Using inductive approach (IA) to enhance students’ critical thinking (CT) skills

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Abstract. CT skills are one of the skills required by students in facing the real world problems in 21st century era. They can be trained by using several approaches in science learning context. However, there is a little study focused to investigate the impact of IA toward CT skills. This present study investigated the implementation of IA to enhance students’ CT skills. The experimental study, which was one group pretest posttest design, has been conducted to garner data from participants. There were 36 students (grade XI) who contributed as participants and they came from one public senior high school in Indonesia. In order to obtain data, an instrument related to CT skills was developed dealing with physics concepts. This finding revealed that students’ CT skills enhanced in medium category based on normalized gain (N-gain). A consideration of the implication of this present study is a deep insight in students’ CT skills in Indonesian high schools.

1. Introduction
Teaching and learning physics, both in high school and college has to facilitate and train students in several thinking skills, namely logical, analytical, systematical, critical, and creative thinking, and also doing cooperation. These competences are required by students so as they can face the problem in 21st century in which they can utilize the fast alteration of technological development in competitive competition.

As a part of science learning emphasizing on thinking skill process, physics learning bridges these skills by a number of students’ activities. For instance, by cooperation project, collaborative task, and analyzing physics problems, students are given great opportunities to explore what they want understanding. Furthermore, contextual problems presented in physics learning also will generate the students’ habit to think critically and train imaginative thinking. This case show that physics concept can be a tool to instruct thinking skills (e.g. critical thinking).

In order to teach students critical thinking skills, contraction of knowledge in learning process has to bridge meaningful learning [1]. In this case, educators or teachers have to train student to think critically
both in analyzing and solving a certain problem dealing with what they learn. Students owning critical thinking are students who can identify, evaluate, and construct an argument and also solve the problems accurately [1,2]. Students who have critical thinking skills can help themselves or others in solving the faced problems.

Based on professional experience of author, there was a different condition between educational concepts and what teachers did in the classroom. Educators which referred to physics teachers were frequently training students to solve the physics problems in which students did not understand physics concepts comprehensively and deeply from what they did dealing with task problems. This situation caused students did not develop their reasoning skills to think solving the problems, and applying concepts from what they learned to factual life so that students’ critical thinking did not develop well. In addition, many teachers when they taught physics concepts did not support their classroom activities with developing higher order thinking skills such as critical thinking skills.

In fact, the different condition seemed in learning activities in the classroom. Students felt a difficulty when the teaching materials were provided in just equations only. The difficulty of students in comprehending physics concepts, caused students were hard to explain physics concepts related to the phenomenon happened in daily life. Additionally, physics teachers were rarely to give students good understanding and explanation of several rich context problems which train students’ critical thinking skills. The efforts of students comprehending the teaching materials were less—this case could be seen from task problems that were hardly done by students optimally. On the other hands, there were several students recalled the teaching materials that they learned, but actually, they did not understand well. This asserted that learning process that was experienced by students meaningless.

In order to make meaningful learning process, one of instructional approaches that can be utilized teachers in developing and enhancing students’ critical thinking skills is inductive approach (IA). IA emphasizes on observation, then taking inference from observation [3,4]. This approach is frequently called as an approach that is going from specific to the general. A learning process utilizing IA needs a learning environment in which students have to fell freedom from horrible and shame risk in proposing an argument, question, inference, and response [5,6].

IA is effective to enhance students’ critical thinking skills due to having appropriateness with students’ characters that tend to passive in embarking learning process. IA also highlights on thinking skills so that students can organize facts in one physics concept system, in which start from providing samples of some specific concepts to making inference, and students are depicted the additional samples of the same concepts in comprehending previous concepts.

According to all previous explanations, this present study investigated the enhancing students’ critical thinking skills with using IA in physics learning process. In the same vein, the research question in this present study was how the enhancement of students’ CT skill did when the learning process of students used inductive approach A consideration of the implication of this present study is to give deep insight dealing with implementation IA in Indonesia high school context.

2. Methods

This present study utilized pre-experimental method in which the participants of this present study were 36 students (grade XI) who were chosen using purposive sampling from population which was one public school in east Indonesia. One group pretest-posttest design was used so that this present study just used one group to garner data. Before participant conducting learning process, they were given pretest dealing with students’ critical thinking. After this condition, students experienced physics learning process during six meetings using IA. When the physics learning process finished, they had to contribute in posttest in which they were assessed their skills in critical thinking using the same instruments.

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< g > = \frac{s_{post} - s_{pre}}{s_{ideal} - s_{pre}}
\]

In order to measure students’ critical thinking skills, an instrument developed with instruments’ indicators referred to indicators of critical thinking developed by Ennis [7]. An instrument was
developed in multiple choice forms and it encompassed 15 items with five indicators. The five indicators utilized were: 1) giving basic or elementary clarification, 2) constructing basic support or skills, 3) making inference, 4) giving advanced clarification, and 5) governing strategy and tactics. Additionally, the validity and reliability of this instrument were valid \( (r = 0.7) \) and reliable \( (\alpha = 0.6) \).

Analysis obtained data in this present study could be divided into two sections: statistical descriptive and normalized gain (N-gain). First, statistical descriptive was utilized to make clarification dealing with baseline condition of participant considered by pretest and posttest score. These scores were also used to know the proportion of students’ achievement in critical thinking skills. Several properties such as mean, standard deviation, maximum and minimum score, and frequency distribution were depicted. N-gain (see equation-1) \[8\], then, was utilized to investigate the enhancing students’ critical thinking skills after the learning process using IA (see equation-1). There are three categories to distinguish categories of N-gain, namely high \( (g > 0.7) \), medium \( (0.3 \leq g \leq 0.7) \), and low \( (g < 0.3) \) which refer to Hakes’ categories \[8\].

3. Result and Discussion

This present study was embarked with carrying out unstructured classroom observation. The findings reveal that many students had a great difficulty in mastering physics concepts. When IA utilized as an instructional approach in the classroom, there was alteration of students’ interest dealing with learning activities in the classroom. IA in this present study was implemented in several meetings and could change the students’ critical thinking score based on posttest score if compared with pretest score (see table-1).

| Table 1. Depiction of descriptive statistics of pretest-posttest score of students’ critical thinking skills. |
|---------------------------------------------------------------|
| **Properties of descriptive Statistics** | **Statistics value** | **Pretest** | **Posttest** |
| Number of participants | 36 | 36 |
| Ideal score | 26 | 26 |
| Minimum score | 3 | 9 |
| Maximum score | 14 | 24 |
| Mean | 8.39 | 18.72 |
| Standard deviation | 3.55 | 5.12 |
| Variance | 12.60 | 26.21 |

| Table 2. Frequency distribution, percentage of students’ critical thinking skills and N-gain. |
|-----------------------------------------------|
| **Range of category** | **Category** | **Frequency** | **Percent (%)** | **N-gain** |
| G > 0.7 | High | 14 | 38.89 |
| 0.3 ≤ g < 0.7 | Medium | 18 | 50.00 | 0.607 |
| G < 0.3 | Low | 4 | 11.00 |

There was big gap between mean pretest and posttest score. This situation, indeed, could be affected by implementation of IA in physics learning process. Although we could not say that it is significantly different, indirect effect was emerged by IA through a number of students’ activities in the classroom. From descriptive statistics was clear that initial condition presented in pretest score depicted the lowness of students’ critical thinking skills, but the opposite situation was achieved in posttest score. In addition the highest proportion of N-gain was centered in medium category that showed IA was effective enough in strengthening critical thinking skills. The high category of N-gain also portrayed that there was meaningful learning process experienced by a number of students. But the least proportion of N-gain positioned some students had a little improvement in critical thinking skills. Many factors that affected
this situation, one of them were the level of students’ preparation before following learning process using IA.

From findings of this present study, we could say that there are pivotal role given by IA in enhancing students’ critical thinking. Several reason that support these findings: the syntax of IA supporting students’ interest and motivation during carrying out learning process, IA providing students great opportunities in constructing their physics concepts comprehensively, and IA giving feedback on students from what they learned in the classroom.

First, the physics learning process using IA engages students doing more activities in the classroom in contextual phenomena context. It was clear that whatever form of this always attracts students to be motivated because they were connected with their daily life. In the first time, they were faced in some problems provided by teacher dealing with a certain concepts to be learned. In this time, students were given huge opportunities to hypothesize why the problem was happened. Directly, students’ interest and motivation were constructed in themselves and these situation urged students enjoying their learning process. Entering the learning process, they carried out the number of scientific activities to obtain data that they want to acquire. These data would be utilized in supporting their hypothesis. The different situation was experienced students because they faced new context from what they saw in initial learning process. In the end of process, they had to argue related to generalization that have to be made by them through a number of specific obtained data. All these process, positioning students in many steps with diverse activities that make them no to bore in doing learning process. The further effect of these, students challenged to think critically to solve new context problem in different phase of IA.

Secondly, IA constructs the better conceptual understanding of students. Why this happened because learning design that was facilitated by educators or physics teachers directed in constructing a number of notions dealing with learned concepts. This was pivotal, new notion was frequently built in students’ mind would strengthen their conceptual understanding. The better conceptual understanding is the higher level of students’ critical thinking [9] because it has strong relationship with critical thinking. By responding process conducted by students during to understand the physics concepts such as to response question, and to infer finding result, the critical thinking students would improve from time to time [7].

The last, IA gave students some feedbacks from what they learned. In this case, argumentation process was constructed because a student had to interact with another student in the classroom and every person had a freedom to speak his argument dealing with the learned concepts. This feedback could reduce negative perception emerging in every student’s mind as long as learning experience such as misconception and wrong concept. This situation was also useful for educators to give new context from the learned concepts to real situation in students’ life and this urged students to think and apply the concepts critically.

4. Conclusion
We could take several conclusions from this present study dealing with implementation of IA in enhancing students’ critical thinking skills: implementation of IA enhancing students’ interest and motivation to physics learning process, IA enhancing student’s critical thinking mostly in medium category of N-gain. A consideration of implication this present study is deep insight related to implementation of IA in Indonesia high school in physic learning. Actually, this approach can widen to other field in science learning such as chemistry and biology. Using the large classroom and large participants also will strengthen the generalization that IA can improve or enhance critical thinking skills. Methodologically, IA can be considered as a new approach that needs to be implanted in many instructional models. For next research agenda, students-teachers interaction can be investigated during the implementation of IA—it has worth value.
5. References

[1] Bailin S 2002 Critical thinking and science education Science & Education 11 (4) 361-375.

[2] Abrami PC, Bernard RM, Borokhovski E, Waddington DI, Wade CA, and Persson T 2015 Strategies for teaching students to think critically: A meta-analysis Review of Educational Research 85 (2) 275-314.

[3] Prince MJ and Felder RM 2006 Inductive teaching and learning methods: Definitions, comparisons, and research bases Journal of engineering education 95(2), 123-138.

[4] Prince Mand Felder R 2007 The many faces of inductive teaching and learning Journal of college science teaching 36 (5) 14.

[5] NiDhiorbháin A and Ó Duibhir P 2017 An explicit-inductive approach to grammar in Irish-medium immersion schools Language Awareness 26 (1) 3-24.

[6] Witte, T. C. H., & Jansen, E. P. W. A. 2015 In search of the excellent literature teacher. An inductive approach to constructing professional teaching standards Teachers and Teaching 21 (5) 565-583

[7] Ennis RH 2002 A super-streamlined conception of critical thinking Faculty education. illinois. edu.

[8] HakeRR 1998 Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses American journal of Physics 66 (1) 64-74

[9] HitchcockD 2017 Do the fallacies have a place in the teaching of reasoning skills or critical thinking?. In On Reasoning and Argument Springer, Cham 401-408

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