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IDENTIFICATION OF TEACHER CANDIDATES' SKILLS IN DESIGNING EXPERIMENTS WITH VARIOUS ASSESSMENT TOOLS

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Abstract

The study aims to investigate the classroom teacher candidates' skills in designing experiments using two assessment tools and the effects of these tools on the experimental design skills. This study is a survey realized on one group. The sample of the study consists of 206 2nd -year students from Abant Izzet Baysal University, In the study, Scientific Operation Skill Test (Test-1) with multi-selective questions and scenario dependent Test of Scientific Processing Skills For Teachers (Test-2) with an open ended structure are used.

The findings of the study showed that teacher candidates answered multiple choice questions covering experimental design more comfortably by not leaving any questions unanswered. However, open-ended questions proved to be an area with significant number of blank answers.

The finding that both tests provide different success rates shows that the selected assessment tool is an important factor in successfully identifying variables and evaluating skills related to validation.

The results of the study show that the teacher candidates have not performed in either test related to experimental design in the expected manner. Suggestions in the light of the findings of the study are provided at the end of the study.

Keywords: Designing experiments, Assessment tools, Teacher candidates.

INTRODUCTION

One of the fundamental aims of modern science teaching is to educate individuals who can do research, explore, investigate, make connections between daily life and science topics, use scientific methods in solving problems in life and look at the world through the eyes of a scientist (Tan & Temiz, 2003). Considering this aim, we can say that it is not possible for individuals to keep up with this process by trying to store existent and ready knowledge in their minds or by trying to take information from its source passively. Instead, individuals should try to prefer methods to acquire and attain knowledge and should have the skills that this process entails. In this context, science education is of vital importance today (Taşdere & Ercan, 2009).

In today's educational programs it is emphasized that classes in the field of science teaching should be taught in accord with the nature of science, based on research and directed at facilitating problem solving skills. In this context, it is essential for students to acquire information by utilizing some skills. These skills and techniques that students need are called "scientific process skills".

Scientific process skills are adapted in the teaching fields (matter and change, living things and life, physical events, earth and universe) that make up of the knowledge content and they are included in the science and technology teaching program that was renewed and put into practice in 2004. According to Aydoğdu & Ergin (2008), scientific process skills and content knowledge are supplementary and it is impossible to think of a solution to a problem without the content knowledge or scientific process skills. According to Bağcı Kılıç (2003) the students should be taught scientific topics with the help of scientific research method and the activities that can be implemented should be geared towards developing scientific process skills such as making detailed observations, measuring and computing, recording the operations and the data, interpreting the data and inferences based on data.

Scientific processing skills are classified in two groups in general: basic processes and combined processes (Brotheton & Preece, 1995). list these skills as below:

Basic processes: Observation, evaluation, classification, prediction, using numbers, using space-time relationships, induction, recording of data.

Combined processes: Interpretation of the data, identification and control of variables, operational descriptions, hypothesis building and experimenting.

Designing Experiments and Assessment Tools

There are various studies about scientific process skills in the literature (German, Aram & Burke, 1996; Bağcı Kılıç, 2003; Aydoğdu & Ergin, 2008; Dönmez & Azizoğlu, 2010; Şahin-Pekmez, Aktamış & Can, 2010). These studies take scientific process skills as a whole and try to assess them by using one survey or assessment tool. However, there are studies in more recent years that assess each skill in the scientific process skills separately and in detail (Ateş, 2005; Hamman et. al, 2008; Temiz & Tan, 2009; Taşdere & Ercan, 2009).

Ateş (2005) set out to investigate the prior knowledge levels of classroom teacher candidates about concepts used in skills of identifying and controlling variables and develop them. The results of the study showed that the majority of the teacher could not identify concepts such as "variable", "dependent variable", "independent variable" and "control variable". It was also identified that control variable was perceived as dependent variable by some teacher candidates whereas some teachers perceived the control variable as independent variable and they confused the concepts with each other.

Temiz & Tan (2009) aimed at identifying the skills of freshmen high school students related to identifying the variables and forming hypotheses. According to the results, misconceptions were detected in the students regarding identification of variables and hypothesis forming such as confusing the dependent and independent variables with each other, identifying the dependent

and independent variables as control variables, controlling only one variable and selecting a hypothesis in the experiment that is not tested.

Some of the scientific process skills require a higher level of knowledge and skills use. One of these higher level skills is the skill of designing experiments and it may even be the skill that consists of all the other skills in its core. According to Tan & Temiz (2003), the skill of designing experiments is composed of building an appropriate mechanism by using various tools successfully; obtaining data by changing and controlling the variables, recording and assessing these data create models, interpreting the data, obtaining results and reporting the operations.

A constructive approach to learning is adopted in the new science and technology teaching program. According to this approach, students are expected to attain knowledge by themselves and construct it in their minds. The skill of designing experiments consists of many sub-skills students should have and can implement while obtaining and producing information (collecting data, forming hypothesis, identifying and controlling variables, interpreting data, forming models). In this context, the skill of designing experiments is believed to be an important and required skill to be used by students in constructive learning environments.

The scarcity of studies in the literature related to the skill of designing experiments is noteworthy (Germann, Aram & Burke, 1996; Hammann et. al., 2008). If we consider the fact that the skill of designing experiments is suitable for science classes we can say that detailed studies about this skill are also important. Also, since the skill of designing experiments involves many sub skills, we believe that studies that examine different aspects of this skills is rather crucial.

Germann & Aram (1996) aimed to identify the sub skills of designing experiments of 7th graders such as recording data, analyzing data, designing the results, providing evidence by the help of the rubric they developed. According to the results, 61% of the students were successful in recording data, 69% of students could not form a hypothesis in designing the results and 81% could not present specific evidence to the findings they reached.

Hammann et. al. (2008) identified biology students' skills in designing experiments by using three different test formats. According to the results of the research, it was determined that open-ended test format and performance-based tests were more successful in presenting student success in more detail. Although these test formats take more time to implement and more difficult to code, they are found to be more appropriate to obtain related information.

The study aims to investigate the classroom teacher candidates' skills in designing experiments using two assessment tools and the effects of these tools on the experimental design skills.

METHOD

This study is a survey which was realized on one group. The sample of the study consisted of 206 2nd-year students from Abant Izzet Baysal University, Education Faculty, Classroom Teaching Department during 2010-2011 educational year Fall Semester.

Data Collection Tool

In the study, Scientific Operation Skill Test (Test-1) developed by Okey, Wise and Burns with multi-selective questions and Test of Scientific Processing Skills For Teachers (Test-2) with an open ended structure depending on a scenario that was developed by Ergin et. al (2005) were used in order to evaluate the skills of classroom teacher candidates related to design experiment. The study investigates two multiple choice questions on experimental design and two open-ended questions regarding the scenario of Test-2. Findings were obtained by examining four questions two of which are multiple choice and two of which are based on the scenario. Although the tests assess various skills related to scientific process skills, this study only investigates the results of analysis pertaining to experimental design.

Test-1 has a multi-selective structure and consists of 4 questions each for 3 different situations. The original published consistency co-efficient is Cronbach alfa, 0,86. The reliability co-efficient for the test translated into Turkish using a sample of classroom teacher candidates was found to be 74% (Ates & Bahar, 2002). Test-2 provides the students scenarios. According to scenario students wrote their alternative experimental design. As a result of a pilot application undertaken in a different study (Aydoğdu, 2006) one item with an item-specificity index of lower than 0.30 was deleted for Test-2 and the reliability co-efficient was calculated as (KR–20) 0.70.

The analysis of the data

The analysis of the data obtained from the study required the reading of answers given to the multiple choice and open-endend questions. The skill of designing experiments by the candidate students was examined. Later, individual analysis for each student was undertaken by investigating which questions were answered correctly and incorrectly. In order to increase the validity of the study, all the answeres were scored and examined by 2 researchers. The data obtained by the study was transfeered to tables and presented in the Findings Section.

FINDINGS

The analysis of data form 206 students produced striking results. Table I represents a visual presentation of the findings. Table I presents the skill of designing experiments for the participants in a comparative manner for Test-1 (multiple choice) and Test -2 (open-ended). There are two questions each for both assessment tools in the table.

When the findings were examined in general it was seen that about half of the participants did not experience problems in both test types prepared to assess the skill of designing experiments and they could be successful in each type.

Table I: Level of answering questions for teacher candidates in Test-1 and Test-2

	2 Correct	1 Correct, 1 Incorrect	1 Correct, 1 Blank	1 Incorrect, 1 Blank	2 Blank	2 Incorrect
Test-1	104	81	----	----	----	21
Test-2	98	52	7	7	11	31

Findings related to Test-1: 104 of the participants (about half) were successful in both questions of Test-1. 81 teacher candidates (40%) answered one question correct and the other incorrect. 21 teacher candidates (10%) could not answer either of the test questions. The participants did not leave any of the questions in the multiple choice format blank.

When we think that multiple choice tests have an element of chance and that Test-1 was implemented at the end of the lab class that lasted for a full year, we can say that in general teacher candidates were not found to be at the desired level in terms of the skill of designing experiments.

Findings related to Test-2: 98 of the participants (47%) successfully answered to both open-ended questions in Test-2 that related to designing experiments. 52 teacher candidates (25%) answered one question correct and the other incorrect and displayed partial success. 7 participants (3%) answered one of the questions incorrectly and left the others blank. Still, 7 participants (3%) answered one of the questions incorrectly and left the others blank. 11 teacher candidates (5%) did not answer either of the questions and could not display any performance in Test-2 related to experiment designing skill. 31 participant (15%) answered both of the questions incorrectly and was not successful in Test-2. Actually, there is not much difference between the group of 11 participants who left both questions unanswered or the group of 31 participants who answered both questions incorrectly. In summary, these 42 teacher candidates are a group that could not display success in the realm of the skill of designing experiments. The data was categorized in order to give more detailed information.

When the data of Test-1 and Test-2 are compared, it is seen that the number of individuals who received full marks from Test -1 is a bit higher than those individuals who received full marks from Test -2.

In this sense, it is difficult to talk about a significant difference. However, instances where there are significant differences between Test-1 and Test-2 appear in the Table. For example, Test-2 displays all combinations that can occur in answering the two questions (2 correct, 1 correct and 1 incorrect, 1 incorrect and 1 blank etc), Test-1 only shows three conditions (2 correct, 1 correct and 1 incorrect, 2 incorrect).

Data in the Table show that the total number of answers that were left blank or answered incorrectly were 42 and 21 for the open-ended questions and for multiple choice questions, respectively. This finding is parallel to the findings of Hammann et. al. (2008) stating that open-ended questions probe for more detailed information compared to multiple choice questions.

Since designing experiments is one of the higher level scientific process skills that consists of identifying and controlling variables, it is expected that a teacher candidate who has problems in identifying and controlling variables will also have problems in designing experiments. Taşdere & Ercan (2009) expressed similar problems in their study with the same sample groups in problems in identifying and controlling variables.

DISCUSSION

The results of the study show that the teacher candidates have not performed in either test related to experimental design in a manner that was expected.

It is thought that many factors can be involved in this failure. Since designing experiments is a complex skill that combines more than one scientific process skills and requires multiple thinking, critical thinking or creativity, it is sometimes a difficult skill to master.

On the other hand, the inadequacy and lack of quality of lab training or science classes (primary or secondary schools) that are taught pre-lab training can also be a factor that plays a role in this failure. The majority of the teacher candidates that participated in the study stated that spent their educational life under the influence of traditional teaching methods and they became distanced from doing experiments in the science classes. When we consider this fact, we can explain why teacher candidates are not at the required level in both designing experiments skill and scientific process skills.

There are studies in the literature that support the findings of the present study and show that both scientific process skills and its sub-skill; designing experiments, are not at the required level for teacher candidates (Budak, 2008; Laçin Şimşek, 2010).

Budak (2008) stated that no meaningful differences occurred in the posttest values in the designing experiment skills in his study implemented with pretest-posttest design. Lacin Şimşek (2010) expressed in his study that teacher candidates did not totally comprehend scientific process skills and were inadequate in learning, teaching and evaluating these skills.

Study shows that different tools may display different results while evaluating the same skill. Hence, in order to have healthy assessment and evaluation procedures, more than one assessment tool should be used or assessment tools that are in line with the skills that need to be evaluated should be utilized.

SUGGESTIONS

Both lab and science classes allow the development of scientific process skills. Facilitating the acquisition and development of these skills will be possible with increasing the quality and quantity of lab activities and science classes. In this context, rich learning environments should be developed in primary and secondary school as well as at the university levels that will allow the development of the scientific process skills. Since better knowledge of teacher candidates in scientific process skills will affect the successful implementation of the teaching program, the best suggestion in this study is to increase lab classes that are geared towards educating teachers

appropriately for this purpose in universities Since the skill of designing experiments consists many psycho-motor skills we can suggest using performance-based assessment tools while assessing this skill. So that the results obtained through performance based evaluation and the results obtained from other test formats can be compared in order to develop the most suitable assessment tool in the evaluation of designing experiments skill.

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ANNEX-1

Test-1. Ahmet is curious about the factors that affect the duration of melting in ice particles. He thinks that the size of ice particles, the temperature of the room and the shape of the particles can affect the duration of the melting. Later he decides to test this hypothesis: the shape of the ice particles affect the duration of melting. Which of these experiment designs should Ahmet implement in order to test his hypothesis?

a. 5 ice particles with differing shapes and weights are obtained. They are placed in 5 similar bowls in the same temperature and duration of melting is observed for each.

b. 5 ice particles with the same shape but different weights are obtained. They are placed in 5 similar bowls in the same temperature and duration of melting is observed for each

c. 5 ice particles with the same weights but different shapes are obtained. They are placed in 5 similar bowls in the same temperature and duration of melting is observed for each

d. 5 ice particles with the same weights but different shapes are obtained. They are placed in 5 similar bowls in different temperatures and duration of melting is observed for each

Test-2: Engin and Hasan are curious whether the heat conduction for two different metals were the same. So they started to simultaneously heat cross sections of copper and aluminum wires with different lengths by dropping wax at the tips. Do you think such an experiment by Engin and Hasan will satisfy their curiosity? If you think they cannot satisfy their curiosity in this manner, what kind of alternative experiment would you undertake?

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