

Effects of Writing to Learn Activities in Hands-on and Virtual Laboratory Environments

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Abstract: The Science Writing Heuristic (SWH) approach mainly developed by Hand and Keys (1999). The approach involves two sets for both teachers and students to be mindfully active in an inquiry based laboratory environments. The set for students provides scaffolds in written form in order to help metacognition about their lab experiments (Hohenshell & Hand, 2006) and the set for teachers enable them to design inquiry based science laboratories. In the current study, it was investigated that the effects of SWH approach in hands-on and virtual lab environments on pre-service science teachers' laboratory skills and science achievements. Quasi-experimental research design was used in the current study. Participants of the study were 52 pre-service science teachers. They were assigned into two groups, one of which them used hands-on laboratory environment, coded as control group. The other group used virtual laboratory environment called as experimental group. The attitude scale towards laboratory skills and the achievement test were used in the study. Overall results indicated that SWH based lab environments are equally effective on students' attitudes and achievements.

Keywords: Science writing heuristic, hands-on lab, Virtual lab, Attitude, Achievement

Introduction

One of the main goals of science education is to educate individuals as scientifically literate. Most of the reforms in science teaching curriculum, including Turkey, are made to encourage students to develop their science literacy (Kingir, Geban & Gunel, 2012). In order to reach this goal, constructivism is one of the efficient approaches. It is defined as constructing knowledge through mindfully active processes (Posner, Strike, Hewson & Gertzog, 1982). In this approach, students are active learners rather than passive recipients.

The Science Writing Heuristic (SWH) approach is also based on constructivism and mainly developed by Hand and Keys (1999). Writing is mode of thinking in SWH based classrooms (Hand, Wallace & Yang, 2004; Kingir, Geban & Gunel, 2012) and it encourages students for construction of meaning for verbal symbols, which then help them to develop scientific knowledge and scientific literacy (Keys, Hand, Prain & Collins, 1999; Hand, Wallace & Yang, 2004). The approach involves two sets for both teachers and students to be mindfully active in an inquiry based laboratory environments. The set for teachers is given Table 1 (Hand & Keys, 1999). It involves activities to prompt students to think about concepts and enables teachers to design inquiry based science laboratories. The set for students (Table 2) provides scaffolds in written form in order to help metacognition about their lab experiments (Hand & Keys, 1999; Hohenshell & Hand, 2006).

Table 1. The set for teachers in SWH approach (Hand & Keys, 1999, p. 28)

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1. Exploration of pre-instruction understanding through individual or group concept mapping.
 2. Pre-laboratory activities, including informal writing, making observations, brainstorming, and posing questions.
 3. Participation in laboratory activity.
 4. Negotiation phase I – writing personal meanings for laboratory activity.
 5. Negotiation phase II – sharing and comparing data interpretations in small groups.
 6. Negotiation phase III – comparing science ideas to textbooks or other printed resources
 7. Negotiation phase IV – individual reflection and writing.
 8. Exploration of post-instruction understanding through concept mapping.
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In SWH based learning environments, students as a group, firstly, posing testable question(s). Then, they design investigation(s) to find answer their question(s). They gather data, analyze them and inferring. After that they share their findings with other groups through discussions. Finally, the new knowledge is integrated with the existed one the reflection. The process can be summarizable as students construct knowledge by making claims and supporting these claims with evidence based on their experimentation (Kingir, Geban & Gunel, 2012, p. 429). Teacher's role is scaffolding students through these processes.

Table 2. The set for students in SWH approach (Hand & Keys, 1999, p. 28)

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1. Beginning ideas – What are my questions?
 2. Tests – What did I do?
 3. Observations – What did I see?
 4. Claims – What can I claim?
 5. Evidence – How do I know? Why am I making these claims?
 6. Reading – How do my ideas compare with the other ideas?
 7. Reflection – How have my ideas changed?
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Laboratories are crucial learning environments in science education because it provides learning by inquiry (Minner, Levy & Century, 2010). Although hands-on labs are common at schools (Kapici & Akcay, 2018), virtual labs enter the classrooms with respect to developments in educational technology. Each type of lab environments has its own affordances. There are a lot of studies about the effects of virtual labs on students' domain knowledge (e.g. McGrath, Wegener, McIntyre, Savage & Williamson, 2010; Zacharia & Constantinou, 2008) and most of these studies concluded that there is no certain boundary between these two lab environments with regard to students' achievement (e.g. Hannel & Cuevas, 2018).

In the current study, it was investigated that the effects of SWH approach in hands-on and virtual lab environments on pre-service science teachers' attitudes toward laboratory skills and achievements. Based on this, two research questions were determined as following:

1. Is there any significant difference between students who used SWH based hands-on lab environment and SWH based virtual lab environment with regard to their achievement?
2. Is there any significant difference between students who used SWH based hands-on lab environment and SWH based virtual lab environment with regard to their attitudes toward laboratory skills?

Method

The study is based on quantitative research methodology and quasi-experimental research design was used in the current study. Participants of the study were 52 pre-service science teachers. They were assigned into two groups, one of which them used hands-on laboratory environment, coded as control group. The other group used virtual laboratory environment called as experimental group. Whereas there were 28 students in the control group, 24 students were in the experimental group.

Two different instruments were used in the study. First of them was attitude scale towards laboratory skills developed by Alkan and Erdem (2012). The scale involves 25 items under four sub-dimensions. These sub-dimensions are recognizing the materials and chemicals in the laboratory, considering feedback, communication in the laboratory and feeling ready him/herself. Cronbach's alpha coefficient for the whole scale was found as 0.91 by Alkan and Erdem (2012). The other instrument was achievement test. The questions in the test were

taken from national university entrance exams. There were totally 12 questions in the test. The data gathered from the attitude scale and achievement test analyzed by independent sample *t* test.

In hands-on lab environment, students used paper form of the template and for the virtual lab environment, students used online form it. Students designed and implemented experiments about four topics, which are acid-base, solutions, electricity and buoyancy force. Open-ended inquiry was followed. Students determined their own research questions and asserted claims. They designed their experiments with respect to their questions (or hypothesis) and implemented. They reached conclusion based on evidences gathered from experiments. Students wrote the entire steps they followed either in paper form or online form. Whereas students in hands-on lab environment used physical materials in a traditional lab environment, students in the virtual lab environment used online lab platform for their laboratory investigations.

Results and Discussion

The effects of hands-on and virtual lab environments on pre-service science teachers’ attitudes toward laboratory skills and achievements were investigated in the study.

The findings based on the attitude scale revealed that there is no significant difference between the groups (see Table 3). This result means that both of the SWH based laboratory environments are equally effective on pre-service science teachers’ attitudes toward laboratory skills.

Table 3. Independent sample *t* test result for the attitude scale

Groups	N	Mean	SD	t	p
Control	28	4.03	.483	.510	.612
Experiment	24	3.97	.478		

Similar way was used to analyze the data gathered from achievement test. The findings showed that there is no significant difference between the groups (see Table 4). This result proves that both of the SWH based laboratory environments are equally effective on pre-service science teachers’ achievements.

Table 4. Independent sample *t* test result for the achievement test

Groups	N	Mean	SD	t	p
Control	28	7.66	1.48	1.035	.305
Experiment	24	8.24	4.17		

Overall results indicated that SWH based lab environments are equally effective on students’ attitudes and achievements. It can also be said that SWH approach can be effective in virtual lab environments as much as in hands-on lab environments.

Such kind of studies can be extended with middle school and high school students. Application of SWH approach into virtual lab environments can be investigated.

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