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Impact of Hands-on Instructions on Students' Cognitive Achievement

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The present study compares traditional instructions and hands-on instructions on students' cognitive achievement for the topic 'Gas Pressure'. The participants in the study were students from a public middle school in Turkey. The research design was a quasi-experimental research design with a control group. In the control group, the teacher did the activities given in the course book whereas, in the experimental group, additional activities were performed by students. The results indicate that there was an increase in the correct response of students in both the groups after instructions, however, it was more in the experimental group. The wrong responses also showed a decrease in the experimental group as compared to the control group. Therefore, it can be concluded that hands-on instructions contribute more to students' cognitive achievement than traditional instructions.

KEYWORDS: Gas Pressure, Hands-On Instruction, Traditional Instruction, Activities

Introduction

Three domains of educational activities or learning are cognitive (thinking), affective (emotion / feeling) and, psychomotor (physical / kinaesthetic) (Bloom, et. al., 1956). Students' achievement about science has been the subject of research especially in relation to these domains. The cognitive achievement has an important place among them. Students' understanding of the concept “Pressure” in science has been widely studied. Research highlights that students have conceptual problems while learning the concept of pressure like other abstract concepts of science (Besson & Viennot, 2004; Engel Clough and Driver, 1985; Kariotoglou & Psillos, 1993; Psillos & Kaiotoglou, 1999; Sere, 1982; She, 2005; Taylor & Lucas, 2000; Tytler, 1992; Tytler, 1998a; Tytler, 1998b).

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Kariotoglou and Psillos (1993) stated that students (13-14 years) get confused with the features of pressure and pressing force. Engel, Clough and Driver (1985) found that pupils think that in liquid pressure depends on the total volume and they believe it is greater in the wider container. Some of them think that the pressure in liquids only acts downwards or it is stronger downwards than laterally. Kariotoglou and Psillos (1993) pointed out that students poorly defined the relation between the volume and shape of liquids. Students consider liquids to be compressible because of their capacity to change their shape. Therefore, they suggested that by conducting appropriate experiments in the classroom the students will be able to compare the compressibility of liquids and gases and differentiate the features of pressing force and pressure.

The concept of air pressure involves an understanding of invisible, abstract and process attributes (She, 2005). She (2005) examined the potential to promote students' understanding of this concept through an examination of the inter-relationships among the teachers' instructional approach, students' learning preference styles, and their levels of the learning process. The participants (grade 8 students) were randomly assigned to four treatment groups. First group (QA) learned air pressure through conventional methods, the second group (QB) by doing experiments, the third group (QC) by watching an interactive flash cartoon in which two characters discussed the concepts and the fourth group (QD) learned the concept by watching a video of an actual experiment in which a teacher demonstrated each experiment, beginning with questions to make the students think, and then provided explanations for why it occurred. One of the results indicated that the meaningful learner is one who has QB learning preference style and also performed best on both the post-test and retention test. The author states that visualizing real events helps make air pressure visible and concrete.

Most of the studies are done on the perception of students about the concept of “Pressure.” Researches comparing different instructional approaches on gas pressure are very limited. So this research compared traditional instruction and hands-on instruction on students' cognitive achievement about gas pressure topic.

RESEARCH METHODOLOGY

The research design was a quasi-experimental research design with the control group. Pre-test and post-test was used in the study.

SAMPLE

The participants consisted of 30 students from a public middle school in Turkey. Twelve of them were male and eighteen were female. The students were aged between 13 to 14 years. They were randomly assigned to control (14 students) and experimental groups (16 students). These groups were named the "Hands-on Instruction Group" and the other group, the "Traditional Instruction Group."

TOOL USED

The questionnaire included eight open-ended questions aimed at students' cognitive achievement about the topic 'Gas Pressure'. It was prepared by the researcher. One of the sample questions from the questionnaire is given below.

Why after flying to a certain height in the hot air balloon, Burak's nose starts bleeding?

ANALYSIS OF DATA

The data obtained from the questionnaire were analysed by document analysis. A rubric was used in evaluating the answers which included correct answer, partially correct answer, correct-wrong answer, wrong answer and no answer as categories given in Table 1.

Table 1

Criteria Used in the Evaluation of the Open-Ended Questions.

Categories	**Abbreviations**
Correct Answer: Responses containing all components of the scientifically accepted response	CA
Partially Correct Answer: Responses that included at least one of the components of validated response, but not all the components	PC
Correct-Wrong Answer: Responses that included both scientifically correct and incorrect information	CW
Wrong Answer: Responses containing scientifically incorrect information	WA
No Answer: Blank	NA

Reliability and Validity

To determine the content validity of the questionnaire, it was evaluated by a physics instructor from the university, a science teacher and a postgraduate student. A consensus was reached on the questions among them. An answer key was created together to ensure data reliability. The coding of the questionnaire was done by one more researcher to ensure the validity. Agreement percentage was calculated with agreement percentage formula (P=(Consensus (Na) / Consensus (Na) + Dissidence (Nd)) X 100) given by Miles and Huberman. The Agreement Percentage (P) of the questionnaire was 98.

Procedure

One week before the formal teaching, students in the control (traditional instructions) and experimental (hands on instructions) groups were given the pre-test. The procedure was explained by the researcher to the science teacher before the application. After examining students' answers and finding out the students' cognitive achievement of gas pressure, the lesson was designed to enhance students' cognition. In the teaching process, the existing science program was bound for both groups. The lessons were carried out with their routine content and time schedule in their natural classroom setting. In the control group, the teacher did the activity (fill a glass with water, and then turn it upside down without spilling the water) in the course book. In the experimental group, additional activities (Table 2) were used differently from the control group. Students performed the activities for this group. All the hands-on activities were low-cost. When students practiced in the activities, a discussion on the following questions was conducted: What is happening here? Why did the tin collapse in? How does the water rise in the glass? Why did the water not fall through the pipette? At the end of the last lesson, both groups were given the post-test.

Table 2
Additional Activities for Experimental Group.

Activities
• Closing the nozzle of the injector with a finger. Pushing and releasing the piston of the injector
• Balloon inflation with injector
• Burning sparkling cotton in a tin
• Water rising in the glass
• Water not falling through the pipette

RESULTS OF THE STUDY

The analysis of the data was done on question-by-question bases. Frequencies and percentages were calculated categories wise. The change in pre-test post-test percentage changes and means are given in Table 3 along with the difference in percentages in the post- and pre-test. The increases is represented as (+), decreases as (-) and no change as (0).

Table 3

Pre-Test Post-Test Percentage Changes in Student Answers by Categories.

	Traditional Instruction Group(N=14)					Handson Instruction Group (N=16)				
Number of Items	CA (%)	PC (%)	CW (%)	WA (%)	NA (%)	CA (%)	PC (%)	CW (%)	WA (%)	NA (%)
1	+21.4	+28.6	+7.1	-57.1	0	+75	+6.3	0	-81.3	0
2	0	-7.1	+7.1	0	0	+68.8	-56.2	+12.5	-25	0
3	0	+28.6	0	-35.7	+7.1	0	+56.3	0	-56.2	0
4	+7.1	+7.1	+7.1	-21.4	0	+56.3	46.3	+18.8	-81.2	0
5	+14.3	+14.3	0	-21.5	-7.1	+12.5	-12.5	+12.5	-12.5	0
6	+14.3	+7,2	+21.4	-42.9	0	+37.5	+25	0	-62.5	0
7	+14.3	-14.2	0	0	0	+50	-37.5	-12.5	0	0
8	+14.3	0	0	-14.3	0	+50	+18.8	+12.5	-81.2	0
Mean	+10.7	+8.1	+5.3	-24.1	0	+43.8	+5.8	+5.5	-50	0

Before the instructions, the traditional instruction group (TIG) had no answers in the correct answer category and most of their answers were in the wrong answer category. In the hands-on instruction group (HIG), only one student had the correct answer for first and seventh questions before instructions. Similar to TIG, most of their answers were in the wrong answer category. After the instruction, there was an increase in correct answers and a decrease in wrong answers in both the groups. When the mean scores were reviewed, the results showed that the percentage of correct answers changed. The students in the HIG were higher than those of the students in the TIG i.e. the students in HIG group gave more correct answers in the post-test. Likewise, the percentage of wrong answers showed the decrease in the HIG after instructions. When the items were examined separately, these results were valid except item five.

In addition to the data given above, a few misunderstandings emerged from the responses of both groups of students which are shown below. Before and after instructions, misunderstandings of hands-on instruction group were coded respectively as BHIG and AHIG. For the traditional instruction group, these were codes as BTIG and ATIG.

- As the inflated balloon rises, the volume shrinks. Because the outside pressure is higher (BHIG)
- Air pressure increases as we go higher (BHIG, BTIG, ATIG)
- The pressure is higher because the atmosphere is more above (BHIG)
- The volume does not change while the inflated balloon rises (BHIG, BTIG,

ATIG)

- We do not feel the atmospheric pressure acting on us due to gravity. (BHIG, BTIG, ATIG)
- Since the atmosphere is in the sky, we do not feel the atmospheric pressure acting on us (BTIG)

Discussion And Conclusions

The study compared traditional instructions and hands-on instructions on students' cognitive achievement about gas pressure. The pre-test results showed that both groups mostly had wrong answers before the instructions. According to the post-test results, there was an increase in correct answers and a decrease in wrong answers for both groups. However, this difference was higher in the experimental group. It means hands-on instructions contributed more on students' cognitive achievement about gas pressure than traditional instructions. The positive impact of hands-on instructions on students' cognitive achievement is supported by some previous studies (e.g., Ates & Eryilmaz, 2011; Dieser & Bogner, 2016; Hussain & Akhtar, 2013; Prokop & Fancovicová, 2017; Stohr-Hunt, 1996; Turpin, 2000).

The responses given in both the pre-test and the post-test showed that both groups had misunderstandings about gas pressure topic. One of the misunderstandings was 'air pressure increases as we go higher' for both groups. This result is similar to the study done by Sahin & Çepni (2012). The present study shows that most of the misunderstandings of traditional instruction group continued after the instructions. However, the experimental group did not have these misunderstandings after hands-on instructions. As the sample of the study is small, its results cannot be generalized, however; the study indicates significant conclusions in itself. She (2005) stated air pressure is invisible and abstract for students, so students may have difficulty to learn such science concepts. Thus, activities that enable visualizing the events in the classroom as in the present study may help in facilitating the student learning.

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