Enhancing students’ cognitive ability by implanting argumentation activity on inquiry lab

Siswanto*, Yusiran, S Gumilar, Hartono, B Subali, A Muhlisin, E Julianto, E Trisnowati and Farikah

1 Department of Natural Science Education, Universitas Tidar, Magelang, Indonesia
2 Department of Physic Education, STKIP Taman Siswa Bima, Bima, Indonesia
3 Department of Primary Teacher of Education, STKIP 11 April Sumedang, Indonesia
4 Department of Physic, Universitas Negeri Semarang, Semarang, Indonesia
5 Faculty of Teacher Training and Education, Universitas Tidar, Magelang, Indonesia

*Corresponding author’s email: siswanto@untidar.ac.id

Abstract. The purpose of this study is to acquire depiction of cognitive ability enhancement which the laboratory activities based inquiry implanted argumentation activities was conducted as a main process in the classroom activities. A quasi experiment method with non-equivalent control group pretest- post-test was carried out to implement this treatment. The participants of this study were students grade XI in one of public senior high schools in Indonesia. They were divided into two groups, experimental and control group, using purposive sampling. Experimental group was provided great opportunities to conduct laboratory activities based inquiry implanted argumentation activities while control group uses laboratory activities based inquiry. In order to recognize the cognitive ability of students, an instrument was developed in form of multiple choices. This study revealed that the mean difference of two groups was significantly different in which students’ cognitive ability of experimental group was higher than this control group and was in medium criteria from normalized gain perspective. From this findings, implanting argumentation activities on inquiry lab played prominent role in constructing model and theory of knowledge for students in enhancing their cognitive abilities.

1. Introduction

Cognitive ability is one of prominent aspects in objective references of physics’ learning outcomes. It is strongly related to the ability of students to master all concepts and laws of physics [1]. Students who have good ability in physics learning, will absorb, master, and apply the concepts mastered [2]. Physics learning therefore has to be designed in order to provide students cognitive ability maximally, so that the mastering concepts of students are comprehensive and meaningful.

The activity of physics learning cannot be elaborated from laboratory activities [3]. It has big role in physics learning in determining the triumph of learning result achievement. By laboratory activities, students are given the great opportunities to investigate, analyse, and discover the concepts in which students want to inquiry [4,5].

One of the laboratory activities that can give meaningful experiences to students is inquiry laboratory. It gives students a chance to train like a scientist through the inquiry activities. The physics learning that
cover inquiry activity can construct the students’ cognitive ability, and higher order thinking skills (HOTs) [6,7].

Departing from the benefits of inquiry activity for students, this present study will combine inquiry activity with scientific argumentation. Some activities in argumentation will be implanted to several phases in inquiry laboratory. Several studies depict that the learning process training the argumentation activity can enhance the students’ ability to master, and retain concepts in their memories [8-10]. Therefore, by implanted the argumentation activities in inquiry phases are wished that students’ cognitive ability can enhance better.

There are several phases or stages of inquiry used in this present study: identify the problems, formulate the objectives, formulate hypothesis, design procedures of experiment, carry out the experiment, interpret the data, and conclude the results [7]. These stages will be implanted the argumentation activities that refer to Toulmin Argumentation Pattern (TAP), namely the activity to propose claim, data, warrant, and backing [2]. There was a reason why scientific argumentation was implanted; students had low cognitive ability and the previous research depicted that scientific argumentation skills could aid to strengthen students’ cognitive ability [9].

Based on the rationale presented in previous explanation, this present study investigates the depiction of enhancing students’ cognitive ability by implanting argumentation activity on inquiry laboratory. A consideration of the implication of finding results of this present study gives deep insight dealing with the scientific inquiry set by using argumentation activities.

2. Methods
This present study utilized quasi experiment with non-equivalent control group pretest- post-test design. The participants of this study were 46 students that came from two different classes of grade-XI in one public senior high school in Indonesia. The purposive sampling was utilized to take participants. The participants were divided into two groups: the experimental group (i.e. 23 students) which was given the scientific inquiry activities implanted scientific argumentation activities, and control group (i.e. 23 students) which was only given the treatment of scientific inquiry activities.

To garner data dealing with students’ cognitive ability, an instrument was developed and used. It was multiple choices and measured the concepts of temperature and heat. The students’ cognitive ability measured leads to revised Bloom’s theory [1], but it was limited to four aspects, namely remembering (C_1), understanding (C_2), applying (C_3), and analyzing (C_4) aspect. The measurement of students’ cognitive ability was measured by pretest which was conducted before learning process and post-test which was carried out after learning process.

There are several processes to analyze the data obtained from pretest and post-test. Firstly, score of pretest and post-test are converted to a scale that has maximum score-100. Secondly, the normalized gain (N-gain) of pretest-post-test is counted both in experimental and control group using the N-gain formulation (see equation-1) [11]. There are three categories in determining types of N-gain: high (\( g > 0.7 \)), moderate/medium (0.3 \( \leq g < 0.7 \)), and low (\( g < 0.3 \)).

\[
< g > = \frac{<S_{posttest}> - <S_{pretest}>}{<100> - <S_{pretest}>}
\] (1)

The last analysis, the mean difference of pretest and post-test between experimental and control group are tested. This test used to determine the significance of mean difference among two groups. Indeed, before testing the significance conducted, the Shapiro-Wilk of normality test was utilized to test the normality data.

3. Results and Discussions
This present study develops the new design of physics learning as a treatment for experimental group. Implanting the scientific argumentation activity to scientific inquiry activities is objected to give the
better meaningful experiences to students. There are two reasons why the argumentation activity implanted to scientific inquiry: two activities emphasizing meaningful learning, and having appropriate between the each component of scientific inquiry and scientific argumentation. This design can be seen in Figure 1.

**Figure 1.** Design of inquiry activities framework implanted scientific argumentation activities.

By implementing inquiry activities implanted scientific argumentation design to experimental group, and another activity which is inquiry activities to control group, some data dealing with students’ cognitive ability are obtained. Table-1 and table-2 portray the result of normality test, and descriptive statistics and also N-gain respectively. According to Table 1, all data pretest and post-test among two groups have no normal distribution.

| Group     | Shapiro-Wilk df | Shapiro-Wilk Sig. | Explanation                  |
|-----------|-----------------|-------------------|------------------------------|
| Experimental | Pretest 23       | 0.101             | Normal distribution          |
|            | Post-test 23     | 0.334             | Normal distribution          |
| Control    | Pretest 23       | 0.510             | Normal distribution          |
|            | Post-test 23     | 0.934             | Normal distribution          |

**Table 1.** Result of normality test.

Table 2. The depiction of descriptive statistics and N-gain.

| Group     | Mean score | N-gain (<g>) | Criteria                  |
|-----------|------------|--------------|---------------------------|
|            | Pretest    | Post-test    |                           |
| Experimental | 46.23     | 76.23        | 0.29          | Normal distribution |
| Control    | 41.30     | 56.80        | 0.56          | Normal distribution |

Based on data on Table 2, there are improvement of students’ cognitive ability in two group investigated. The treatment applied in two groups has the effect toward students’ cognitive ability. In
In this case, experimental group has the higher improvement than that control group. This means that implanting scientific argumentation into inquiry laboratory have contributed to enhance students’ cognitive abilities. In addition, table-3 depicts that the test of mean difference between experimental and control group using student test (t-test) are significantly different. This finding result reveals that implanting the scientific argumentation to inquiry lab activities can enhance obviously students’ cognitive abilities rather than the physics learning using scientific inquiry laboratory without scientific argumentation activities.

**Table 3.** Result of student test dealing with mean difference among two groups.

| Properties                                  | T  | df | Sig  | Explanation        |
|----------------------------------------------|----|----|------|--------------------|
| Posttest to posttest between experimental and control group | -6.694 | 46 | 0.000 | Significantly different |

**Table 4.** Result of student test dealing with pretest to post-test in two groups.

| Group        | Properties tested | T       | df | sig  | Explanation        |
|--------------|-------------------|---------|----|------|--------------------|
| Experimental | Pretest- post-test| -11.546 | 23 | 0.00 | Significantly different |
| Control      | Pretest- post-test| -17.519 | 23 | 0.00 | Significantly different |

The scientific argumentation activities that encompass proposing claim, data, warrant, and backing make students understanding concepts of physics comprehensively [9,10]. In this case, students are trained to construct the conceptual framework of complex theories and they are making meaning from what they conduct in the classroom. Some finding studies reveal that argumentation activity carried out in learning process of science can enhance students’ abilities in mastering concepts [2,12,13]. These evidences have the resemble results with this present study in which argumentation activity applied in physics learning can improve the students’ cognitive abilities (see Table 4).

Additionally, the inquiry laboratory which is to be “main framework” in implanting scientific argumentation also gives positive impact toward students’ cognitive ability. The evidence to support this statement can be seen from control group, there is an enhancement of students’ cognitive ability which is significantly different when the learning process using only inquiry laboratory activities. This means that the phases of inquiry support the students’ cognitive ability. There are several reasons why inquiry laboratory activities have advantages for learning process: making learning process to be meaningful, and giving easier comprehension in understanding concepts and laws of knowledge. Diverse studies show that the learning outcomes will be achieved maximally when students’ motivation and interest improve—or students’ attention during learning process improves [14,15]. The other benefits from inquiry laboratory are also training intellectual skills of students, and providing an opportunity how science is constructed by process and product [6,7].

4. **Conclusion**

We conclude several finding results from this present study: there is meaningful learning process when the physics learning process using inquiry laboratory activities implanted scientific argumentation, students have deep understanding dealing with concepts and laws learned when using inquiry lab implanted scientific argumentation, and inquiry laboratory implanted scientific argumentation can be scaffold so as students can construct the knowledge gradually. Indeed, the implication of this present study in instructional learning design context is a new framework in learning design in training and embedding students’ cognitive ability and HOTs to students.
5. References

[1] Tijaro-Rojas R, Arce-Trigatti A, Cupp J, Pascal J and Arce P E 2016 Education for Chemical Engineers 17 31
[2] Siswanto et al 2018 J. Phys.: Conf. Ser. 983 012021.
[3] Gilbert JKand Reiner M2010 Thought experiments in science education: potential and current realizationInternational Journal of Science Education 22 3 265-283
[4] Kai Wu H2006 Developing Sixth Graders’ Inkuiri Skills to Construct Explanations in Inkuiribased Learning EnvironmentsInternational Journal of Science Education 28 11 1289–1313
[5] Zohar A and Nemet F 2002 Fostering students knowledge and argumentation skills through dilemmas in human geneticsJournal of research in science teaching 39 1 35-62
[6] Wenning C J 2011 Experimental inkuiri in introductory physics coursesJournal of Physics Teacher Education 6 2 2-8
[7] Harlen W 2014 Helping children’s development of inkuiri skillsInkuiri in primary science education (IPSE) 1 5-19
[8] SampsonV and Gerbino F2010 Two Instructional Models That Teacher Can Use to Promote & Support Scientific Argumentation In the Biology ClassroomThe American Biology Teacher 72 7 427-431
[9] Siswanto 2014 Penerapan Model Pembelajaran Pembangkit Argumen Menggunakan Metode Saintifik untuk Meningkatkan Kemampuan Kognitif dan Keterampilan Berargumentasi SiswaJournal Pendidikan Fisika Indonesia 10 2 104-116
[10] Yusiran and Siswanto 2016Implementasi Metode Saintifik Menggunakan Setting Argumentasi untuk Meningkatkan Kemampuan Kognitif Jurnal Penelitian dan Pengembangan Pendidikan Fisika 2 215-22
[11] Caballero M D, Greco E F, Murray E R, Bujak K R, Jackson, Marr M, Catrambone R andSchatz, M F 2012 American Journal of Physics 80 638
[12] Acar O and Patton 2012 Argumentation and formal reasoning skilssin an argumentation-based guided inkuiri course Procedia - Social and Behavioral Sciences 46 4756-4760
[13] Akarsu B, Bayram K, Slisko J and Cruz AC 2013 Understanding Elementary Students’ Argumentation Skills through Discrepant Event “Marbles in the Jar”International Journal of Scientific Research in Education 6 3 221-232
[14] Deslauriers L and Wiemen C 2011 Learning and retention of quantum concepts with different teaching methodsPhysical review special topics - physics education research 7 1 1-6
[15] Nsungo N, Arikpo U 2013Teaching Physics for Retention International Journal of Modern Management Sciences 2 1 18-25

Acknowledgement

The authors would like to thank all parties who assist in the collection of research data. The Authors also would like to thank Indonesian Ministry of Research, Technology, and Higher Education that have provided research funding for doing this research.