Developing guided-inquiry-student worksheets to improve the science process skills of high school students on the heat concept

M Mahyuna, M Adlim and I Saminan
Syiah Kuala University, Jl. Teuku Nyak Arief Darussalam, Banda Aceh 23111, Indonesia
E-mail: adlim@unsyiah.ac.id

Abstract. Conventional student worksheets applied in schools had not been effectively improve the student creativity because the students were not trained science process skills in most lab practical activities. Practical works were only confirmation of lab procedure. The purpose of this research is to compose guide inquiry-based student worksheets using R & D methods with ADDIE model. The validated student worksheet was implemented at public senior high school in Banda Aceh by randomly sample the class from five parallel classes. After implementation, a test for basic science process skills was performed by students and students’ respond were collected using questioners. The finding showed that the student process skills were significantly improved after the guided-inquiry learning was implemented using the effective student worksheet. Most students recommended the guide inquiry students worksheet to apply in other classes because easy to understand, contextual and motivating students to do science investigation.

1. Introduction
Previously study had been explored remoteness of school location caused lower in quality of learning [1]. Later we found also nearly similar problems at public high school in the capital of Aceh. The school still uses conventional student-worksheets in science subjects. The conventional worksheet has not accommodated constructivism learning. The students just follow the fix laboratory procedure without activity of drilling students to do science skill process even in basic level. The basic science skill process that are hypothesizing, identifying tools and materials, analyzing data, and summarizing the results of the investigation.

One of the learning methods that accommodate the science process skills were guided inquiry and it is recommended as a learning method in 2013-national curricula [2]. Guided inquiry is a learning method that helps students to learn and acquire knowledge by themselves discovering what is being studied [3]. In guided inquiry, students are given a problem but the teacher will not provide the experimental procedure for the students, they have to develop by themselves under guidance of teachers. Unlike confirmation inquiry, the conclusion in guided inquiry cannot easily answered theoretically, it must come from the experimental work. The model also includes discovery of meaning, organization, and ideas, gradually they learn how to organize and conduct research to achieve the learning objectives. Guided inquiry student worksheets have been reported as an effectively method to improve learning outcomes, knowledge, attitudes and students skills [4-7]. Similar studies on other subject has also reported that guided-inquiry learning method
significantly improve the students’ science process skills, but teachers usually reluctant to perform due to time consuming and tide teaching schedule [8-11]. Guided inquiry module and the students’ worksheet have not been widely published commercially especially in high school physics of heat concept. Therefore, the purpose of this study is to develop guide-inquiry student worksheets and the impact on science process skills of student improvement.

2. Method
The guided inquiry student worksheet was developed by using R & D with ADDIE (Analysis, Design, Develop, Implementation and Evaluation) model. The implementation was carried out at public senior high school in Banda Aceh and 27 students on grade 11 were the participants. The students group (class) were randomly selected from five parallel classes in this target school based on similarity of previous student test scores. All stages of ADDIE procedure started from need assessment, analyses (A), designing (D), developing (D), implementation (I) and up to evaluation (E) were carried out. The student guided-inquiry worksheets were validated by 5 experts previously before implemented. Revision was conducted several times based on expert suggestion and respond from students and teachers following ADDIE steps. Instrument for basic science skills were modified from previously reported [12] and validated and test the reliability. Based on Spearman-Brown reliability tests, all test items were reliable but 11 out of 20 test items were removed due to low validity. Prior to worksheet implementation, pretest was administered to the students to examine their initial science process skills and posttest was carried out after implementation.

3. Result and discussion

3.1. Development of student guided-inquiry worksheet with ADDIE model
The need assessment found that the school has not have guided-inquiry module and the student worksheet. It was confirmed by interviewed, documented and direct observation. In design step, the revision has been done according to reviewers’ suggestion including adjustment on the font, color, illustration, inquiry learning syntax, adaptable language almost in entitle draft. Almost similar types of correction with some additional citation and references were performed on the step of develop. At implementation stage, the validator gave appropriateness score of 84.00, 83.33 and 80.00 for content, presentation and language of worksheet respectively. Four students’ worksheets were composed that were heat experiment, Joseph Black principle, conduction, convection and radiation. The list of contents was the title, the objective of project, the problem statement, material and equipment, hypothesis, experimental procedures, data analysis, conclusion, questions. After material and equipment section, there was instruction for students to read the problem statement, the objective, the material and equipment and a blank of observation table & experimental diagram given in experimental procedure before they wrote their experimental procedure.

3.2. Student respond on student guided-inquiry worksheets
Students’ response collected from on student worksheets were dominantly on positive response at the stage of strongly agree (19.4%), agree (62.9%), disagree (14.5%), strongly disagree (3.08%) toward several statements in questioners as describe the characteristic of guided inquiry worksheet. The worksheets were on experiment of heat and heat transfer for 5 groups of students with different projects: (a) heat experiment (kalor), Joseph Black principle (asas Black), conduction (konduksi), convection (konveksi) and radiation (radiasi). A representative quote of student worksheet and activities are described in Figure 1. The students were instructed to read the project problem statement, to observe the experimental diagram (pictures) in worksheet and to note the design-observation-data-sheet containing experimental variables. An experimental simulation was demonstrated before students start their project. Students, then, were asked to write their hypothesis, to write experimental procedure, to run project (collecting data), to analyze data and to write conclusion and to present the project accomplishment. Figure 1 was a representative of experimental
work conducted by students. The students compared the different of temperature elevation of fluid in the different color of containers (a black and a white tin). They recorded in observation sheet, analyzed and wrote the conclusion.

![Image](image_url)

Figure 1. (a) Student conducted the experiment at high school laboratory, (b) fragment of student guide-inquiry student-worksheet containing an experimental diagram to guide student to be able to compose their own experimental procedure.

3.3. Science process skills data analysis

The student science process skills data analysis is provided in Figure 2. It shows that the post-test scores increased significantly after applying the guided inquiry project where students were guided by the inquiry student worksheets. Guided inquiry learning model emphasizes the process of discovery of a concept that appears scientific attitude on students and can be designed for use by teachers according to the level of intellectual development of students [13]. The pre-test scores were only 55.5% and after treatment the post-test score was 90.2% and the gain was up to 34.7%. The students’ activities during the class were composing hypothesis, designing experimental, using tools, interpreting data, applying concepts and asking questions, classifying and stating the conclusion. Students were actively involved in class activities, so class was not boring and they enthusiastic to run experiment and confirming the previously [14]. This finding aligns to the previous study that inquiry learning in the laboratory gave significant effect on student science process skills [15,16].
Further analysis of student science process skills for each indicator component was presented in Figure 3. Generally, for all indicator components, post-test score was higher than the pre-test. Student skill on asking question represents a large gap between pre- and post-test. Each indicator shows high score and this consistent with previous study in different subject that implementation of inquiry learning let to improve the basic science process skill of students [17,18].

Giving a problem to the student will arise his curiosity, how to use the tool to solve the problem, the concepts needed for the solution and what method is appropriate for its completion. It will encourage them to use the knowledge and tools they already have and look for what needs to be known to solve the problem and teacher played important role on stimulate students to run the project [19].

![Figure 2](image2.png)

**Figure 2.** Comparison of pre- and post-tests before and after project implemented.

![Figure 3](image3.png)

**Figure 3.** Science process skills analysis categorization based on the indicator clusters.
4. Conclusion
Guided inquiry students’ worksheets have been developed and considered valid by experts. The validation score was 84 and highly appropriate in implementation for high school students as shown by high positive respond from students with distribution score of 82.3%. The students show their high capacity to use the worksheet in learning of heat transfer. Applying the worksheet in guided inquiry learning gave significant improvement on science process skills of students especially on this topic. The post-test score was 90.2% and the N gain was up to 34.7% after implementation of student worksheets.

Acknowledgment
We would like to thank public high school of SMAN 4 Banda Aceh who have participated in this research. High appreciation was addressed to instrument validators who gave significant contribution in this study.

Reference
[1] Adlim M, Soewarno S, Khairil, Usman, Hasbi, Hasmunir, Armia, Ishak and Yasin B 2014 Inter. J. Sci. Math. Educ. 12 817
[2] Kuhlthau C 2010 School Libraries Worldwide 16 17
[3] Wahyudi L E and Supardi Z A I 2013 J. Pend. Fisika 2 62
[4] Annafi N, Ashadi and Mulyani S 2015 J. Inkuiri 4 21
[5] Abdi A 2014 Universal J. Edu. Res. 2 37
[6] Alameddinea M M and Ahwalb H W 2016 Proc. Social Behavioral Sci 232 332
[7] Kitota A K A, Ahmada A R and Seman A A 2010 Proc. Social Behavioral Sci. 7 264
[8] Gormally C, Brickman P, Hallar B and Armstrong N 2009 Inter. J. Scholarship Teach. Learn. 3
[9] Astuti Y and Setiawan B 2013 J. Pend. IPA Indo. 2 88
[10] Yunus S R, Sanjaya I G M and Jatmiko B 2013 J. Pend. IPA Indo. 2 48
[11] Aristini N K D, Sudarman I K and Riastini P N 2017 e-J. PGSD Universitas Pendidikan Ganesha 5 1
[12] Herman 2015 J. Sains Pend. Fisika 11 120
[13] Dewi N L 2013 J. Pend Dasar. 3 1
[14] Chebib R, Samwuel W and Joel K 2012 Sci. Res. 3 1291
[15] Khan M and Iqbal M 2010 J. Strength for Today and Bright Hope for Tomorrow 11 169
[16] Rahmawati R, Haryani S and Kasmui 2014 J. Inovasi Pend. Kimia 8 1390
[17] Kitot A K A, Ahmad A R and Seman A A 2010 Proc. Social Behavioral Sci. 7 264
[18] Yasmin N, Ramdani A and Afriana A 2015 J. Pijar MIPA X 5 69
[19] Rauf R A A, Rasul M S, Mansor A N, Othman Z and Lyndon N 2013 Asian Social Sci. 9 47