted with 33 fourth grade students at a state primary school in the Babaeski-Kirklareli district located in the Northwestern part of Turkey during the autumn term of the 2007-2008 academic year. Students were divided into two groups, a control group (CG, n=17) and experimental group (EG, n=16). Groups were regular classrooms.

Table I. Description of the sample.

Gender	Grade 4 Control Group	Grade 4 Experimental Group	Total
Girls	10	7	17
Boys	7	9	16
Total	17	16	33

Data collection

The preparation of the research instrument

Initially, an achievement test consisting of 20 open-ended questions for the unit on matter was developed taking into account the views of chemistry, science and classroom teachers. The preparation of the questionnaire items took into account both the content and curriculum objectives of the 4th grade level textbook unit titled "We Shall Learn about Matter." Then a questionnaire including 20 questions (13 questions about matter and its states, 7 questions about mixture, melting and dissolving) was pilot-tested in order to ensure the clarity of questions and to check the effectiveness of the research instrument. The pilot study was administered to a total of 15 fifth grade children from the same state primary school. This process provided valuable insights in relation to revision of the questionnaire. There was no particular problem concerning children's understanding of questions, but a few responses led us to be aware of an interesting misconception and to include a question *"Do you think that tomato is matter?"* in the final questionnaire. Another point to be considered in the main phase of the study was the time given for the administration of the questionnaire. In the pilot study, this took around 35 minutes, which was too long for its successful administration. In addition, the scope of the literature review seemed to be too extensive in order to complete the study in the planned time. Therefore, the researchers eliminated 7 of the questions about mixture, melting and dissolving, and the final version of the achievement test included 13 open-ended questions about the matter and its states.

The application of the research instrument

The application of the study was completed in six weeks. During the first week, pre-tests were applied to both the CG and EG, in order to see whether there were differences in achievement between the groups. During the following four weeks, the EG was taught using the constructivist teaching practices in science lessons (four hours per-week) while the CG was taught using the traditional teaching practices based on direct speech and question-answer. In the last week, the post-tests were carried out to determine the effects of the constructivist teaching approach on student learning.

The application of teaching activities

The researcher (classroom teacher) carried out the teaching in both the CG and EG. For the EG, teaching materials and course plans were prepared in accordance with the science program. They included experiments based on scientific reasoning, concept maps, games, worksheets, signboards and meaning analysis tables. Keeping in mind the constructivist view that meaningful learning requires students' existing ideas to be initially elicited, challenged and then exchanged with scientific ones, the teacher always started the lesson by asking questions to students about the topic of matter. Taking the students' preconceptions into consideration, the teacher organized the classroom activities to clarify misconceptions and to aid the development of a scientific view. According to the constructivist learning theory, students need to interact with objects in order to actively engage in the learning situation, and therefore, a great variety of matter was brought to the classroom for activities, e.g. a tomato, a newspaper, some vinegar, water, soil, rice, olive, soap, flour, bread, cream and rubber. Students were given many opportunities to use their knowledge in different situations.

During the science lessons, students usually worked in groups of four. They were often encouraged to share their ideas and talk about what they were doing. The aim was to help students go through the reasoning involved in the application of related concepts about the matter and its states. Below are a few examples of the teaching activities experienced by the experimental group.

The teacher entered the classroom with a bag containing various substances (e.g. a tomato, a newspaper, a rubber, a pencil, a soil, a stone, soap, a spoon, a button, wood and a nail). Directing several questions to the students, the teacher drew their attention to each of these items and then asked the students to list which objects represent matter and which do not. The students actively engaged in classifying each substance into groups. During this process, the teacher guided students through some critical questions such as: "What do we know about the features of matter?" and "Do you think that something around us could be called both matter and another name?". Students seemed to experience difficulty in classifying the tomato as a matter. The teacher then gave a tomato and a blank card to each group, and instructed the students to think, "Is it a matter? Please, write your reasons on the card." When they wrote down their answers based on the group consensus, the teacher redirected their attention to the front of the classroom to share and discuss their statements as a whole class. Questions were encouraged from the students. Later, this engagement was followed with a meaning analysis table. Students filled in the table for each item, based on the questions; "Is it matter?" and "What are its physical features?"

In another lesson, the teacher delivered various materials to each group of students, including some sand, limestone, flour, salt, a piece of plastic, a stone, a pebble and some sugar. The students were requested to categorize these substances based on their states. Blank cards then were given to each group. The name of the substance and the group consensus as to the state of the matter was to be written on one side of card, and the reason for the classification state on the other side. This categorization revealed many misconceptions the students held about the states of the various matters, e.g. sand is the state of powder, grain or liquid. The teacher considered the students' misconceptions when organizing teaching activities and presented new substances in order to provoke the students' thinking. For example, she gave a glass of water, vinegar, sugar and sand to each group and let them touch the materials. The students put their fingers into each substance and observed the changes on their surfaces. Later they put a spoonful of water, sugar and sand on a flat table, and talked about their appearances. Afterwards, each group crumbled limestone into pieces (dust) and commented on the state of limestone dust. During this process, the teacher moved around the classroom to assist groups, and directed students' attention to the features of the states of matter. This created a good opportunity for the sharing, discussing and exchanging of students ideas, and seemed to be very effective in enhancing students' understanding of the states of matter.

Teacher also benefited from games in the EG. For example, after reminding that all matter is composed of small particles, the teacher instructed students, "When I call out a state of matter, you must move like the small particles at that state." Students stood up by their desks (solid). Students walked slowly around (liquid) and walked quickly or ran around the classroom (gas). Participating in such a demonstration game seemed to facilitate the students' understanding of the states of matter as student pairs then successfully completed worksheets. Students even continued to play this game in their free time.

In the CG, the topic of matter was presented in a traditional, teacher-centered style by the same teacher (the researcher). The teacher followed only the textbook, but did not bring any matter-related materials or examples to the classroom. Demonstrations and inquiry questions were rarely used during the teaching process. Exercises in the textbooks have been done as a whole class rather than in small groups. During the class, the focus of teaching was on the teacher's questions instead of the students' questions. Very little time was provided for student questions and the exchange of views among students.

Data analysis

Initially, the content analyses of data were made for the students' responses to the open-ended questions. The questions revealed different ranges of responses in terms of their accuracy. Analyses were conducted for each of the questions. Students' responses to the questions have been categorized mainly as scientific, partially scientific and non-scientific in the tables. The scientific category represents mostly correct answers, while the partially scientific category includes partially correct responses or some correct incidences of scientific information. The non-scientific category includes incorrect responses or those that are not accepted as correct from a scientific viewpoint. However, there were considerable differences in children's non-scientific responses in terms of the accuracy of their reasoning in relation to the scientific phenomenon in the question. Therefore, further classification of non-scientific responses was considered to be a necessity. Their non-scientific responses have been further classified as either misconceptions or nonsensical. The misconception category represented non-scientific beliefs, conceptual misunderstandings or preconceived notions, which do not match what is known to be scientifically correct. Nonsensical responses were those that are nonsense and unreasonable. For example, the statement "tomato is not matter because we eat it" was categorized as a nonsensical response, while the response "tomato is not matter, it is vegetable" was categorized as a misconception.

All categorization of responses were made based on the consensus of both researchers. After the number and percentage of each type of response was determined, a comparison of the responses between the CG and EG was made using a chi-square test to see if there were significant differences between them.

Findings

According to the pre-test results, there was no statistically significant difference between the CG and EG. However, the post-test results revealed that there was a statistically significant difference in favor of the EG compared to the CG in terms of the students' achievement ($p<.01$). Examples of the five questions used in the post-test about matter and its states and student responses to them are given below.

The question "What are the states of matter in nature?" aimed to reveal the children's knowledge concerning the states of matter. Matter is classified by its physical state as a solid, liquid or gas. As seen in Table II below, based on the post-test results, although all children in the EG knew the states of matter in nature, less than half of the children knew in the CG. This difference was statistically significant. However, there was one interesting finding in this question. Two children (11.8%) in the CG thought that matter can exist in four different states; solid, liquid, gas or evaporated. These children tended to consider vapor differently from the gas state of matter. They were not aware that vapor is the gaseous state of water.

Table II. Responses to the question "What are the states of matter in nature?"

The responses of the children	**Control Group** *(pre-test)* *f*	*%*	**Experimental Group** *(pre-test)* *f*	*%*	**Control Group** *(post-test)* *f*	*%*	**Experimental Group** *(post-test)* *f*	*%*
Scientific responses*	**1**	**5.9**	**2**	**12.5**	**8**	**47.1**	**16**	**100**
Matter exists as solid, liquid or gas in nature.	(1)	5.9	(2)	12.5	(8)	47.1	(16)	100
Partially scientific responses	**4**	**23.5**	**3**	**18.8**	**2**	**11.8**	**-**	**-**
Matter can exist as evaporated, solid, liquid or gas in nature.	(4)	23.5	(3)	18.8	(2)	11.8	-	-
Non-scientific responses	**11**	**64.7**	**10**	**62.5**	**7**	**41.1**	**-**	**-**
a) Misconception	**7**	**41.2**	**5**	**31.5**	**6**	**35.3**	**-**	**-**
Matter exists only as solid.	(2)	11.8	(4)	25.0	(2)	11.8	-	-
Matter exists only as liquid.	(5)	29.4	(1)	6.3	(4)	23.5	-	-
b) Nonsensical	**4**	**23.5**	**5**	**31.5**	**1**	**5.9**	**-**	**-**
Matter exists only as meals and drinks.	(4)	23.5	(5)	31.5	(1)	5.9	-	-
No answer	**1**	**5.9**	**1**	**6.3**	**-**	**-**	**-**	**-**
Total	**17**	**100**	**16**	**100**	**17**	**100**	**16**	**100**

*$X^2_{(1)}$= 11.64, P<.01 for post-test.

The possible reason for this view is that children often observe hot (boiling) meals, boiling water, etc. in the kitchen, and they simultaneously see rising steam into the air. These experiences may lead children to think that if air is the gaseous state of matter, this rising steam is an evaporated state of matter. Similarly, in the study conducted by Andersson (1992), students tended to regard steam as a different substance from water.

The following question, "What state of matter is a sponge?", explores children's ideas about the solid state of matter. A sponge is a solid state of matter. Solid is the state in which matter maintains a fixed volume and shape. Solids resemble liquids in having a definite volume, but differ from both liquids and gases in having a definite shape. A solid does not take the shape of the container, and it will not change regardless of what container it is placed in. A sponge is a solid, yet it changes its shape when it is pressed down. It has a lot of air trapped inside it (the holes) and it is the air that is compressed, causing the sponge to look smaller and change shape.

Table III. Responses to the question "What state of matter is a sponge? Explain your reason."

The responses of the children	**Control Group** *(pre-test)* *f*	*%*	**Experimental Group** *(pre-test)* *f*	*%*	**Control Group** *(post-test)* *f*	*%*	**Experimental Group** *(post-test)* *f*	*%*
Scientific responses*	**1**	**5.9**	**1**	**6.3**	**3**	**17.7**	**16**	**100**
It is solid because it has a certain shape.	(1)	5.9	-	-	(2)	11.8	(13)	81.3
It is solid because it does not flow like liquids.	-	-	(1)	6.3	(1)	5.9	(3)	18.8
Partially scientific responses	-	-	-	-	-	-	-	-
Non-scientific responses	**15**	**88.2**	**13**	**81.3**	**13**	**76.5**	-	-
a) Misconception	**15**	**88.2**	**13**	**81.3**	**13**	**76.5**	-	-
Sponge is a soft state of matter. We feel softness when we touch it.	(6)	35.3	(7)	43.8	(5)	29.4	-	-
Sponge is a liquid state of matter because it is soft, not like a solid.	(9)	52.9	(6)	37.5	(8)	47.1	-	-
b) Nonsensical	-	-	-	-	-	-	-	-
No answer	**1**	**5.9**	**2**	**12.5**	**1**	**5.9**	-	-
Total	**17**	**100**	**16**	**100**	**17**	**100**	**16**	**100**

*$X^2_{(1)}$= 22.88, P<.01 for post-test.

As shown in Table III, all children in the EG gave scientifically correct responses about the state of matter of a sponge. However, this decreased to 17.7 percent in the CG. A great majority of the children (76.5%) gave non-scientific responses. Of these, 29.4 percent viewed sponge as the soft state of matter. 47.1 percent said that sponge is the liquid state of matter and too soft to be solid. This finding shows that although children knew that matter exists as solid, liquid and gas, they have difficulty in applying this knowledge to the substances in their environment. They tended to classify the matter based on their feelings.

The question "What state of matter is a bag?" also revealed that the majority of children in the CG retain naive views about the state of plastic bags. They could not provide a scientific answer to this question. Children, in their daily life, often hear about petrol, plastic and bag concepts mainly through the mass media. On many occasions, it is stated that bags are made of petrol. Children might think that if petrol is a liquid, then bags should be liquid as well. In addition, 29.4 percent of children considered bags as the plastic state of the matter, based on their feelings when they touched plastic bags. Briefly, plastic bags, like the sponge, seem to form a major problem for matter classification.

Table IV. Responses to the question "What state of matter is a bag? Explain your reason."

The responses of the children	**Control Group *(pre-test)***		**Experimental Group *(pre-test)***		**Control Group *(post-test)***		**Experimental Group *(post-test)***	
	f	***%***	***f***	***%***	***f***	***%***	***f***	***%***
Scientific responses*	**-**	**-**	**-**	**-**	**4**	**23.5**	**15**	**93.8**
It is the state of solid. It does not flow and isn't wet like liquids.	-	-	-	-	(4)	23.5	(15)	93.8
Partially scientific responses	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Non-scientific responses	**17**	**100**	**15**	**93.8**	**12**	**70.6**	**1**	**6.3**
a) Misconception	**17**	**100**	**15**	**93.8**	**12**	**70.6**	**-**	**-**
It is the state of liquid, it contains petrol.	(7)	41.2	(5)	31.3	(6)	35.3	(1)	6.3
It is the state of plastic. We feel plastic when touching on it.	(8)	47.1	(10)	62.5	(5)	29.4	-	-
It is the state of gas it smells when burning.	(2)	11.8	-	-	(1)	5.9	-	-
b) Nonsensical	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
No answer	-	**-**	**1**	**6.3**	**1**	**5.9**	**-**	**-**
Total	**17**	**100**	**16**	**100**	**17**	**100**	**16**	**100**

$*X^2_{(1)} = 16.63$, $P<.01$ for post-test.

Solids usually have a definite shape and a definite volume. However, when a solid is broken into smaller pieces it is changed physically. For example if you crush a limestone or aspirin into a powder using wire brush or your fingers it is still a solid just in smaller pieces. Similarly, if you crush a stone into small pieces/sand it is still a solid just in smaller pieces. Nevertheless, many children (88.2%) in the CG had seriously naive views about the classification state of sand. For some, sand can pour from one cup to another just like water, hence it must be liquid. The other children tended to consider the state of sand based on its appearance. For them, sand is the dust, powder or grain state of matter.

Table V. Responses to the question "What state of matter is sand? Explain your reason."

The responses of the children	**Control Group *(pre-test)***		**Experimental Group *(pre-test)***		**Control Group *(post-test)***		**Experimental Group *(post-test)***	
	f	***%***	***f***	***%***	***f***	***%***	***f***	***%***
Scientific responses*	**-**	**-**	**1**	**6.3**	**2**	**11.8**	**16**	**100**
It is the state of solid. It has a certain shape.	-	-	-	-	-	-	(3)	18.8
It is solid. It is not wet when touched.	-	-	(1)	6.3	(2)	11.8	(13)	81.3
Partially scientific responses	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Non-scientific responses	**17**	**100**	**15**	**93.8**	**15**	**88.2**	**-**	**-**
a) Misconception	**17**	**100**	**15**	**93.8**	**15**	**88.2**		
It is liquid because it pours (pourable).	(5)	29.4	(7)	43.8	(4)	23.5	-	-
It is the state of dust (powder).	(6)	35.3	(4)	25.0	(5)	29.4	-	-
It is the state of grain.	(6)	35.3	(4)	25.0	(6)	35.3		
b) Nonsensical	-	**-**	**-**	**-**	-	**-**	**-**	**-**
No answer	-	**-**	**-**	**-**	-	**-**	**-**	**-**
Total	**17**	**100**	**16**	**100**	**17**	**100**	**16**	**100**

*$X^2_{(1)}$= 25.88, P<.01 for post-test.

Children are not aware that granular materials like sand, wheat and flour are powders. Powders can be poured from one vessel to another, and take the shape of the vessel. In this sense, they seem to behave like fluids. However, if you pour a powder on a flat surface, they form a conical pile. If powders were fluid, they would not have piled up (Dhar, 2009).

Table VI. Responses to the question "Do you think that a tomato is matter? Explain your reason."

The responses of the children	**Control Group** ***(pre-test)*** *f*	*%*	**Experimental Group** ***(pre-test)*** *f*	*%*	**Control Group** ***(post-test)*** *f*	*%*	**Experimental Group** ***(post-test)*** *f*	*%*
Scientific responses*	**-**	**-**	**-**	**-**	**1**	**5.8**	**14**	**87.5**
The tomato is matter because it has mass and volume.	-	-	-	-	(1)	5.8	-	-
The tomato is a solid matter. We can find its mass and volume.	-	-	-	-	-	-	(14)	87.5
Partially scientific responses	**2**	**11.8**	**4**	**25.0**	**3**	**17.7**	**2**	**12.5**
It is matter because it is liquid inside when we eat it.	-	-	-	-	(1)	5.9	-	-
It is matter, including liquid inside and solid outside.	(2)	11.8	(4)	25.0	(2)	11.8	(2)	12.5
Non-scientific responses	**15**	**88.2**	**12**	**75.0**	**13**	**76.5**	**-**	**-**
a) Misconception	**12**	**70.6**	**10**	**62.5**	**11**	**64.7**	**-**	**-**
It is not matter, it is a vegetable.	(6)	35.3	(7)	43.8	(6)	35.3	-	-
It is matter because we eat it.	(4)	23.5	(2)	12.5	(3)	17.7	-	-
It is matter it provides us with nutrition.	(2)	11.8	(1)	6.3	(2)	11.8	-	-
b) Nonsensical	**3**	**17.7**	**2**	**12.5**	**2**	**11.8**	**-**	**-**
It is not matter because we eat it.	(3)	17.7	(2)	12.5	(2)	11.8	-	-
No answer	-	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Total	**17**	**100**	**16**	**100**	**17**	**100**	**16**	**100**

*$X^2_{(1)}$= 22.14, P<.01 for post-test.

As seen from Table VI above, the question about whether a tomato is matter revealed a deep lack of understanding in relation to matter. Matter is anything that has mass and takes up space. However, only one child in the CG and 87.5 percent in the EG provided scientifically correct responses by mentioning the volume and mass of tomato. A great majority of children in the CG gave non-scientific responses. Of these, some thought that a tomato is matter because of the fact that we eat it or because it provides us with nutrition. On the contrary, two children stated that foods like tomatoes are not matter because they are eaten. Interestingly, some students (35.3%) in the CG stated that tomato is not matter because it is vegetable. This means that for some students vegetables are not matter. It is worth noting that children also need to know that a tomato is not a vegetable but a fruit.

Discussion and Conclusion

The research results showed that teaching activities designed with a constructivist approach had a significant effect on the student achievement in the EG, as shown by previous studies (Balci, Çakiroglu & Tekkaya, 2006; Ceylan & Geban, 2009). However, the CG was taught using traditional teaching methods and displayed a lack of knowledge and several misconceptions about matter including:

• Some children tended to consider vapor as a different state of matter or as a fourth state of matter (Andersson, 1992).

• Although children mention that matter has three states, some had difficulty in applying their knowledge to the substances in their environment e.g. sponge is not solid because it is soft. Sand is powder or a granular state of matter (Stavy & Stachel, 1985; Varelas et al., 2007). Bag is a plastic state of matter.

• In this study, distinct from the literature, we asked children "Do you think that a tomato is matter?" Interestingly, some children thought that a tomato is not matter but only a vegetable. The reason for this view may be that children, from their early years, often hear about the terms tomato and vegetables, and are very familiar with these terms. Therefore, it is easy for them to associate tomato with vegetable, but seems difficult to think accurately in regard to whether a tomato is a matter.

It is obvious from the results that children consider the states of matter not restricted to only three kinds. For some children, there are more than three kinds of stuff in nature: powder, food, plastic, sand, grain, dough, etc. The main reason is that children's sensory experience leads them to a naive view of matter including more than three states (Kind, 2004). For example, sand is the powder or granular state of matter. Children are not aware that if a solid is crumbled into small bits it will pour and fill a container it is poured into. Small solid particles can move like liquid particles, but unlike liquids they will pile up on any flat surface instead of being pulled by gravity to form a horizontal surface. Clearly some children understand the standard solid, liquid and gas concept, but then classify some materials as different from these three states of matter. In this context, children's own theory of matter works very well from their standpoint (Millar, 1989). Children obtain naive views about matter through their experiences during childhood. These naive views lead them to incorrect ideas (Brook et al., 1984).

Before attributing the poor understanding problem to the pupils, we must consider the possibility that the difficulties are sometimes unnecessarily created for the pupils by the "teaching" (Johnson, 1998, p.393). During the teaching of the unit on matter, teachers should give a particular importance to basic concepts related to matter, e.g. mass, volume, state, vapor, etc. Rather than giving classical examples for matter in the classroom, such as table, stone, pencil, water and air, they should stress examples from different contexts, as in the case of the tomato. Teachers also need to help children think that matter is everything around us, i.e. the books we read, shirts we wear, and chocolate we eat, are all made up of matter. We are made of matter. This study shows that giving different and thought-provoking examples in the classroom, such as a plastic (bag), sponge, paper, oil, sand, sugar and rice, can be very effective in developing children's understanding about matter and its states.

In conclusion, children's understanding of matter in the CG seemed to be based on memorization of some scientific knowledge, rather than comprehending matter and its states. Traditional ways of teaching, which are based on transmission of knowledge, does not effectively help children to use their knowledge in the similar examples given from everyday lives (Papadimitriou, 2004). In order to provide more effective science education, any teaching-learning strategy should take into account the ideas that the pupils already have prior to instruction (Driver & Oldham, 1986). Millar (1989, p.589) states that the process of eliciting and the construction of new ideas takes place internally within the learner's own mind, and hence "science should be taught in whatever way is most likely to engage the active involvement of learners." It is important to consider what children bring with them into the learning situation and the consequent active construction of meaning by them in the classroom. However, as Ayas, Özmen and Çalik, (2009) pointed out, the practice of the newly structured science curricula, which is based on constructivism and a student-centered approach, will take time to change the existing situation and to convince the teachers of its effectiveness.

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