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The influence of inquiry-based learning on Indonesian students' attitude towards science

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Abstract. Firstly, this study examined changes in Indonesian high school students' attitude towards science after the implementation of inquiry-based learning (IBL). Using a quasi-experimental approach, TOSRA questionnaires were administered before and after intervention to access changes on students' attitude. The results indicate IBL did not have a positive impact on students' attitude towards science. Secondly, this study describes an attempt to discover factors limiting or supporting the implementation of IBL in Indonesian classrooms practice. Qualitative analysis of observation and teacher's interview data was performed. Our findings reported that time, questioning techniques, task difficulties, insecurity of self-directed learning, and experience with group influenced IBL lessons' implementation.

1. Introduction

In recent decades, the study of affective domains of learning science has become well established in science education. Many researchers have become more attentive to recognize the range of interest, attitudes, beliefs, and values that influence students in learning science [1-3].

Students' attitude in learning science varies from one country to another. Their perception, confidence, and beliefs are environmental and cultural constructions. The PISA results in 2015 reported that there is a difference in students' enjoyment of science across countries and economies [3]. Particularly in Indonesia, a trend of decline in students' positive attitude towards science has been observed. Fraser, Aldridge & Adolphe stated that Indonesian students had a less positive attitude towards scientific inquiry but a more positive attitude towards career interest in science [4]. Similarly, a significant decrease of enjoyment of science in Indonesian students was reported by the PISA results 2015. A change of the PISA results between 2006 and 2015 revealed that Indonesian students were less engaged in science activities and less interested to acquire science knowledge [3].

A number of learning strategies can be used to foster students' engagement in learning science. One of the strategies, inquiry-based learning (IBL) has proven to be beneficial to promote students' engagement in science learning activities [5-6]. Furthermore, IBL makes students become more active participants [7], gives more autonomy for students to solve the problem by themselves [6,8] and lets students acquire greater confidence and interest in the nature of science [9].

A recent review study on students' attitude towards science [2] showed that the majority of the collected studies was carried out in US, Turkey, and a few countries from Africa. Little has been written on the study of students' attitude that is representative for Asian countries. With that in mind, it is necessary to perform a research regarding students' attitude towards science in order to gain more information from countries that are underrepresented.



In Indonesian context, hardly any studies can be found on the effect of IBL implementation in relation with promoting or investigating students' attitude towards science. On the other hand, IBL has been widely used to study the improvement of learning outcomes and motivation of students [10-12].

Consequently, it can be expected that IBL may positively contribute to the development of students' attitude towards science in Indonesia. The aim of this study is to provide empirical evidence for that hypothesis.

2. Methods

To explore the influence of IBL lessons on Indonesian students' attitude towards science as well as factors limiting and supporting the implementation of IBL in class, a quasi-experimental approach with mixed method of data collection was used. Data was collected using a questionnaire, interviews, field notes, and video recordings.

2.1. Participants

The research was conducted in 2 schools. In each of the schools, the researcher randomly chose one class as a control group and one other class as an experimental group. The experimental class consisted of 65 participants in the pre-test and 59 in the post-test. The control class consisted of 55 participants in the pre-test and 47 in the post-test. As noted, there were difference in number of the pre- and post- test between the participants of both experimental and control class since not all students participating in the pre-test conducted the post-test. For the data analysis, only students who conducted pre- and post- test were taken. The control groups worked with the regular textbook while the experimental groups were taught with the IBL lesson. Students in the experimental group performed 4 IBL tasks that have been redesigned from conventional tasks in students' textbook.

2.2. Data Collections

To analyze the result of the first research question, a comparison between experimental and control group was made. A questionnaire was given to analyze students' attitude towards science. The questionnaire was given in two steps: 1) before the research started (pre-test), 2) at the end of this research (post-test). An attitudinal scale adapted from Fraser's (1978) Test of Science Related Attitude (TOSRA) instrument was used to assess the influence of the IBL lessons on students' attitude toward science. For this study, we adapted the scale to fit our specific context. Thus items were reduced from a total of 70 Likert-type items to 30 items, 10 for each interest construct which are enjoyment of science lessons, leisure interest in science, and career interest.

Meanwhile, to answer the second research question, recorded activities and the field notes were collected and compiled together in an observational sheet. The observational sheet contains a record of cognitive processes of the students when working with an inquiry task. To support findings emerging from the observational sheet, the teachers were also interviewed. Each interview was conducted after the teacher had performed the four IBL lessons in order to gain more knowledge or opinions on conditions that might be seen as a limiting or supporting condition towards IBL implementation in the class. The data from the observational sheet as well as from the open interview with the teacher was coded and combined into one transcript separately.

2.3. Intervention Program

We designed four IBL lessons, each composed of 2x45 minutes. We designed the IBL lessons by, firstly, redesigning the conventional task from students' textbook into a task supporting IBL, a task that has a meaningful context, gains multiple solution, enable students do the inquiry and encourages students to collaborate and communicate [13]. Secondly, we developed a Hypothetical Learning Trajectory (HLT) that consisted of learning goals of the students, students' activity, hypothesis of the process of the students' learning, and teacher's activity [14] as a guidance for redesigning the lessons. For our research, we added an extra column on the HLT table, namely 'connection to IBL' to provide a clear direction for us to examine which part of the HLT presented an IBL characteristic, and the kind

of IBL characteristic. We adapted the aspect of the IBL from the MASCIL Project [15] to set our own IBL characteristic that we want to see presented in the lessons. They are: students do the inquiry, display collaboration and communication (collaboration), explain situation and phenomenon (exploration), and use their knowledge to find solution (owning solution by themselves).

3. Result and Discussion

The first research question addresses the influence of IBL lessons on Indonesian students' attitudes towards science. Both the experiment class as well as the control class were given pre-questionnaires to measure their attitudes before the intervention and post-questionnaires to measure students' attitude after the intervention. The change of their attitude is shown in Table 1.

We expected that the use of IBL lessons in both schools would increase the interest of students in science. The main finding of this explorative study suggests the IBL lessons did not have effect on students' attitude towards science. On one school students showed more negative attitudes after the IBL interventions, while in the other school students showed similar score after the IBL lessons. These findings are in contrast with prior research which has delved into the connection of IBL learning with students' attitude toward science [6, 16] and revealed that students can become more engaged and develop more interest by IBL.

Table 1. The result of pre- and post- questionnaires on students' attitude towards science

	School 1				School 2			
	Experiment class		Control class		Experiment class		Control class	
	pre	post	pre	post	pre	post	pre	post
Enjoyment	3.8	3.7	4.2	4.0	3.5	3.5	3.4	3.4
Career interest	3.5	3.6	4.0	3.7	3.4	3.4	3.2	3.2
Leisure interest	3.5	3.5	3.6	3.5	3.3	3.3	3.2	3.2

There are possible explanations on why IBL lessons did not have positive impact in our research. Firstly, most studies on students' attitude mostly offered in a longitudinal study [e.g. 17, 18] so therefore we assumed that we cannot conclude either a positive or negative relationship between IBL and the students' attitudes due to the short time of conducting this research. Secondly, an incomplete implementation of our intervention had hindered us to see the impact of IBL and students' attitude. For example, some of the lessons had to suffer due to the time limitation. Thirdly, the result of independent t-test analysis suggests that this study need more sample/participants to better seeing the impact of IBL on students' attitude. And lastly, students struggling with IBL such as frustration/confusion for the unstructured tasks of the IBL might cause lower satisfaction in learning and less confidence than those in the conventional class [18].

The second research question addressed supporting and/or hindering factors that are found during the implementation of IBL lessons in daily practice in Indonesia. In this research, measurements were carried out using notes taking, video observations, and teacher interviews. The data collection from notes taken and video recordings during the classroom observations were compiled into one observational sheet. In the analyses, each of the IBL characteristic (inquiry, collaboration, exploration, and solution by themselves) were coded to look to what extent students were able to do the inquiry, display collaboration, and communication, explain situation and phenomenon, and use their knowledge to find solution by contrasting observations with the hypotheses that were formulated in our HLT. To support research finding from the observational sheet, interview with the teacher was conducted.

The results show that various factors influenced the implementation of our IBL lessons. We subsequently discuss the factors time, questioning techniques, task difficulties, insecurity of self-directed learning, and experience with group work.

3.1. *Time*. Both teachers reported that some of the lessons performed suffered from insufficient time. Our finding is similar to that of earlier researchers on IBL that studied several obstacles for the IBL performance in class. For instance, according to Engeln, Euler & Maass (2013) as well as Ramnarain & Hlatswayo (2018) reported that IBL is very challenging for students because it is plainly more-time consuming approach [19-20].

3.2. *Questioning Techniques*. Our observations indicate that teachers face challenges in organizing and supporting the process of inquiry of the students. In order to facilitate the inquiry and problem-solving processes, a teacher must support questioning and sharing ideas in the class. However, from our observation, this can hardly be seen. Instead of buying time for the process of problem explorations of the students, the teacher often hurried up think-time students by spilling out the answers. From the observations, we can conclude that teachers were not familiar with strategic questions and mostly gave theoretical or rhetorical questions.

3.3. *Task Difficulties*. We have found that task difficulty was likely associated with the poor performance of IBL lessons in class. From the interview as well as observations we conjecture that students' puzzlement caused by the difficulty level of the tasks since the topic torque itself is difficult for students and that students were new to the unstructured design of IBL tasks. It was found that students often stop working when they got confused. Students' puzzlement was evident in the lessons. For example, in the fourth lessons, we observed the teacher said: "you can ask your friends next to you or come to me if you have no idea what to do with the task".

3.4. *Insecurity in Self-Directed Learning*. Students' autonomy in learning is also a characteristic of IBL. It is expected that when students learn with IBL they can do the exploration and owning of the solution by themselves. However, most notably, our observation was most students when they work on a problem given by the teachers were uncertain of their answers or approaches. Observation from the first lesson on the first school together with the third lessons on the second school confirmed that students frequently needed their teachers to validate their answer or approaches when working with the task.

3.5. *Experience with Group Work*. Our observation provides compelling evidence on the advantage of the group work in supporting the process of collaboration that becomes the characteristic of IBL. For example, our observation from the second lesson on both schools illustrated that when students work in groups most of them participate equally by sharing equivalent work with their team members. However, the excessive use of group work can also decrease students' enthusiasm when studying.

4. Conclusion

In summary, this study has shown that the implementation of IBL in Indonesian classroom was unrelated to a positive change in students' attitude toward science. Our findings indicate that both schools had slightly more negative attitude after the post questionnaires. Additionally, we found that the IBL lessons were impeded by time management of the lessons, questioning techniques used by the teachers, the unfamiliarity of the students with self-directed learning, and the task difficulties designed by the researchers. However, experience with the group work was proved to be essential in allowing students to experience more lessons using IBL.

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