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The effect of argument-driven inquiry on pre-service science teachers' attitudes and argumentation skills

Tuba Demircioğlu [a1], Sedat Uçar [a]

ªÇukurova University, Faculty of Education, Sarıçam/Adana, Turkey

Abstract

The purpose of this study was to examine the effect of Argument-Driven Inquiry (ADI) laboratory activities to pre-service elementary science teachers' attitude towards physic laboratory and their argumentation quality. Participants (n=63) were pre-service science teachers at Research University in Turkey. The students in the control group (n=32) participated in six different traditional laboratory activities. The students in the experimental group (n=31) participated in six different Argument-Driven Inquiry (ADI) laboratory activities. Data were collected through Physics Laboratory Attitude Questionnaire and the reports that were written individually by students. All of the participants took physics laboratory attitude questionnaire before and after the instructional intervention. The results of this study showed that no significant differences were observed in Attitude Questionnaire between the ADI instruction and traditional instruction groups. The results of the study showed that the ADI instructional method was more effective in improving the argumentation quality compared to the traditional method. ADI did not changed the attitudes but the argumentation skills changed significantly.

Keywords: Argumentation, attitude, science education, teacher education

1. Introduction

The importance of argumentation in science education was highlighted broadly in recent years (Zohar & Nemet, 2002; Aufschnaiter, Erduran; Driver, Newton& Osborne, 2000; Duschl & Osborne, 2002). Although argumentation has a significant role in science education, it is rarely used in science courses and laboratory activities (Driver, Newton & Osborne, 2000; Jimenez-Alexander, Rodriguez, Duschl, 2000; Kim & Song, 2005). Science education should emphasize critical reasoning and argumentation (Simon, Erduran & Osborne, 2006; Driver, Newton & Osborne, 2000; Jimenez-Alexander, Rodriguez & Duschl, 2000). Engaging in an argumentation process requires making claims, using data to support this claims and using reasons to justify this claims. With argumentation process, students both learn science concepts and also have the opportunity to practice the scientific methods while they are justifying or refuting their ideas.

Argumentation researches conclude that the students' discussions were weak and some of the students did not engage in argumentation in science classes (Zohar & Nemet, 2002; Watson, Swain & McRobbie, 2004; Jimenez-Alexandre, Rodriguez & Duschl, 2000; Kelly, Druker & Chen, 1998; Sampson, Grooms & Walker, 2011). There are many reasons that affect students' engagement in argumentation. Students' attitudes could be one of these reasons. Affective domain play an important role in learning (Uçar and Demircioğlu, 2010; Cobern et al. 2010). Simpson et al. (1994, p.212) defined attitude as follows: "Attitude is commonly defined as a predisposition to respond positively or negatively to things, people, places, events, or ideas''. Many factors affect attitude towards science and one of these variables is laboratory instruction. Laboratory instruction has a positive effect on students'

attitudes towards science (Freedman, 1997). Laboratory instructions trigger students' interests and motivate them to learn science. (Lunetta, Hoffstein and Clough, 2007; Freedman, 1997). Attitude toward science is an important component of argumentation skills. There are no measures of teachers' and students' attitudes and beliefs about the role of argument in science and in science education (Erduran, 2007).

Most of the researches reported that "cookbook" laboratory activities in which students are often passive in the laboratory (Walker, Sampson, Grooms, Anderson & Zimmerman, 2010; Hoffstein & Lunetta, 2004). However, instead of "cookbook" laboratory activities in which each step is given by the lab manual, students need laboratory activities in which they can inquire, they can suggest hypotheses and test them, share their ideas clearly. Therefore, a variety of models and methods were used in laboratory courses and investigated the effectiveness of these models (Lunetta, Hoffstein & Clough, 2007). In laboratory activities one of the suggested methods to improve students' success is "Argument- Driven Inquiry, ADI" (Sampson & Gleim, 2009). The difference of this method from the others is that students design their own research questions and reach the conclusion by themselves. The model provides students to engage in argumentation by sharing their ideas, supporting and discussing them. And also the model requires students to peer-review others' lab reports that develop students' critical thinking abilities. In addition, in ADI, the students share their findings with the other students so that they could develop communication and writing skills. Therefore, the method ADI could be an effective method in laboratory instruction.

The purpose of this study is to examine the affection of ADI laboratory activities to pre-service elementary science teachers' attitude towards physic laboratory and argumentation skills.

Specifically following research questions were investigated in the current study:

RQ1: How does ADI based laboratory instruction affect students' attitude towards physics laboratory in an electricity and magnetism laboratory?

RQ2: How does ADI based laboratory instruction affect argumentation quality of students?

2. Method

2.1. Context

The study was conducted with pre-service science teachers in an electricity and magnetism laboratory. The students in the control group participated in seven different traditional laboratory activities. In this instruction, students followed a step by step procedure. The students in the experimental group participated in seven different Argument-Driven Inquiry (ADI) laboratory activities. Each laboratory activity in ADI includes six steps (Sampson & Gleim, 2009; Sampson, Grooms & Walker, 2011): 1) The definition of the problem by the instructor, 2) Proposing an inquiry method with collaborative groups of students, 3) Development of an argument on a "whiteboard" that consists of an explanation, evidence and reasoning by each group, 4)A round-robin argumentation session, 5)Production of a lab report that answers what they were trying to do and why, what they did and why, what their argument was, 6) A double-blind peer-review of written reports.

2.1.1. Sample

The participants were pre-service science teachers at a major research university in south of Turkey. A total of 63 pre-service elementary science teachers (32 in the control group, 31 in the experimental group) participated in this study. Among those, 47 of them were female and 16 of them were male.

2.1.1.1. Data Collection and Analysis

A quasi experimental model was used. In this model, the participants are not randomly assigned to control, and experimental group but two groups were randomly assigned as the control and experimental group (Creswell, 2008). Data were collected before and after the instruction using both quantitative and qualitative data collection methods (Creswell, 2008). All of the participants took physics laboratory attitude questionnaire (PLAQ) developed by Yeşilyurt (2004) before and after the instructional intervention. PLAQ consists of 34 items Data were analyzed

through SPSS 17.0. Independent-Sample t-test was used for the analysis of attitudes towards physics laboratory. The reports that were written individually by students were used to assess the quality of argumentation. To analyze this reports the framework developed by Erduran, Simon and Osborne, (2004) was used. First the arguments in the reports were coded through Toulmin's Model (1990), then argumentation level for each report were determined through the framework developed by Erduran, Simon and Osborne, (2004). The argumentation levels can be found in Table 1 (Erduran, Osborne and Simon, 2004, p.928). Each level was scored from 1 to 4 by researchers and these scores were used for independent-sample t-test.

Table 1. Analytical Framework Used for Assessing the Quality of Argumentation

Level 1 Level 1 argumentation consists of arguments that are a simple claim versus a
counter-claim or a claim versus a claim.
Level 2 Level 2 argumentation has arguments consisting of a claim versus a claim with
either data, warrants, or backings but do not contain any rebuttals.
Level 3 Level 3 argumentation has arguments with a series of claims or counter-claims
with either data,warrants, or backings with the occasional weak rebuttal.
Level 4 Level 4 argumentation has arguments with a claim with a clearly identifiable
rebuttal. Such an argument may have several claims and counter-claims.
Level 5 Level 5 argumentation displays a next ended argument with more than one rebuttal

To assess coding reliabilty, two coders coded the 20 % of the written reports independently. Then the analysis of the reports were compared by the coders and resolved differences in interpretations. İnterrater agreement between two coders were 80 % which is a medium agreement level.

3. Results

3.1. Attitudes Towards Physics Laboratory

The independent-sample t-test showed that there were no significant differences in PLAQ between the ADI instruction and traditional instruction groups (t_{61}= .54, p=.05, $M_{control}$=118.88, $M_{experimental}$=122.52). Independent t-test results are provided in Table 2.

Table 2.Independent-sample t-test results from PLAQ

Groups	Pre-Test Mean	Post-Test Mean	t	df	p
Control Group	123.47	118.88	-.69	61	.05
Experimental Group	120.58	122.52			

3.2. Argumentation Quality

The written reports were categorized in four levels. These levels are respectively Level 1, Level 2, Level 3 and Level 4. An example from the arguments in the students' written reports for level 2 and level 4 was presented below. And then, the results of the argumentation level for t-test from control and experimental groups were given.

Level 2: There were data, warrant or backings with claims in these reports. But there were no rebuttals. These reports were scored "2" by the researchers.(S: Student)

S 57:

Yellow	Purple	Orange	Gold
4	7	10^3	5 %

47. 10^3=47000 Ω= 47 k Ω
47 k Ω. 5%= 2,35 k Ω
47+ 2,35= 49,35 k Ω
47-2,35= 44,65 k Ω   (DATA)
The resistance score that we measured by multimeter= 46,5 k Ω

Beslan has to use this resistor (CLAİM) because the nearest resistance value is the one which Lena has yellow-purple- orange- gold resistor (WARRANT).

Level 4: There were arguments with a claim with a clearly identified rebuttal. These reports were scored "4" by the researchers.

S 37:	*In Series Circuit: $R_{total} = R_1 + R_2 + ... + R_n$*
In Series Circuit $_{(Teorical)}$= 47,9+0,831+0,0553=48,78 $k \Omega$
In Series Circuit $_{(Experimental)}$= 48,8 $k \Omega$ (We measured this value by multimeter in series circuit) (DATA)

When we connected the three resistors that we have in series, we found the value 48,8. But in the question was 52 k Ω. (DATA) We cannot connect the resistors in series (REBUTTAL) because that value isn't equal to our value (WARRANT).We must set up a parallel circuit (CLAİM). When we connected the three resistors that we have in parallel, we found the value 52,2. We must set up a parallel circuit because the value given in the question is equal to the value we measured.

The independent sample t-test results showed that there was significant difference in argumentation quality between the ADI instruction and traditional instruction groups (t_{61}=2 .30, p=.02, $M_{control}$=2.28, $M_{experimental}$=2.74).

4. Conclusion

An untraditional laboratory instructional model (ADI) was used in electricity and magnetism laboratory instruction. And the results of this study showed that the ADI instructional method didn't improve students' attitude significantly compared to traditional laboratory instruction. Similar results were reported by Freedman (1997), Yeşilyurt (2004), Altıparmak and Nakiboğlu (2005) who showed that there was no significant difference on attitudes of groups. Although there was no significant difference, the scores on the post-test of attitude towards physic laboratory showed that the experimental group scored higher than the control group. And the control group decreased the scores on the post-test compared to pre-test. The students want to design the experiments themselves (Nuhoğlu and Yalçın, 2004). In ADI the students design their own research questions and reach the results themselves and in traditional laboratory activities students do the experiments step by step which were given by the lab manual. That can be the reason of the decrease of control groups' attitude scores. Similarly Yeşilyurt (2004) showed that students had quite negative attitude towards physics laboratory after laboratories studies. For the further studies this study could be supported by qualitative data for attitude measure.

Although no significant differences observed in attitude scores between the groups, there were significant differences in argumentation skills between the groups. The students in the control group made an explanation based on the conclusions of the experiment in their conclusion section of their written reports (claim) and in the data section of the report, they reported the data that they found during the experiment. In the reports that were written by the experimental group, there was a section that the students proposed an explanation that was an answer to research questions, supported their explanation, proposed reliable and valid evidences. In that section the students gave answers to "What is your argument?". Also the students used rebuttals in this section. So in this context, because of the method, the difference in preparation of report could be the reason for the improvement in argumentation skills. We conclude that the opportunity to refute each other's ideas in "Argumentation Sessions" help students to write their lab report easily and help them to use *rebuttals* in their reports. Zohar and Nemet (2002) showed that the students' argumentation skills significantly improved after the implementation. In the study of Walker et al. (2010) the undergraduate students in ADI laboratory sections improved significantly their ability to use evidence and reasoning to support a claim compared to the students in traditional lab sections. On the other hand, Osborne et al. (2004) reported that no significant difference between the groups at the end of the research.

Engaging in argumentation and production of oral and written arguments improve scientific knowledge and abilities (Sampson, Grooms & Walker, 2010; Kelly & Chen, 1999). This study contributes to science teachers and teacher educators for trying different methods to use argumentation in the classroom and to develop scientific knowledge and writing abilities.

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