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Improving students' science process skill and achievement through experiment in laboratory :volumetric titration

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ABSTRACT

This study aimed to investigate students' learning achievement and retention of acid base volumetric titration by using four inquiry-based learning These experiments included: 1) acidimetri 2) alkalimetri, 3) complexometri, 4) argentometri. Twenty eight students at Open University of Banjarmasin during the first academic semester of 2012 were purposively selected as participants. The data collected, included students' learning achievement test scores of acid base titration, learning retention scores 30 days after the implementation, and a survey of student satisfaction in learning inquiry-based learning were analyzed. Pretest-posttest control group design was adopted for this study with two classrooms. Control group was taught by traditional lecture supplemented with readings on aggressive behavior of and other animals while experimental group was experienced with an intervention with the same period of time (three hours), and with the same contents and the same learning objectives as control group. Experimental skills test, students' group poster, questionnaire, semi-structured interview, and classroom observation were used to gather data. The results revealed that students experiencing an intervention gained better both aggressive behavior understanding and experimental skills than the tradition.

KEYWORDS: *volumetri titration, inquiry based learning, science process skill*

Introduction

Science process skills allow individuals to solve the problems they face in daily life as scientists do. Science process skills in science education are skills that make students active, give them to learn research methods and the responsibility and provide a permanent learning.

Science process skills are defined by different researchers. Beauomant et al. and Padilla et al. divided science process skills into two groups as basic process skills and integrated process skills [1, 2]. Basic process skills include observing, classifying, measuring, using numbers, building the space-time relationship, predicting, making conclusion and communicating. And integrated process skills are interpreting, controlling variables, hypothesizing, defining operationally experimenting, formulating models inferring, communicating and concluding.

The compilation of all these skills is what we call "science process skills" which are always associated with scientific inquiry [3]. The science process skill, as well as being a necessary tool to learn and understand the science, is also an important aim in science education. Not only the scientists, but also all individuals in the society should have these skills in order to be scientific literate, and to solve the problems encountered in daily life [4]. In this context, the science process skills are defined as the skills which help to learn, provide to gain the discovering and researching ways and methods, increase the permanence of the learning, make the students active, improve the responsibilities of the students, and help them to understand the practical studies, improve the sense of taking responsibility on their own learnings [5, 6].

Inquiry is one most effective teaching approaches to enhances students' science process skill [7]. It should be implemented as often as practical. If students experience even a few inquiry activities each semester throughout their study in higher education, they become more self-confident, possess high skills in the science process and critical thinking, and unafraid of doing science [8]. There is some concern that inquiry-based instruction is time-consuming, so the introduction of inquiry into the traditional Chemistry course takes more time and involves fewer topics, and the easiest action would be to implement inquiry instruction as supplements or demonstrations in the traditional class [9].

The role of laboratories is important in the acquisition of science process skills on the part of students [4]. As is well known, laboratories play a central role in science education. Science educators report that learning tends to be more effective thanks to the use of laboratories [10]. In addition to the aforementioned importance of laboratories, the experimental techniques used in laboratory applications are crucially significant. Many techniques are used in order to increase the effectiveness of laboratory applications. In parallel with modern learning approaches, the techniques used in laboratories have been transformed in recent years into high level structured activities based on open-ended research rather than teacher-centered ones [11]. Harlen (1999) categorized laboratory education into four groups based on their degree of openness [12] (Table 1). In this research it is aimed to determine Science Process skill (SPS) teacher candidates'(TC) use of integrated process skills to find a solution to a problem they faced through an example of a volumetric titration Also determining Science and Technology teacher candidates' readiness levels when they apply integrated process skills is sub-goal of the research.

Method And Sampling

Sample collection:

The study was carried out in the academic year of 2011-2012 at the Faculty of Education in Open University in Banjarmasin. The sample group consists of a total number of 68 senior undergraduate students at the Department of Chemistry Teacher Education.. This study was carried out within course of Analytical Chemistry. In this course, some theoretic information related to SPS was given to the TC. The data was collected by using document analysis technique. This technique has comprised the analysis of written documents which give information about the target situation In the context of the course of the Analytical Chemistry that TC were taught about SPS theoretically, they were required to determine SPS in the experiments which they selected. The science inquiry activities related to volumetric titration were implemented for four weeks, and four hours a week. Students were asked to participate in the following process: 1) complete a pre-achievement test related to volumetric titration, 2) perform science inquiry activities related to volumetric titration, in which they were required to submit a group science inquiry activity plan and report prior to and after finishing each activity, and 3) complete a post-achievement test related volumetric titration (parallel to pre-test).

Scince Inquiry activities in volumetri titration:

Four science inquiry activities related to volumetric titration (12 hours) were these included : 1**)** acidimetric (three hours) 2) alkalimetri (three hours), 3) complexometri (three hours), 4) argentometri (three hours). Each activity was designed as a science inquiry that required student to participate in the five essensial feature of inquiry

Data Collecting Tools:

The collect data in this study consisted of two main tools

1. Achievement test of volumetric titration .The test consisted of 20 multiple choice and 10 essays. The reliability and validity of the test calculated by the Alpha Cronbach was 0.82.
2. Science process skills rubric system rated science process skills from their plan prior to the activity and reports after the activity.

Data analysis:

The collected data in this study included pre- and post- achievement test scores related to volumetric titration and integrated process skills. Paired-sample t-test analysis was performed to identify mean differences between the pre- and post-achievement test scores for this one group pretest and post integrated science process skills were analyzed in terms of means and SDs. Percentages of mean scores in the ranges of 0-50, 51-60, 61-70, 71-80, and 81-100 were interpreted as very poor, poor, fair, good, and excellent respectively.

Result:

The study results were categorized into two aspects, achievement scores and integrated science process skills.

Learning achievement scores related to volumetric reaction:

The paired-samples t-test analysis indicated that students obtained a post-achievement score (mean 52.56, SD 9.01) significantly higher than the pre-achievement score (mean 816.32, SD 9.01) related to volumetric titration at *p*-value less than 0.05 (Table 2). In addition, the post-achievement score for each topic was statistically higher than the pre-achievement score at *p*-value less than 0.05. The highest gains in content knowledge were in the topics of acidimetri 25.8.60%) and alkalimetri (17.33%), while the lowest gains were in the topics of complexometri (8.88%) and argentometri (8/70%). These results may have been due to the fact that there was just a model (no experiment) illustrating the complexometri and argentometri so the students might not have been able to understand the concepts as well as the topics with corresponding experiments. In addition, there are many factors influencing complexometri, such as pH, pKa of ligand, Kf complex, volume and concentration of the ligand and metal ion, so students may have become confused about influences of complexometri titration when two or more factors were present in the reactions being considered.

Table 2: Pre- and post-achievement test scores related to volumetric titration

Topics	Ideal score	Pre test		Post test		gain		t-Test
		Mean	S.D	Mean	S.D	Mean	%	
Acidimetri	15	6.00	1.06	21.52	1.27	15.52	25.86	2.51
Alkalimetri	15	5.84	1.38	16,24	1.18	10.40	17.33	2.43
Complexometri	15	1.98	4.54	6.84	4.04	4.86	8.33	2.11
Argentometri	15	2.54	2.04	7.56	2.58	5.02	8.70	1.81
	60	16.32	9.01	52.56	9.08	34.80	49.42	

Integrated science process skills:

Science activity plans and reports were scored in terms of integrated science process skills by the use of the rubric developed by the authors. The study showed that the students achieved a good level (74.52%) in integrated science process skills. Students were identified e at the skill of identifying and controlling variables and good at defining operationally (74.76%), formulating hypotheses (76.08%), and experimenting skills(74.65%). Interpreting data and drawing conclusion (74.52%). This may have been due to the fact that they had opportunities to practice the skills of identifying and controlling variables, defining operationally, formulating hypotheses, and experimenting skills, which were more emphasized by instructors during their middle and high school careers. However, they had only a few opportunities to practice the skill of interpreting data and drawing conclusion since many instructors often skipped this time-consuming step. As a result, the skill of interpreting data and drawing conclusion was less developed.

Table 3: integrated science process skills

Integrated science process skills	*Ideal Score*	Score			
		Mean	S.D	%	Interpretation
Defining operationally	10	6.80	1.56	68.00	fair
Hypothesizing	10	7.20	1.85	72.00	good
Identifying variables	10	7.15	2.06	71.50	good
Experimenting	25	18.50	2.67	74.00	good
Interpreting data	25	16.30	4.88	65.20	good
Communicating	20	12.45	3.24	61.22	fair

Discussion:

From the data analysis, the four year science undergraduates of the Faculty of Education, Open Univercity Banjarmasin are facing the problem of defining the scientific skills, especially the understanding of 'inference', 'hypothesis' and 'definition of operation'. While in term of communicating the skills, they show weaknesses in writing the intrepreting of operation and the table of results, as well as making measurements. According to Chiappetta & Koballa, "a hypothesis is a generalization that relates to a class of objects or events whereas an inference is related to a specific object or event" (p.204) [3]. A hypothesis is an "educated guess" [13]. To formulate a hypothesis, it should be based on observations and inferences. Inferring is to use logic to draw conclusions from what is observed. From the excerpt presented earlier regarding hypotheses and inferences, none of the undergraduates tried to relate observations with inferences and to related inferences with hypotheses. As for defining operationally, Martin et al. stated that it is to describe what works; explain how to measure variables in an experiment, relationships between observed actions to explain phenomena and to explain relationships by generalizing to other events not observed [14].

It is to give interpretations of a concept by stating it in terms of what to be done and observed. For this, the understanding among the undergraduates is not too far from the correct definition, however, in practice, not many of the undergraduates correctly stated the definitions of operation in their laboratory reports. Moreover, six out of 12 undergraduates did not write the definitions of operation in any of the laboratory reports analyzed in this research. It could be that the undergraduates perceived that this is not an important part of a scientific investigation because when they were asked during the focus group interview about the purpose to state the definition of operation in an experiment, they said, they did not think that it is necessary to report it.

Conclusion:

From this research, it is apparent that science undergraduates at Uniersity do not have the correct understanding of interpreting data, communicating and definitions of operation. However, in writing laboratory reports, it seems that they do not face too much of a problem to write the correct inferences and hypotheses. It could be argued that they do not need deeper understanding to be able to state the inference and hypothesis of an experiment. On the other hand, it could also be argued that they might copy a part of the report from text books, reference books or from the past year reports obtained from senior undergraduates – as suggested by some undergraduates involved in the focus group interview. If the later is the stronger possibility, it will not help the undergraduates in improving their scientific skills. Sharifah & Lewin argued that the less students involved in planning a scientific investigation, the poorer their mastery of scientific skills [15]. If these pre-service teachers fail to master the scientific skills to a level that they can inculcate these skills to their students in the future, the students will only learn science as any other subjects in schools.

It is also the duty of the lecturers to provide opportunities for undergraduates to acquire such skills. One of the ways to achieve this is to let the undergraduates perform real scientific investigations from planning until reporting. During the focus group interview, the undergraduates stated that they actually learn deeper about scientific skills when they were put into a new situation of scientific investigation. They need to read the related materials about a new experiment that they are going to carry out. On the day of conducting the experiment, good questioning from the lecturers also highly facilitate the learning of scientific skills because questions that probe the undergraduates to want to find out more will lead them to plan and perform more investigations. It is through hand time to explore as much as they like about a topic using the facilities in the laboratory.

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