Enhancement of problem solving ability of high school students through learning with real engagement in active problem solving (REAPS) model on the concept of heat transfer

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Abstract. This study aims to influence the enhancement of problem solving ability before and after learning using Real Engagement in Active Problem Solving (REAPS) model on the concept of heat transfer. The research method used is quantitative method with 35 high school students in Pontianak as sample. The result of problem solving ability of students is obtained through the test in the form of 3 description questions. The instrument has tested the validity by the expert judgment and field testing that obtained the validity value of 0.84. Based on data analysis, the value of N-Gain is 0.43 and the enhancement of students’ problem solving ability is in medium category. This was caused of students who are less accurate in calculating the results of answers and they also have limited time in doing the questions given.

1. Introduction
The development of an increasingly modern era as it currently requires the existence of human resources quality. One of the ways to improve the quality of human resources is education. Education conducted in Indonesia has a role to develop all the potential in students itself. One of the goals of physics learning should be build a student's initial knowledge, real-life experience and direct experience of the nature around related to daily life. However, the demands of curriculum is the student thinking ability. Thinking is included in the intellectual ability which is the ability that needed to execute various mental activities (thinking, reasoning and problem solving).

One of the indicators of intellectual behavior is the ability to solve problem (problem solving). Thus, a student is expected to have adequate problem solving ability that will help them in solving academic and non-academic problems. In addition, with adequate problem solving ability, it will facilitate students in faced work situations filled of various problems that must be resolved by them. According to Patnani [1], problem solving ability is needed by the students to face global competition, thus, students will be ready to plunge and participate in the world of work. Therefore, various efforts need to be conducted to improve problem solving ability in students. These efforts include improving students' ability related to their problem solving ability and improving the quality of teaching by repairing the methods and characteristics of teachers. Thus, it is expected that students will become more prepared if faced some problems, especially if they have been directly involved in the community. This because when solving a problem an individual not only needs to think, but they need...
to think critically to be able to see a problem and think creatively to be able to solve the problem. In an effort to solve the problems encountered, an individual will do the steps associated with the problem solving process.

The ability of problem solving is a complex problem solving skill that characterizes one of the most intelligent human activities. This is because in solving the problem an individual must be able to manage the information obtained. The ability of problem solving could be said very important for students because this ability will be used by students’ in the future in daily life. On the other hand, to achieve a real problem solving, students will gain new ability. This allows students to acquire a new complex rule rather than the rules used in the composite.

The ability of problem solving can strengthen students in their education, skills and personal life. The ability of problem solving in various learning contexts is essential for develop knowledge in innovative and creative ways and gaining insight [2]. Heller et al [3] states that problem solving is one of the main tools of physics learning. Heller et al [4] states that there are five stages to be scored in order to assess the problem-solving abilities. The five stages are as follows.

- Focusing the problem, can be developed through the form of images or words that can help students.
- Describe the problem into the physics concept, students can simplify the problem by doing by linking the problem with the concept of physics in terms of principles and physical symbols.
- Planning a problem-solving solution (student the solution), students create a framework of equations based on the relationships that have been proposed in the previous stage.
- Implementing execute the plan, students can manipulate equations, enter known numbers and solve algebraic problems.
- Evaluating the solution (evaluate the solution), the student must evaluate the answer and make sure that the answer is satisfactory.

Observing the importance of developing problem solving skills in physics learning, students are required to have these abilities accompanied by creativity in finding a solution to a problem. In the application of daily life students are required to work together or collaborate with others. In the learning activity, the teacher should also facilitate the students properly to develop the abilities. In this research, the model that will be applied to improve problem solving ability is the Real Engagement in Active Problem Solving (REAPS) model.

The Real Engagement in Active Problem Solving (REAPS) Learning Model is a model developed in the USA. This model has been applied in elementary, junior and senior high school. The development of the REAPS model began in 2004 when Maker, Zimmerman and Schiever, in collaboration with doctoral students from Turkey, Saudi Arabia, Taiwan, Russia, and Egypt. They used three models together in a professional development project for teachers who were gifted in mathematics and Science from Korea [5]. The learning of this model is student-centered, through the incorporation of different problem-solving strategies. The REAPS model is a model that combines several models including Discovering Intellectual Strengths and Capabilities (DISCOVER), Thinking Actively in a Social Context (TASC) and Problem-Based Learning (PBL) to assist students in their learning process while they engage in meaningful real-life issues And science solving activities [6]. Merging the three models can be illustrated in Figure 1 below.

![Figure 1. Reaps Model](image-url)
In implementing the REAPS model planning is required based on guidelines that have been made. According to Maker et al [7] the REAPS model implementation guidelines are as follows:

- The first important factor is to identify the concept to be taught.
- Determine how to collect information about students' prior knowledge of concepts that would be developed during the learning process. The way to be conduct in this research is to do pretest before giving treatment of learning with REAPS model.
- Identify real life problems that students will solve. The problem that would be solved in this study related to the concept of heat transfer.
- Conduct case studies about this issue.
- Identify content of areas and general information about students, identify activities that would be undertake to organize students and learn the content from concepts, and developed the solutions for selected issues.
- Create a chronological learning activity format and identified the component models (PBL, TASC, DISCOVER) for each activity. For example, if you want students to explain certain phenomena thoroughly, the three REAPS components will be organized as follows: (a) DISCOVER: Problem type III + type of intelligence (e.g. artistic, linguistic and oral); (b) TASC: Students identified the main components and definitions of it phenomenon; and (c) PBLs: identified problems that contribute toward a particular phenomenon.
- After all activities have been sequenced, structured and followed the REAPS pattern, next step is preparing the resources needed for each activity, including fieldwork, visiting class by experts, and group projects.

Based on the description on the background, it is generally formulated the subject of this study is "how to improve students' problem solving abilities by Real Engagement in Active Problem Solving (REAPS) learning model on the concept of heat transfer?"

In general, the purpose of this research is to know the enhancement of students' problem solving ability with Real Engagement in Active Problem Solving (REAPS) learning model on the concept of heat transfer.

2. Methods

This research use experimental method. According to Sugiyono [8] experimental research methods can be interpreted as a research method that used to find the effect of particular treatment toward the others in controlled conditions. Beside, this research uses experimental method with experimental research design that used quasi experiment. Based on the data that has been collected, the researchers will analyzed, for example through identifying, summing, counting and so on, then with all the results researchers will describe the results of data analysis.

Meanwhile, the population in this study is the students of class X MIA in SMA Negeri 7 Pontianak in the academic year of 2016/2017 which has 4 classes with 132 students divided into 4 classes namely X MIA 1, X MIA 2, X MIA 3, and X MIA 4.

In this research, to determine the sample through technique by purposive sampling, it is using some selections which based on particular purpose or consideration. Consideration of sampling in this research was based on direct observation with physics teacher and case study at SMA Negeri 7 Pontianak. Based on that problem above the selected class is class X MIA 2 which have 35 students.

In addition, to obtain the data that support this research, the researcher compiled an instrument to answer the research. The test of problem solving ability tested in the form of a description. The test is given twice in pretest and posttest using the same problem. This test aims to measure students' problem solving abilities before and after the implementation of the Real Engagement in Active Problem Solving (REAPS) model. In measurement of this ability is limited by the problem solving ability according to Heller & Heller [4] which focuses on the subject matter, describes the problem, plots of problem solving, executes the plan, and evaluates the results that have been obtained.

On the other hand, to see the improvement of student problem solving ability, it was conducted the analysis of average score gain that normalized from pretest and posttest score. Giving pretest and
posttest in student problem solving abilities aims to be able to compare the problem solving ability of students before and after getting learning using Real Engagement in Active Problem Solving (REAPS) model. The data of problem solving ability of students is obtained from the result of pretest and posttest which is measured using description problem with score is in the range 0 - 14.

Thus, the scoring of the answers based on the steps used in this study refers to the guidance of problem solving scoring according to Huffman [9], however, the scoring criteria is following the Heller & Heller criteria [4] which can be seen in the Table 1.

### Table 1. Problem Solving Scoring Rubric

| Scoring Rubric          | Score | Description                                                                 |
|-------------------------|-------|-----------------------------------------------------------------------------|
| Focusing Problem        | 0     | No answer or does not work totally.                                         |
|                         | 1     | Describing the purpose of the questions with incomplete or create a list    |
|                         |       | knowing uncompleted.                                                        |
|                         | 2     | Describing the purpose of questions completely or create a list knowing     |
|                         |       | completely.                                                                 |
| Describing Problem      | 0     | No answer or does not work totally.                                         |
|                         | 1     | Writing asked completely, converging unit correctly, writing what is ‘known’ |
|                         |       | with physic signs incomplete and writing heat rate conduction formula.      |
|                         | 2     | Completing picture with physic signs, converging unit correctly, writing    |
|                         |       | what it is asked, writing what it is known with physic signs completely and  |
|                         |       | writing heat rate conduction formula.                                       |
| Planning settlement     | 0     | No answer or does not work totally.                                         |
|                         | 1     | Writing some components which include in planning but wrong.                |
|                         | 2     | Writing some components which include in planning but not all correct.      |
|                         | 3     | Writing some components which include in planning uncompleted and correct.  |
|                         | 4     | Writing some components which include in planning completely and correct.   |
| Implementing plan       | 0     | No answer or does not work totally.                                         |
|                         | 1     | Writing wrong answer but procedure which was doing incorrect or incomplete |
|                         |       | and no explanation.                                                        |
|                         | 2     | Writing wrong answer but procedure which was doing incorrect or incomplete |
|                         |       | and the explanation that less supported.                                   |
|                         | 3     | Writing correct answer but procedure which was doing incorrect or incomplete |
|                         |       | and no explanation.                                                        |
|                         | 4     | Writing the answer with processing and calculating procedure correctly, and |
|                         |       | the explanation fully supported by student answer.                         |
| Evaluating Result       | 0     | The result obtained wrong and the answer incomplete.                       |
|                         | 1     | • The answer result is correct but incomplete                              |
|                         |       | • The answer result is wrong but complete                                  |
|                         | 2     | The answer result is correct and complete.                                 |

### 3. Result and Discussion

Along with the development of era especially the 21st century that causes the problem solving ability including one of the abilities that student must have [10]. The ability of problem solving in this research means the ability of students to use knowledge based on experience and material of heat transfer that has been learned to solve various problems in daily life. Increasing ability problem solving students as a whole can be seen from the average score of pretest and posttest results that can be seen in Figure 2.
Figure 2. The diagram of pretest and posttest average score of students' problem solving ability

Based on Figure 2 the problem solving ability of students has an average value of Gain of (). The acquisition of average Gain then normalized to the N-Gain value, the result is 0.43. The N-Gain results are confirmed in the Hake [11] category, in this case the problem solving ability of students could be said in moderate.

However, the problem solving abilities used in this study consisting of the ability to focus on the subject, to describe the problem, to plan the problem solving, to implement the plan, and to evaluate the results that have been obtained [4]. Pretest and posttest averages on each indicator of problem solving ability that have measured can be seen in Figure 3.

Figure 3. The average of pretest-posttest score of problem solving ability of each indicator

Based on Figure 3, it can be seen that the average score of pretest and posttest result of problem solving ability of each indicator. The average pretest result score on the indicator focuses the subject matter of 45.24, describes the problem of 43.81, plans the problem solving of 20.48, executes the plan by 14.76 and evaluates the results obtained by 13.81. This is because the students are not yet familiar with the complete answer of each step, which is often done by the students is the writing is known without representing the matter into the picture, asked then the direct answer formula. As found in the student's answers during pretest, the student only writes briefly and has not been able to work to completion because the students only get matter of heat transfer at junior level. In addition, for the average posttest results respectively 78.10; 77.62; 46.19; 42.14 and 40.48. From Figure 3 it can be seen that if it is compared between the average score of pretest and posttest results, all indicators of...
problem solving ability have increased. The improvement of problem solving ability of students based on N-Gain calculation of each indicator can be seen in Figure 4.

Figure 4. Average N-Gain score of problem solving ability for each indicator

Based on Figure 4.6 it can be seen that the highest N-Gain is in the indicator focusing the subject matter (0.55) and planning the completion (0.55), while the lowest is in the indicator of implementing the plan (0.30) and evaluating the result (0.30). If the average N-Gain is confirmed in the category developed by Hake [11], then all indicators fall into the medium category. This was caused by students who are less accurate in calculating the results of answers and students also have limited time in working on the questions given. In general, problem solving ability have increased as a result of the application of Real Engagement in Active Problem Solving (REAPS) model.

However, the planning ability to solve problem has include in high category and highest increase because while doing pretest student still hesitate or does not know yet the material, meanwhile, at the time of posttest student need to learned and comprehend the material which can planning that problem solving. For the ability of focus on problem and describe the problem, students were not increase significantly, this is because students are usually write down the information contained in the problem that was presented, in this case the implementation of this model learning would not make students difficult if it required to know the subject matter firstly or understanding a problem before planning and resolving the problem that would face.

Therefore, this model is combination of three models that consisting of Discovering Intellectual Strengths and Capabilities (DISCOVER), Thinking Actively in a Social Context (TASC) and Problem-Based Learning (PBL). Problem-Based Learning (PBL) can help students in their learning process while they engage in meaningful real life issues and solving science activities [6]. The role of PBL in the REAPS Model is to facilitate teachers to integrate theory and practice, and to develop analytical and practical abilities in their students. One of the important goals of the PBL experience is that student can become independent learner. The REAPS model as a basic for developing the ability to solve real problems in a creative way is an approach that can be used with all students in a way that connects them to their communities, the environment, the animals and plants, and the people in it [12].

4. Conclusion
Based on the research that has been conducted from data analysis, findings and discussions that have been presented, it can be concluded that the improvement of problem solving ability of students with the provision of REAPS learning model can be said to increase with the N-Gain rating of 0.4 and in the medium category. The highest increase of indicators is in the indicator focusing the subject matter (0.55) and planning the settlement (0.55), while the lowest is in the indicator of executing the plan (0.30) and evaluating result (0.30). If the average N-Gain is confirmed in the category developed by Hake [11], then all indicators fall into the medium category.
The use of the REAPS model can be used in the learning process to improve problem solving and problem-solving skills especially on heat transfer materials. Students begin by investigating core topics related to real-world problems, then participate in activities, cooperate with classmates, and experience a series of steps in the problem-solving process [13]. Learning with REAPS model can be used as an alternative learning that can be used by physics subject teachers. Provision of practice questions, both of which are dealing with the number of problems and who related with the level of difficulty about the question really want to be, so that can be decided by the students in accordance with the time set. Completion of the timely question can provide teachers with longer opportunities to make feedback, so that teachers can correct mistakes during the learning process.

5. References
[1] Patnani M 2015 Upaya Meningkatkan Kemampuan Problem Solving Pada Mahasiswa Journal Psikogenesis 1 2 130-142
[2] Crebert G, Patrick C J, Cragnolini V, Smith C, Worsfold K and Webb F 2011 Problem solving skills toolkit. Retrieved from the World Wide Web, 4th April.
[3] Heller P et.al 1992) Teaching Problem Solving Through Cooperative Grouping Part 1: Group Versus Individual Problem Solving (Minnesota: Department Of Curriculum And Instruction, University Of Minnesota)
[4] Heller K and Heller P 2010 Cooperative Problem Solving In Physics A User’s Manual (US: University Of Minnesota)
[5] Maker C J 2016 Recognizing And Developing Spiritual Abilities Through Real-Life Problem Solving Gifted Education International 32 3 271-306
[6] Gomez-Arizaga M P, Bahar A K., Maker C, Zimmerman R and Pease R 2016 How Does Science Learning Occur In The Classroom? Students’ Perceptions Of Science Instruction During The Implementation Of Reaps Model Eurasia Journal Of Mathematics, Science & Technology Education 12 3
[7] Alhusaini A A F 2016 The Effects Of Duration Of Exposure To The Reaps Model In Developing Students’ general Creativity And Creative Problem Solving In Science (US: University Of Arizona).
[8] Sugiyono 2010 Metode Penelitian Kuantitatif, Kualitatif dan R&D (Bandung: Alfabeta)
[9] Huffman D 1997 Effect Of Explicit Problem Solving Instruction On High School Student’ Problem Solving Performance And Conceptual Understanding Of Physics Journal Of Research In Science Teaching 34 6 551-570
[10] OECD 2012 PISA 2009 Technical Report (PISA : OECD Publishing)
[11] Hake R R 1998 Interactive-Engagement Versus Tradisional Method: A Six-Thousand-Student Survey Of Mechanic Tes Data For Introductory Physics Course American Journal Of Physics 66 1 64-74
[12] Maker J, Zimmerman R, Alhusaini A and Pease R 2015 Real Engagement In Active Problem Solving (Reaps): An Evidence-Based Model That Meets Content, Process, Product, And Learning Environment Principles Recommended For Gifted Students New Zealand Journal Of Gifted Education 19 1
[13] Wu I C, Pease R and Maker C J 2015 Students’ Perceptions Of Real Engagement In Active Problem Solving Gifted And Talented International 30 1-2 106-121