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Turkish pre-service teacher's perspectives of demonstrations and hands-on activities in science classrooms

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Abstract

This study aims to investigate pre-service science teachers' ideas of hands-on experiments and demonstrations in science classes and to compare them according to science disciplines (physics, chemistry, and biology) in order to obtain which of them are more preferred and are considered easy to generate science activities. Data was collected at Erciyes University in Turkey during spring term of 2010. A total of 27 (out of 119) students in science education program were asked to participated in this study. Results of the investigations revealed that pre-service science teachers lack to produce biology demonstrations and are able to create more hands on activities in chemistry than in physics or biology. The reason for such findings, according to the participants, lies in what they have gathered during high school education that shows that we are unable to offer them adequate knowledge of physics of biology demonstrations.

Keywords: Hands-on science, science teaching, laboratory activities, physics education.

Resumen

Este estudio tiene como objetivo investigar las ideas de profesores de ciencias en formación sobre experimentos prácticos y demostraciones en las clases de ciencia y compararlos de acuerdo a las disciplinas de ciencia (física, química y biología) a fin de obtener los que son más preferidos y que son considerados fáciles para generar actividades científicas. Los datos fueron recogidos en la Universidad Erciyes en Turquía durante la primavera de 2010. Se interrogó a un total de 27 (de 119) estudiantes en el programa de ciencias de la educación que participaron en este estudio. Los resultados de las investigaciones revelaron que a los maestros de ciencias en formación les falta producir demostraciones de biología y que son capaces de crear más actividades experimentales de química que física o de biología. La razón para explicar este hallazgo, según los participantes, se encuentra en lo que se han comprometido durante la educación secundaria y que muestra que estamos en condiciones de ofrecerles un conocimiento adecuado de demostraciones de la física de la biología.

Palabras clave: Experimentos de ciencia, enseñanza de las ciencias, actividades de laboratorio, enseñanza de la física.

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I. INTRODUCTION

The purposes of this study are two fold: firstly, to investigate which major science discipline (physics, chemistry, and biology) pre-service science teachers favor and secondly, what the reasons are behind their preferences. There have been many attempts done by education researchers to describe hands-on activities is and where it stands in the curriculum since 1980s. For example, a very common accepted definition of hands-on is that any science laboratory activities in which students can handle, manipulate or observe a scientific process [1]. Hoffstein *et al*. [2] defined hands-on science as "contrived learning experiences in which students interact with materials to observe phenomena" (pp. 201-202). Another very popular definition of hands-on science is that it refers to a general approach to instruction and can be though of as philosophy guiding when and how to use the broad range of teaching strategies need to address diversity in contemporary classrooms.

A. Hands-On and Demonstrations in Science Learning

Developments of scientific skills require experiments, and hands-on activities [3]. In order to accomplish this condition, educators must consider involving students in laboratory activities and classrooms demonstrations to enhance their knowledge on various science concepts. Students must work like a scientist to conduct measurements and to achieve results by themselves as they discover them for the first time in their life. Actually, they do so. According to Jean Piaget, the more students are involved in science learning process, the better they learn subjects and the longer they retain them.

For his whole life, Piaget strongly supported the idea that science education researchers and science teachers should encourage students using materials and involved in research-based activities in learning process. Later, Jerome Bruner further studied science learning process and made major contributions with his idea of discovery learning and concept learning process. According to his theory of learning, learning can only be achieved by discovery because its foundations are mainly composed of critical thinking, trials, and discovering.

Based on learning theories of Piaget and Bruner, several science learning activities have been developed for decades. Investigations on hands-on activities in science classrooms have been started early 1980s that is fairly new compared to theoretical establishments of science learning. Hands-on activities can be divided into two categories: (a) Demonstrations in classroom and (b) Experiments in laboratory. Hands-on science can be applied to main science disciplines, physics, biology, chemistry, as well as to other applied disciplines such as environmental science [4], instructional technology [5], and effects of three methods of instructions in combination with computer-assisted instruction (CAI) [6]. Another branch of investigations is interdisciplinary relationships such as science and art connection to enhance students understanding and to generate various hands-on activities for that purpose [7].

Other studies were conducted to elaborate more about the relationships between hands-on science activities and most popular instructional approaches such as Inquiry [8, 9], Pupils' reasoning and practice [10], teacher demonstration laboratory methods, cooperative learning approach [11], and discussion, text reading and writing [12, 13]. No matter what the other discipline or teaching approaches hands-on science is combined, the researchers came up with similar findings that revealed if hands-on activities are ideally employed it will boost students knowledge of related sub disciplinary topics. In general, there hasn't been a similar study conducted to collect and discuss the preferences of the students concerning science activities in classrooms. However, most of the above mentioned studies discussed how these activities affect students' knowledge of science concepts [8, 9, 10, 11, 12]. None of them explored why the students prefer different subjects and hands-on activities.

II. PARTICIPANTS

For the present study, data was collected from participants who were selected among junior level pre-service science teachers enrolled in elementary education program at a public Turkish University (Erciyes University (ERU)) during 2009-2010 academic semesters. They were between 20-22 years old. Selection of the participants was completed randomly. Initially, 27 students (19 females and 8 males) agreed to reflect their opinions about hands-on activities and explain which activities they have more tendencies to conduct. Next, we have selected 3 of them to investigate further the reasons for why they prefer such hands-on activities. In order to be more balanced, we deliberately selected activities for each sub disciplines (physics, chemistry, and biology). The high school students who select teaching career must pass a general university entrance exam to study elementary science teacher education curriculum in college. In order to graduate, they must successfully complete 153 credit hours courses at a public university in Turkey. Every public university has same criteria for science education programs. The weight of method courses constitutes 70 credit hours and 10 for students teaching and remaining 73 credits were related to content courses (mathematics, physics, chemistry, biology, earth science, environmental science, genetics and biotechnology, astronomy, and computers in education). Once they finish the courses, they have to pass a two section tests which consists of analytical and educational sciences sections. We have added overview of the activities mostly preferred be them in the following sections.

III. METHOD

All of the participated students were primarily selected by using volunteering system. At the second part of the study, three students were chosen randomly from there particular disciplines to generate more balanced results. A total of 114 third year students in elementary science teacher program was the pool of the study. They were asked to participate and 27 of them (24%) volunteered to express their perspectives regarding hands-on activities in science learning and explain what kinds of demonstrations they generally prefer. In other words, data about their preferences of hands-on science and plans of conducting them in their teachings were collected. Initial step was to ask them to fill out a questionnaire to gather information about their academic backgrounds, their preferences of hands-on science activities, and explain them in details with providing information about how to conduct them in the classroom.

In the second step, following the collections of general data regarding hands-on science, we have decided to select some of the participants to collect more data about the reasons why they chose and reported their particular activities. In order to achieve that goal, three students were randomly selected and were interviewed during the spring term. Specifically, they were asked to discuss more about what they think of hands-on science, why they think it is important, why they selected specific science activity to demonstrate is as hands-on demonstration in the classroom. Each student interviewed preferred hands-on activity in different disciplines of science and this was intentional because we were seeking why they chose different discipline hands-on.

IV. RESULTS

Having completed collecting data, table I was constructed to indicate students' hands-on science preferences according to science sub disciplines. As shown in the table, results reveal that chemistry activities are most preferred and biology activities are least. A feasible explanation for this outcome is number of hours of offered biology courses. Although a total of five physics and chemistry core courses are offered in teacher preparation program, only three biology courses are offered. Accordingly, students learn more chemistry and physics lab activities than biology. This dilemma might be resolved by offering same number of science discipline courses with revising the curriculum. Otherwise, many students lack generating and learning hands-on science activities in biology and this will lower the quality of biology education.

Brief explanations and steps of each hands-on activity were explained on the following for the science teachers. We didn't comment any of the explanations. We only translated them into English.

TABLE I. Pre-service Teachers' Hands-on activity preferences.

Physics	Chemistry	Biology
1.Heat transfer 2.Atmospheric pressure (4) 3.Evaporation 4.Light Spectrum 5. Electrification 6. Burglar alarm	1. Obtaining pure water 2.Resolution 3.Density(2) 4.Acids and bases 5.Combustion reactions (2) 6.Expansion (4) 7.Thermometer construction(2) 8. Effects of pressure on boiling temperature 9. Cooling the coke	1. Hazardous Smoking 2. Eye health 3. Digestion

*Number of students who choose this activity is shown in parenthesis.

Atmospheric pressure-1
Place some paper pieces inside a 2-liter bottle. And try to put an egg into it but you cannot do that. Then, burn the paper and try again. It will be able to go through the neck of the bottle into it because burning the paper decrease the amount of oxygen in the bottle so it behaves as suction and it sucks in it. Another nice activity to demonstrate atmospheric pressure can be done by filling up a cup with hot water and covering with a piece of paper. Then, flip it and you will see no water dripping because internal pressure inside the cup is equal to the outside atmospheric pressure.

Evaporation
First, fill up a tube and place it's a cap on it. Then, you start heating it up on a burner. When you heat it up, you will see it will shoot the cap because of vapor pressure. This shows that steam pressure can be observed with a simple set of materials.

Light Spectrum
When placing a regular triangle prism above a piece of paper under the sun, there will emerge colors of a rainbow on the paper according to their frequencies. This activity can be combined with spectroscopy activity in an optic experiment.
Electrification
Place an empty can of coke on top of a table. Rub a glass rod to your hair and store some static electricity on it. Then, when you bring near the can, it will turn around. This is because of static electricity and can is electrified.

Burglar alarm
Build a model home with movable doors. Then, connect some wires and speakers to build a circuit. When it is opened, aluminum foils contact each other and close the circuit so alarm rings.

B. Biology Hands-On Activities

Hazardous Smoking
Light up a cigarette and cover it with clean piece of cotton. Take a small bottle and put a hole on the bottom. Then, place it in the bottle and wait until you see water from the hole. You will see cigarette is burning slowly. After a while when the water is gone you will see clear cotton is turned into yellowish dirty color.

Eye health
Take a small piece of glass. Rub some sands on it for a while and you will see it scratched. When you try to get anything out of your eye with opening and closing it, you eye will be damaged in the same way.

Digestion
Put some biscuits in a plastic bag and smash it into small pieces. This will demonstrate physical digestion. In addition, if you want to show chemical digestion then you should add some chemical mixtures such as acids.

C. Chemistry Hands-On Activities

Obtaining pure water
Pour some boiling water into a big cup and put one table spoon food dye and mix them together. Then, place a small cup at its centre and cover it with a plastic foil. Put a nickel or a dime on the foil and a few hours later you will observe some water in the big cup is transferred to the small cup.

Dissolving
Pour same amount of cold and hot water into two separate cups. Add same of sugar into both cups. You will observe sugar will dissolve in hot water faster.

Density of irregular shaped objects
Pour 50 mL water into a graduated cylinder. Measure mass of a piece of rock and put it in the graduated cylinder. You will see water rises. Measure differences between before and after and calculate density of the rock by using density, mass and volume formula.

Acids and bases
Pour some apple vinegar into a bottle. Add some carbonate to it. Then place a balloon on the bottle. You will see it

blows as you wait. This is because of the gas released during acid-base reaction.

Burning reactions
Light a candle with a match and place it on a plate. When you place a glass on it, you will observe the burning candle dies out. This is because we need oxygen for burning reaction.

Expansion
Place a balloon on top of an empty bottle. When heated up, you will see it blows dues to expanded air inside the bottle.

Thermometer construction
Pour water into a glass bottle to the top and place a cap on it with a hole on it. Put a pipette into hole and attach a graded cartoon to it. Then, cover cap and pipette with some play dough. Heat up the bottle with Bunsen burner. You have built a thermometer!

Effect of pressure on boiling temperature
Pour some water into a balloon and start heating it up on a Bunsen burner. Heat it until it boils and turn off the burner. Then, wait until boiling stops. When you place it under cold sink water, you will observe it starts boiling again!

Cooling the coke
Pour some water in a wide cup. Add plenty of salt and place a can of coke in it. Mix them altogether and make salt to dissolve. Due to endothermic reaction (dissolving of salt) it will take heat from the coke and coke cools down.

V. CONLUSION

Based on participated students preferences, results revealed that they tend to prepare chemistry activities (15 students) most. Second most preferred discipline is physics with 9 students produced activities. Only three students came up with hands-on activities in Biology. This consequence was not surprising because generating hands-on activities in Biology is not an easy task. Since all of the participants were one year away from becoming a science teacher and completed most of science education methods courses by the time of the study, it is not expected to learn and add more activities to their instructional library. Possible reasons for why students choose less biology hands-on activities should be investigated more. Also, which disciplines are required to teach with more hands-on activities is another research topic, which can be elaborated more in further studies [1].

When students are asked why they preferred more chemistry hands-on activities, one student responded:

> "I think chemistry is easier to generate any hands-on activity than other science disciplines and easy to understand by both students and teachers themselves because its logic is straight forward but physics requires more theoretical background and higher order thinking in addition".

Above mentioned reasons possibly stem from a traditional myth of reality because of test results of students in science disciplines. Physics is usually lowest scores achieved by the students and they often express their opinions as physics requires higher order thinking than chemistry of biology. This common understanding of physics is number one reason why students do not like physics as much as others. Since they assume it is difficult and most of the times they get lazy, their score on the achievement tests on physics lies in the low percentiles. They tend to get lazy because they usually believe that no matter how hard they study, they are not able to succeed in a physics course. We, as science and physics educators, strongly believe that this misunderstanding idea of physics should be demolished and true understanding must be established. One way of the solution of this problem might be conducting better designed physics hands-on activities rather than traditional ones (such as Cartesian divers etc.) to motivate students more and change their ideas towards physics.

Another potential reason why students think that perhaps lie in the curriculum in science disciplines. In a regular program of elementary science teacher, students are required to take main branches of science courses in the first two years. In the first year, they take two general physics courses, two general chemistry courses, and in the second year two more intermediate levels of physics and chemistry courses and two biology courses. Junior and senior year students have to take one additional advanced course for each discipline. Generally, five physics and chemistry course courses and only three biology courses are offered to pre-service science teacher prior to graduation. Therefore, curriculum designers have to modify number of hours dedicated to each sub discipline.

In conclusion, our main purpose of this study was to gather various hands-on activities common in science education and next step is to generate new and original activities for science educators to utilize them in their classrooms. Related further studies aims to investigate how we can organize and design these activities among science curricula. Finally, a general science activities book will be generated for science educators to utilize in their teachings.

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