The effect of discovery learning-based worksheet on students’ metacognition skill and learning outcomes

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Abstract. This research aims to improve metacognition skill and student learning outcomes by applying a discovery-learning-based student worksheet. The research method employed was the pretest-posttest with control group design. Samples of this research were class XI IPA 1 as the class of control and XI IPA 2 as the class of experiment selected using purposive sampling at MAN Banda Aceh. Aspects of metacognition skill assessed consist of planning skill, monitoring skill, and evaluation skills which were measured using a questionnaire of metacognition inventory. Learning outcomes were measured through the pretest and posttest. Data analysis using an independent sample t-test obtained the value of $t_{\text{count}} > t_{\text{table}}$ (7.076 > 1.998) and showed that there is any significant difference in learning outcomes between the experimental and control. The test of N-gain for the experimental group showed the improvement of learning outcome with a score of 0.67 as a medium category, whereas the control group was in the same category with a score of 0.41. Data on the student’s metacognition skills were obtained through questionnaires by 82%. The result implies that the application of a discovery-learning worksheet can improve the student’s metacognition skills and learning outcomes.

1. Introduction

Education has important roles to educate human resources. The learning outcome has seen a success determinant toward better education systems. One factor causing low learning outcomes for students lies in the learning process. Chemistry is one subject emphasizes the provision of direct observation by involving a number of skills and reasonings. These skills focus both on mastering concepts and the process of discovery. Students who are taught with science process skills in studying chemistry subjects can improve their academic achievement [1]. Learning achievement is influenced by many variables, some of the most important are cognitive, metacognitive, self-regulation and emotional intelligence learning strategies [2].

National education standards agency data shows the percentage result of the national examination for chemistry subjects at the Islamic high school level began to decline if viewed from the last three years. One to mention is MAN 1 Banda Aceh. In the academic year of 2014/2015, the result for student achievement reached 76.22; in 2015/2016 amounted to 59.04 and in 2016/2017 the capacity of students only reached 40.00. Based on the results of observations made at MAN Banda Aceh, it was learned that...
the students are lacked the awareness to learn especially in chemistry lessons. Besides they were also not active in learning activities so that it led to low learning outcomes.

The results of interviews with teachers exhibited that they have difficulties in applying the learning model included in the K-13 curriculum which demands inquiry learning, discovery learning, and problem-based-learning. All of these models require a scientific approach where students are required to be active in learning and thinking scientifically. Another factor is the lack of supporting media such as student worksheets. It is one of the teaching materials that ease the teachers in delivering the subject matter and it also acts as a guide for practical activities.

The observation results revealed that the worksheet in several MAN Banda Aceh was mostly obtained from publishers containing material, assignments and practise questions, but the worksheet was not accompanied by learning models. In accordance with the demands of the 2013 curriculum, a good worksheet is integrated with the learning model so that it can train students to gain knowledge of concepts and principles independently. The results of the study found by Chong et al. [3] reported that it allows students to understand the concept of metal bonding material. Learning that is accompanied by worksheets will be more effective in chemistry lessons than without using it [4]. The results of research conducted by Astra et al. [5] state that students are very enthusiastic in working on the activities involving discovery learning because it can develop and facilitates them in understanding concepts clearly. The discovery learning models equipped with worksheet affect the success of student learning outcomes in chemistry material [6]. Therefore it is necessary to utilize a worksheet to train students’ metacognitive skills so that they can improve their academic achievement.

2. Conceptual Framework
The research design carried out in this study a pretest and posttest with a control group design. The population in this research was 170 students of MAN in Banda Aceh. The sample selection used purposive sampling, class XI IPA 1 as the control class and XI IPA 2 as the experimental class with students. The data obtained in concern of learning outcomes were analyzed using the normality and homogeneity test.

Determining the improvement of student learning outcomes was analyzed by the N-gain test. This test used a formula developed by Hake [7], namely: calculating the difference in the posttest score with the pretest score compared to the difference between the maximum score and the pretest score. The questionnaire metacognition used in this study has gone through the validation stage and is adapted from Cooper et al. [8]. The questionnaire contains 20 positive statements. Metacognition skills measured include planning skills, monitoring skills, and evaluation skills. These skills questionnaire data were measured with a score of 1-4, then the score was converted into the value of metacognition skills. The average score obtained was later interpreted as the result of metacognitive skills level analysis in accordance with the criteria by Adita and Azizah [9] that 0-20 (very undeveloped), 21-40 (undeveloped), 41-60 (sufficiently developed), 61-80 (developing), 81 -100 (very developing).

3. Research Aim and Question
The implementation of a discovery learning-based worksheet was seen from two aspects, namely the skills of metacognition that were assessed using questionnaires and learning outcomes which was assessed by performing pretest and posttest. Before the implementation, the experimental and control classes classified. The discovery learning-based worksheet was applied in the class alone, while the control class was not.

3.1. Metacognition Skill
Metacognition assessment was done by using a questionnaire that aims to find out the thinking process of the students themselves that cannot be observed only by conducting field observations. Metacognition skills measured include three components, they are planning skills, monitoring skills, and evaluation skills [10]. The assessment of metacognition skills can be seen in Figure 1.
Based on Figure 1, it can be seen that the scores of the control class and the experimental class in metacognition skills have different mean values for each indicator. Planning indicators is a major component that plays an important role for students in solving problems. The ability that is assessed on planning indicators is those concerning managing initial knowledge, identifying objectives, sorting out important information, making investigations to solve problems and determining the time needed to solve problems. The average value of metacognitive skills of control and experimental class with each value of 67% with a fairly developed category and 84% with criteria ‘developed’, respectively.

The second indicator is monitoring. The indicators assessed are checking various stages, asking friends, identifying problems and correcting wrong answers. The average value obtained 64% and 82% with the developed category for the class of control and experiment, respectively. The last skill is evaluation, this stage is very important to be applied by students during the learning process because it is related to accuracy. The assessed ability was checking the final answer and verifying the answers that have been given. The average value of the control class and experimental class metacognition skills is 65% and 80% with developed criteria, respectively.

Overall, the average percentage of metacognitive skills of control class students is in fairly developed criteria, while in the experimental class the categories develop both on planning, monitoring, and evaluation skills, hence almost all students experience the development of metacognitive skills. The difference in the range of values far enough between the control class and the experiment is caused by the control class was treated in the absence of the discovery-learning worksheet. Meanwhile, the experimental class used the worksheet. This statement is supported which stating that students who are taught with discovery learning models can improve their metacognition and learning outcomes [11].

According to [12] the higher the value of student metacognition skills that a student has, the higher proportionate it would contribute to the learning outcomes, and vice versa if students are not empowering metacognitive skills, their learning would be low. Eriawati revealed that the high value of metacognitive skills makes students care and give a positive response when learning takes place and they will try to take the learning process seriously and actively during the teaching of ecosystem material [13].

Metacognition skills must be more often trained and familiarized so that students can measure their ability to learn [14]. Metacognitive development becomes something important to consider in the learning process [15,20]. Cognitive and metacognitive strategies have a synergistic relationship in improving students’ academic performance [16,21]. In accordance with the research explaining that metacognition skills need to be developed in an attempt to support the students’ success in completing
tasks, this skill depends on the awareness of what is known and how to apply it or it is named cognition [17]. A similar study was also conducted showing that metacognition skills need to be developed and applied to learning methods so that students are aware of their own thinking processes and know effective strategies in generating understanding by perceiving how much time is needed to learn something [18,22].

3.2. Cognitive Learning Outcomes

Statistical tests were carried out in this study to see the increase achieved in the students’ learning outcomes by conducting a prerequisite test, which is normality and homogeneity test. The results of processing data can be seen in Table 1.

Table 1. Normality and homogeneity test to score pretest, posttest, and N-gain.

| Learning outcomes | Classes | Normality | Homogeneity |
|-------------------|---------|-----------|-------------|
| Pretest           | Experiment | 0.255      | 0.403       |
|                   | Control   | 0.247      |             |
| Posttest          | Experiment | 0.127      | 0.148       |
|                   | Control   | 0.225      |             |

Table 1 above that the normality test of the experimental class pretest value is 0.255 and control class 0.24, it is stated that both classes are normally distributed and have the same variance of 0.403. The learning outcomes of the posttest values in both classes have also met the categories of normality and homogeneity with the values obtained greater than the 0.05 significance. Furthermore, hypothesis testing was done by using the t-test utilizing SPSS version 20. The results of the t-test are presented in Table 2 below.

Table 2. Test of different for averaged pretest, posttest and N-gain of student learning outcomes.

| Source of data | Classes | t-test | Conclusion |
|----------------|---------|--------|------------|
| Pretest        | Experiment | 0.718  | 1.998      | No difference |
|                | Control   |        |            |
| Posttest       | Experiment | 5.683  | 1.998      | Different     |
|                | Control   |        |            |
| N-gain         | Experiment | 7.076  | 1.998      | Different     |
|                | Control   |        |            |

In Table 2 it can be seen that the pretest mean difference test is 0.718 <1.998, which leads to the conclusion that there are no significant differences in the pretest of both classes. This indicates that the two classes have the same academic ability before the application of the worksheet in the treatment phase. The difference test of the average posttest value is 5.683> 1.998, which implies that there are significant differences in cognitive learning outcomes between the two classes. Experimental class students who used the discovery-learning worksheet gained higher learning outcomes than the control class whose grades are lower without using the worksheets. The results of this study are supported that the use of worksheets accompanied by guided discovery models can improve student learning outcomes [19,23].

Improved learning outcomes of students tested with N-gamin values showed that the experimental class has a higher value than the control class which can be seen in the average difference test for the two classes the values obtained were 7.076> 1.998. Based on the average N-gain value obtained in Table 2, it shows that there is a significant difference between the experimental class and the control class. A significant difference in the two classes is due to the influence of the application of discovery-learning...
worksheet that has effects on student learning outcomes. Data on the learning outcomes increase of experimental and control class students are provided in Table 3.

**Table 3. Average score of pretest, posttest and N-gain**

| Classes  | Learning outcomes | N-gain |
|----------|-------------------|--------|
|          | Pretest | Posttest |        |
| Experiment | 41     | 81     | 0.67   |
| Control   | 40     | 64     | 0.41   |

The application of worksheet based on discovery-learning on buffer solution method is able to improve student learning outcomes, but the increase obtained is still in the moderate category as evidenced by the results of statistical testing obtained N-gain value of the experimental class of 0.67, while the control class of N-gain value is 0.41. Worksheet based on discovery learning trains students to find their knowledge independently through a series of procedures contained in the model that can train skills and act like scientists in identifying problems, formulating hypotheses, proving hypotheses, and being able to generalize to the results obtained.

4. **Conclusions**

Based on the results of the research that has been done, it can be taken some conclusions, namely, the first application of worksheet based on discovery learning can improve student metacognition skills. Secondly, there are differences in cognitive learning outcomes between the experimental class and the control class. Then experimental class N-gain test results obtained an increase in learning outcomes of 0.67 moderate categories, while the control class was 0.41 as medium criteria. Therefore, the use of worksheets in the class of experiment obtained higher learning outcomes compared to the class of control.

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5. **References**

[1] Chebii R, Samwuel W and Joel K 2012 Effect of science process skills mastery learning approach on students’ acquisition of selected chemistry practical skills in school *Scientific Research* 3 1291

[2] Noghhabae M S 2016 The impact of cognitive and metacognitive strategies on self-esteem and selfefficacy in students *International Journal Of Humanities And Cultural Studies* 3 983

[3] Chong V D, Salimah M S and Irene P A 2013 Using an activity worksheet to remediate students’ alternative conceptions of metallic bonding *American International Journal of Contemporary Research* 3 39

[4] Celikler D 2010 The effect of worksheets developed for the subject of chemical compounds on student achievement and permanent learning *Educational Research Association The International Journal of Research in Teacher Education* 1 42

[5] Astra I M, Hadi N and Nur D M 2015 Development of student worksheet by using discovery learning approach for senior high school student *Journal of Education in Muslim Society* 2 91

[6] Kurnianto H, Masykuri M and Yamtinah S 2016 Pengaruh model pembelajaran discovery learning disertai lembar kegiatan siswa (lks) terhadap prestasi belajar siswa pada materi hidrolisis garam kelas xi sma negeri 1 karanganyar tahun pelajaran 2014/2015 *Jurnal Pendidikan Kimia* 5 32
[7] Hake R R 1998 Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses American Journal of Physics 6 64

[8] Cooper M M, Sandi-Urena S and Steven R 2008 Reliable multi method assessment of metacognition problem solving Chemistry Education Research and Practice 9 18

[9] Adita E R and Azizah U 2016. Keterampilan metakognitif siswa melalui model pembelajaran inkuiri terbimbing pada materi pokok laju reaksi di SMAN 1 manyar gresik kelas xi Unesa Journal of Chemical Education 5 143

[10] Tanner K D 2012 Promoting student metacognition Journal CBE-Life Science Education 1 113

[11] Mawaddad N E, Kartono and Suyitno 2015 Model pembelajaran discovery learning dengan pendekatan metakognitif untuk meningkatkan metakognisi dan kemampuan berpikir kreatif matematis Journal of Mathematic Education Research 4 10

[12] Nuryana E and Sugiarbo B 2012 Hubungan keterampilan metakognisi dengan hasil belajar siswa pada materi reaksi reduksi oksidasi (redoks) kelas xi SMA negeri 3 sidoarjo Unesa Journal of Chemical Education. 1 83

[13] Eriawati 2013 Aplikasi keterampilan metakognitif dalam pembelajaran ekosistem di MAN rukoh Jurnal Biotik 1 60

[14] Schraw G and Moshman D 1995 Metacognitive theories Educational Psychology Review 7 351

[15] Mahdavi M 2014 An overview: Metacognition in education International Journal of Multidisciplinary and Current Research 2 529

[16] Hosseinilar F and Mohammad A K 2013 The effect of using cognitive and meta cognitive strategy on creativity level academic achievement of high school student International Research Journal of Applied and Basic Science 7 114

[17] Kamid 2013 Vol 3 Metakognisi siswa dalam menyelesaikan soal matematika (studi kasus pada siswa SMP berdasarkan gender) Edumatica 3 64

[18] Hidayah N, Syahmani and Iriani R 2014 Penerapan strategi metakognitif dengan model pembelajaran ikrar untuk meningkatkan hasil belajar pada materi larutan penyangga dan hidrolisis garam untuk siswa kelas xi-ipa sma darul hijrah putri martapura Jurnal Inovasi Pendidikan 5 1

[19] Aryani F and Hiltrimartin C 2011 Pengembangan LKS untuk metode penemuan terbimbing pada pembelajaran matematika kelas viii di SMP negeri 18 palembang Jurnal Pendidikan Matematika 5 129

[20] Halim A, Yusrizal, Mazlina H, Melvina & Zainaton 2018 Questioning skill of science teacher from the students perspectvie in senior high school Journal of Physics: Conf. Series 1088 012109

[21] Halim A, Yusrizal, Susanna and Tarmizi 2016 An Analysis of Students’ Skill in Applying the Problem Solving Strategy to the Physics Problem Settlement in Facing AEC as Global Competition Jurnal Pendidikan IPA Indonesia 5 1-7

[22] Halim A, Subhan and Halim L 2009 Development and Application of Diagnostic Test to Identify Students' Misconceptions of Quantum Physics Sains Malaysiana 38 543-550

[23] Halim A, Lestari D, and Mustafa (2019) Identification of the causes of misconception on the concept of dynamic electricity Journal of Physics: Conf. Series 1280 052060.