Science Get Journal
Vol. 01, No. 2, July 2024, 41-52
e-ISSN: 3062-6595

Implementation of the Problem-Based Learning Model to Improve Student Learning Outcomes on Green Chemistry Material in E Phase MAS MTI Batang Kabung, Padang City

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Article Information
Received: July 31, 2024
Revised: August 05, 2024
Online: August 21, 2024

Keywords
Problem-Based Learning, Green Chemistry, Student Learning Outcomes, Classroom Action Research

ABSTRACT

This study investigates the efficacy of problem-based learning (PBL) in enhancing student learning outcomes in Green Chemistry at MAS MTI Batang Kabung, Padang City. The research addresses the prevalent use of conventional teaching methods, which have resulted in low student engagement and academic performance. A classroom action research design, based on Kemmis and McTaggart's model, was employed. The study population comprised Grade X Phase E students from the 2023/2024 academic year, with a sample drawn from classes X.1 and X.2. Data collection methods included observation, questionnaires, documentation, and field notes. Analysis of learning outcomes utilized percentage techniques and t-tests. The implementation of PBL showed significant improvement in student learning outcomes. Average scores increased from 71.61% in the first cycle to 86.96% in the second cycle. These results demonstrate that PBL effectively enhances student performance in Green Chemistry education at MAS MTI Batang Kabung. This research contributes to the growing body of evidence supporting the use of active learning strategies in chemistry education, particularly in the Indonesian context. The findings suggest that wider adoption of PBL could lead to improved educational outcomes in similar settings.

Keyword: *Problem-Based Learning, Green Chemistry, Student Learning Outcomes, Classroom Action Research*

http://dx.doi.org/10.69855/science.v1i3.66
https://gpijournal.com/index.php/science
PUBLISHED BY : GetPress Indonesia

INTRODUCTION

Education serves as a crucible for shaping human resources (HR) through the learning process. High-quality HR is developed through effective and superior learning processes. Efforts to enhance the quality of learning can be observed through various aspects of students' abilities, personalities, and responsibilities (Utami, 2010).

Learning outcomes encompass all changes experienced by students after the learning process, including concept mastery, skill improvement, and attitudinal shifts. These outcomes are significantly influenced by the teaching methods employed by educators. The selection of appropriate media or learning models by teachers can have a profound impact on the results achieved by students. The use of engaging learning media combined with suitable instructional models can boost student learning activities, consequently leading to improved learning outcomes (Audie, 2019)].

Based on observational findings, the learning process at MAS MTI Batang Kabung in Padang City predominantly employs conventional teaching models, relying heavily on lecture-based methods. This approach results in teacher-centered learning, where educators maintain complete control over content delivery, leading to passive student engagement. Such conventional methods have proven inadequate in developing students' potential, rendering them increasingly obsolete in modern educational contexts. These traditional approaches fail to cultivate students' enthusiasm for learning, relegating them to mere recipients of information without active participation in the learning process. This passive engagement has emerged as a primary factor contributing to suboptimal learning outcomes (Matlala, 2021)

Despite educators' efforts to enhance the appeal of chemistry education by linking theoretical concepts to everyday applications, these initiatives have yet to significantly boost student engagement. Teachers have attempted to diversify their instructional models and methods, but student performance remains below desired levels. Current classroom dynamics reveal that active participation is largely confined to high-achieving students, while the majority continue to struggle with low academic performance.

To tackle the problem of inadequate learning results, the Problem-Based Learning (PBL) model offers a promising approach. PBL aims to help students construct new understanding by expanding on their current knowledge base, while also improving their ability to think critically and solve problems. This method works well with simulations, fostering comprehensive, collaborative learning. Unlike traditional lecture-based teaching, PBL supports the integration of ideas from various viewpoints.

Incorporating PBL into chemistry education, especially in the area of Green Chemistry, fits with modern educational philosophies that stress hands-on learning, critical analysis, and addressing real-world issues. This strategy is particularly relevant as environmental awareness and sustainable methods become increasingly crucial in chemistry.

This study aims to evaluate the effectiveness of PBL in improving student learning outcomes in Green Chemistry at MAS MTI Batang Kabung. By implementing this innovative pedagogical approach, we seek to address the current challenges in chemistry education and provide empirical evidence for its efficacy in enhancing student engagement and academic performance. The findings of this research may have significant implications for curriculum development and teaching practices in similar educational settings, potentially offering a model for transforming chemistry education to better meet the needs of 21st-century learners (Matlala, 2021). In the Problem-Based Learning (PBL) model, teachers primarily assume the roles of guides and facilitators. This approach requires students to identify real-world problems or analyze case studies before delving into the subject matter. PBL emphasizes student-centered learning, encouraging learners to develop self-directed learning skills and collaborate in groups to solve authentic, real-world problems. The model uses problem scenarios as stimuli to activate students' curiosity before they begin studying a particular subject. Recent studies have further reinforced the efficacy of PBL in various educational contexts. For instance, Almulla (Almulla, 2020) found that PBL significantly enhanced students' critical thinking skills and motivation in science education. (Affandi, Darmuki, & Hariyadi, 2022) reported improved problem-solving abilities and conceptual understanding among chemistry students exposed to PBL methodologies.

Furthermore, the integration of technology with PBL has opened new avenues for enhancing its effectiveness (Ramadhani, Umam, Abdurrahman, & Syazali, 2019) explored the use of digital platforms in conjunction with PBL, noting significant improvements in student engagement and collaborative skills. This blended approach aligns well with the evolving landscape of educational technology and the needs of 21st-century learners.

These findings collectively underscore the potential of PBL as a powerful pedagogical tool in chemistry education, particularly in addressing complex, interdisciplinary topics like Green Chemistry. By fostering critical thinking, problem-solving skills, and collaborative learning, PBL aligns closely with the goals of modern science education and the demands of an increasingly complex global environment.

Problem-Based Learning (PBL) is a student-centered educational approach where learners engage with subject matter through the experience of solving open-ended problems presented by an instructor. It is a teaching method in which complex real-world issues are given to students for analysis as part of their course of study (Kassymova, et al., 2020). PBL accustoms students to think critically and analytically, encouraging them to discover knowledge independently through active and creative learning (Pawson, et al., 2006). Through the PBL model, students are trained to cultivate curiosity towards available information to solve problems they encounter, forming the basis of the PBL process (Wahyuni, Slameto, & Setyaningtyas, 2018).

The PBL model requires students to learn critically and creatively, with the teacher acting as a facilitator. The collaboration between students and teachers in implementing PBL can enhance learning outcomes, as each phase of this model trains students' ability to seek information systematically, logically, and critically (Trianto). The use of PBL can foster motivation and learning activities among students, thereby leading to improved academic performance.

Enhancing student learning outcomes is a manageable endeavor that can accommodate the diverse characteristics of individual learners. This improvement is expected to assist students in comprehending chemistry more broadly, beyond just theoretical knowledge acquired in school. The implementation of PBL has been shown to contribute significantly to increasing the percentage of students achieving good grades in examinations. Prior to the introduction of PBL, the pass rate in exams was notably low. However, since the adoption of PBL, the number of students passing exams and achieving good grades has substantially increased compared to previous results (Sakir & Kim, 2020).

Based on the issues and background presented, this study investigates the application of the Problem-Based Learning (PBL) model to enhance student learning outcomes in Green Chemistry. The research focuses on Phase E students at MAS MTI Batang Kabung, Padang City, during the Odd Semester of the 2023/2024 academic year.

METHODS

This study employs a Classroom Action Research (CAR) design, conducted in four stages per cycle: planning, action, observation, and reflection. The research was carried out at Madrasah Aliyah Swasta (MAS) MTI Batang Kabung in Padang City, focusing on Phase E students from classes X.1 and X.2. The sample consisted of 34 students: 17 from X.1 (11 males, 6 females) and 17 from X.2 (9 males, 8 females).

The CAR procedure was implemented over two cycles, utilizing the Problem-Based Learning (PBL) model to enhance Green Chemistry education. The first cycle commenced with planning, group division, and implementation of learning activities involving group discussions and presentations. This was followed by observation and reflection phases. The insights gained from the reflection phase informed the planning of the second cycle. Cycle two began with identifying issues from the first cycle, developing a revised instructional design, and implementation with a focus on improvements based on previous experiences. This cycle also incorporated group discussions, presentations, and evaluation activities.

Data on learning outcomes were collected through cognitive tests, observations, and reflections. The effectiveness of the PBL model on student learning outcomes was assessed using statistical analysis.

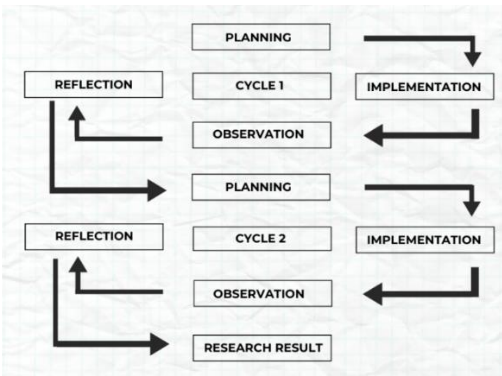

Figure 1. Research Cycle

RESULTS

A. Research Findings

1. Cycle I

Cycle I was conducted over four face-to-face sessions with students in the classroom. This cycle consisted of four stages: planning, action, observation, and reflection. The research findings obtained in Cycle I are as follows:

a. Observation Results

The observations in this study focused on student learning outcomes. Data on students' cognitive domain learning outcomes were obtained from a final test administered at the end of Cycle I. The final test was taken by 17 students. The test questions were presented in essay format, consisting of 7 items. Students were given 60 minutes to complete the test.

Table 1. Learning Outcomes Cycle I

No	Experimental Class	Control Class
Average	71,61	63,43

The analysis of student learning outcomes data was conducted to draw conclusions from the information obtained from the students' final evaluation results. This analysis focused on the students' competency in the knowledge domain of green chemistry. To achieve this objective, several statistical tests were performed on the Cycle I data, including normality tests, homogeneity tests, and hypothesis testing.

1) Normality Test of the Sample Class

Based on the tests conducted using SPSS 25 software, when compared with α = 0.05, the results indicate that the sample falls into the category of normal distribution. The results of the normality test can be seen in Table 2.

Table 2. Normality Test Results for Sample Classes in Cycle I

Research Class	Significance	Conclusion
Experimental Class	0,200	Normal
Control Class	0,200	Normal

The One-Sample Kolmogorov-Smirnov Test for normality revealed that both the experimental and control classes had significance values of 0.200, exceeding the 0.05 threshold. This indicates that both samples follow a normal distribution.

2) Homogeneity Test

The homogeneity test was conducted to analyze whether the two samples used have homogeneous or heterogeneous variances. This test was performed using SPSS version 25 software. The results of the homogeneity test can be seen in Table 3 below.

Table 3. Homogeneity Test Results for Sample Classes in Cycle I

Research Class	Significance	Conclusion
Experimental Class	0,697	Homogeneous
Control Class		

Based on the homogeneity test table above, it can be concluded that the cognitive learning outcome data for students in both the experimental and control groups are homogeneous. The homogeneity test produced a value of 0.697, where 0.697 > 0.05. Thus, it can be concluded that the learning outcome data from both sample groups are homogeneous.

3) Hypothesis Testing

Based on the normality and homogeneity tests that were conducted, it was determined that both classes are normally distributed and have homogeneous variances. Hypothesis testing was carried out using a T-test. The calculations, performed with SPSS 25 software, produced the results presented in Table 4.

Table 4. Hypothesis Test Results for Sample Classes in Cycle I

Research Class	Average Score	Significance	Conclusion
Experimental Class	71,61	0,697	H_0 rejected
Control Class	63,43		

Based on the hypothesis test using the independent samples t-test method, the obtained t-value was 2.193, while the t-table value was 2.037. Thus, t-value ($T_{calculated}$) exceeded the critical value (T_{table}) leading to the rejection of H0. Additionally, the t-test calculation yielded a Sig-(2-tailed) value of 0.036 < 0.05, with a significance level $\alpha = 0.05$, further confirming the rejection of H0 and acceptance of H1. Therefore, it can be concluded that the learning outcomes of students in the experimental class, where the problem-based learning model was applied, were significantly better than those of students in the control class, where conventional learning methods were used.

According to Table 4, it is evident that student learning outcomes were still low, as the percentage of students achieving mastery did not reach 75%. The competency in the knowledge domain of the students remained very low, as demonstrated by the final test results of Cycle I, where only 4 out of 17 students scored above the Minimum Competency Criteria (KKM). The highest score was 91.30, and the lowest was 56.52.

4) Reflection

In this stage, the researcher collected data obtained during the observation, including teacher activity observation sheets and student test results. This observational data was analyzed and then reflected upon through discussions with the observer. The reflection activity is a crucial step aimed at evaluating the results of the actions taken, identifying areas that need improvement, enhancement, or maintenance. This action represents a form of self-evaluation.

The outcomes of the reflection on the problem-based learning process implemented in Cycle I will serve as a reference for planning actions in Cycle II. The conclusions of the reflection, including causes and follow-up actions for Cycle I, are detailed in Table 5. From these reflective findings, solutions were sought and subsequently implemented in the next cycle.

Table 5. Reflection Results of Cycle I

No.	Reflection	Cause	Follow-up Action
1.	During the introductory activities, apperception, and motivation, some students were still not focusing on the teacher.	Lack of student concentration at the beginning of the learning process.	The teacher will politely address unfocused students and ask questions to ensure all students pay attention to the teacher.
2.	The students who asked questions and responded to the teacher's questions were the same individuals.	Many other students were unprepared and had not read the lesson material beforehand	The teacher will strive to distribute questions among all students and provide opportunities for different individuals to respond to questions from both the teacher and other students.
3.	During discussions, some students were still unfocused and playfully interacting with their group members.	This was due to students' concentration in learning not being well-controlled.	Before discussions, the teacher will inform students to focus and actively participate in their groups, and will note down students who play with their group mates.
6.	Limited time for presenting group discussion results, preventing all groups from presenting their findings.	The number of groups (four) combined with limited learning time.	The teacher will motivate students to manage their time effectively during group discussions, so that the first group to complete their task gets to present.

2. Cycle II

Cycle II was conducted over four face-to-face sessions with students in the classroom. This cycle, like Cycle I, consisted of four stages: planning, action, observation, and reflection. Based on the reflective outcomes of Cycle I, Cycle II was implemented, following the same procedural stages as the first cycle. The research findings obtained in Cycle II are as follows:

b. **Observation Results**

The observations in this study focused on student learning outcomes. Data on students' cognitive domain learning outcomes were obtained from a final test administered at the conclusion of Cycle II. The final test was taken by 17 students. The test questions were presented in essay format, consisting of 7 items. Students were allotted 60 minutes to complete the essay questions.

In Cycle II, the average learning outcomes for the experimental class reached 86.96, indicating a significant improvement in comparison to the control class, which had an average score of 74.68. This data demonstrates that the experimental class outperformed the control class, suggesting the effectiveness of the intervention or teaching method applied to the experimental group during this cycle. The results highlight the impact of the educational strategies used, potentially leading to enhanced learning achievements.

The analysis of student learning outcomes data was conducted to draw conclusions from the information obtained from the students' final evaluation results. This analysis focused on the students' competency in the knowledge domain of green chemistry. To achieve this objective, several statistical tests were performed on the Cycle II data, including normality tests, homogeneity tests, and hypothesis testing.

1) **Normality Test for Sample Classes**

Based on the tests conducted using SPSS 25 software, when compared with $\alpha = 0.05$, the results indicate that the sample falls into the category of normal distribution. The results of the normality test can be seen in Table 7.

Table 7. Results of Normality Test for Sample Classes in Cycle II

Research Class	Significance	Conclusion
Experimental Class	0,054	Normal
Control Class	0,084	Normal

Based on the normality test using the One-Sample Kolmogorov-Smirnov Test, the significance value for the experimental group was 0.054 (0.054 > 0.05), while for the control group, it was 0.084 (0.084 > 0.05), indicating that both groups follow a normal distribution. Thus, it can be concluded that both samples are normally distributed.

2) **Homogeneity Test**

The homogeneity test was conducted to determine whether the two samples used have homogeneous or heterogeneous variances. This test was carried out using SPSS version 25 software. The results from the homogeneity test are presented in Table 8 below.

Table 8. Results of Homogeneity Test for Sample Classes

Research Class	Significance	Conclusion
Experimental Class	0,71	Homogen
Control Class		

Based on the table above, it can be concluded that the cognitive learning outcome data of students in both the experimental and control classes are homogeneous. The homogeneity test yielded a value of 0.71, where 0.71 > 0.05. Therefore, it can be concluded that the learning outcome data from both sample classes are homogeneous.

3) Hypothesis Testing

Based on the normality and homogeneity tests that have been conducted, it was found that both classes are normally distributed and have homogeneous variances. The hypothesis testing was performed using a t-test. Calculations using SPSS 25 software yielded results as shown in the table below:

Table 9. Results of Hypothesis Test for Sample Classes

Research	ClassMean Value	Significance	Conclusion
Experimental Class	86,96	0,071	H_0 rejected
Control Class	74,68		

Based on the hypothesis test conducted using the independent samples t-test method, the obtained t-value was 4.076, compared to a t-table value of 2.037. Since t-calculated > t-table, H0 was rejected. Furthermore, the t-test calculation revealed a Sig-(2-tailed) value of 0.000, which is less than 0.05, at a significance level of $\alpha = 0.05$. This also supports the rejection of H0 and the acceptance of H1. Therefore, it can be concluded that the learning outcomes of students in the experimental class, which implemented the problem-based learning model, were significantly better than those of students in the control class that utilized conventional teaching methods.

4) Reflection

The chemistry instruction utilizing the Problem-Based Learning (PBL) model in Cycle II demonstrated significant enhancement compared to the learning process in Cycle I. This improvement is reflected in the rise in students' mastery rates of knowledge competency.

DISCUSSION

Based on the research findings, the application of the problem-based learning (PBL) model has effectively improved the chemistry learning outcomes of 10th-grade Phase E students at MAS MTI Batang Kabung. This enhancement is evident from the increasing test scores between Cycle I and Cycle II. The PBL model encourages students to focus on problem-solving and understanding conceptual material. Additionally, PBL acts as an alternative approach that can enhance learning outcomes (Stentoft & Thomassen, 2020) state that students who participate in problem analysis can develop the competencies required for the future.

After the intervention in Cycle I, a mastery percentage of 23% was recorded. The analysis of Cycle I revealed that the learning process using the PBL implementation had not yet met the 75% mastery criteria, indicating that the students' cognitive learning outcomes in Cycle I were not successful. This was attributed to students feeling confused and struggling to complete the provided student worksheets (LKPD). As noted by Majid (2013), learning difficulties can hinder students' efforts to achieve their learning objectives. Reflecting on Cycle I, the teacher took steps to enhance the learning process in Cycle II.

In Cycle II, a classical mastery percentage of 82% was achieved. The improvement in cognitive learning outcomes from Cycle I (23%) to Cycle II (82%) was 59%. This increase was due to students actively participating in the learning process and grasping the material presented to them. Overall, the learning process in Cycle II was considered successful, as it met the learning mastery criteria of 82%.

The lower cognitive learning outcomes of students using the conventional model, compared to those using the problem-based learning (PBL) model, can be attributed to several factors. The conventional model primarily relies on a lecture method, which positions the teacher as the active participant in explaining the material (Merrit, Lee, Rillero, & Kinach, 2017). his approach results in students being passive recipients of the teacher's explanations, leading to a one-sided learning experience. Moreover, the lecture method does not promote student responsibility or collaboration in completing tasks. This analysis is consistent with recent research on the effectiveness of PBL in science education. As noted by (Raman, Surif, & Ibrahim, 2024), PBL can significantly improve student engagement and learning outcomes in chemistry education.

The results of this study are in agreement with research conducted by Najma (Najma, 2017), which indicates that the use of the problem-based learning model can enhance student learning outcomes. The improvements observed in this study stem from the model's capacity to convert passive learning situations into active ones, compelling students to tackle the problems presented to them. This approach allows students to independently discover the knowledge being explored, thereby making the learning process clearer. Additionally, the problem-based learning model motivates students and strengthens their self-acquired knowledge. Other studies, such as (Wulan, 2018). also provide evidence that the implementation of the problem-based learning model can lead to increased student learning outcomes.

Several factors contribute to the effectiveness of this learning model. Primarily, it emphasizes the development of critical thinking skills and encourages students to engage in problem-solving related to real-life situations. Problem-Based Learning (PBL) motivates students to take an active role in the learning process and to create a product or project. PBL enhances students' understanding of chemistry concepts by allowing them to construct their own knowledge. During this learning process, students participate in activities such as observing, gathering data, analyzing problems, and engaging in critical thinking. By utilizing this model, students can improve their problem-solving abilities and intellectual skills.

CONCLUSIONS

This Classroom Action Research (CAR) was carried out in two cycles, with each cycle consisting of four stages: planning, action, observation, and reflection. Based on the results and discussion of the research, it can be concluded that the Problem-Based Learning (PBL) approach effectively improves student learning outcomes in chemistry at the E Phase MAS MTI Batang Kabung, Padang City, particularly regarding the topic of green chemistry.

REFERENCES

Affandi, Y., Darmuki, A., & Hariyadi, A. (2022). The Evaluation of JIDI (Jigsaw Discovery) Learning Model in the Course of Qur an Tafsir. *Int. J. Instr, 15*(1), 799-820.

Almulla, M. (2020). The Effectiveness of the Project-Based Learning (PBL) Approach as a Way to Engage Students in Learning. *SAGE Open, 10*(3). doi:10.1177/2158244020938702

Audie, N. (2019). Peran Media Pembelajaran Meningkatkan Hasil Belajar. *Posiding Semin. Nas. Pendidikan FKIP, 2*(1), 586-595.

Kassymova, E., Akhmetova, A., Baibekova, M., Kalniyazova, A., Mazhinov, B., & Mussina, S. (2020). E-learning environments and problem-based learning. *Int. J. Adv. Sci. Technol, 29*(7), 356-356.

Matlala, S. (2021). Education Perceptions and Views of Problem-based Learning Through Simulation. *Curationis*. doi:doi:10.4102/curationis.v44i1.2094

Merrit, J., Lee, M. Y., Rillero, P., & Kinach, B. M. (2017). Problem-based learning in K-8 mathematics and science education: A literature review. *Interdiscip. J. Porbl. Learn, 11*(2), 5-17. doi:10.7771/1541-5015.1674

Najma, S. (2017). Application of Problem Based Learning Model in Improving Students' Learning Outcomes on the Theme of Always Save Energy in Class Iv Min3 Banda Aceh. 1-23.

Pawson, E., Fournier, E., Haigh, M., Muniz, O., Trafford, J., & Vajoczki, S. (2006). Problem-based learning in geography: Towards a critical assessment of its purposes, benefits and risks. *J. Geogr. High. Aduc, 30*(1), 103-116. doi:10.1080/03098260500499709

Ramadhani, R., Umam, A., Abdurrahman, A., & Syazali, M. (2019). The effect of flipped-problem based learning model integrated with LMS-google classroom for senior high school students. *J. Educ. Gift Young Sci*, 137-158. doi:10.17478/jegys.548350

Raman, Y., Surif, J., & Ibrahim, N. H. (2024). The Effect of Problem Based Learning Approach in Enhancing Problem Solving Skills in Chemistry Education: A Systematic Review. *Int. J. Ineract. Mob. Techol, 18*(5), 91-111. doi:10.3991/ijim.v18i05/47929

Sakir, N. A., & Kim, J. G. (2020). Enhancing Students' Learning Activity and Outcomes via Implementation of Problem-based Learning. *Eurasia J. Math Sci. Techol. Educ, 16*(12). doi:10.29333/EJMSTE/9344

Stentoft, D., & Thomassen, A. O. (2020). Educating students for a complex future: Why integrating a problem analysis in problem-based learning has something to offer. *Interdiscip. J. Probl. Learn, 14*(2). doi:10.14434/ijpbl.v14i2.28804

Trianto. (n.d.). *Designing Innovative, Progressive, and Contextual Learning Models.*

Utami, N. (2010). Mathematics Learning Experiment Using Think-Pair-Share (TPS) Method Reviewed from Students' Initial Abilities. Retrieved from http://eprints.ums.ac.id/id/eprint/8389%0Ahttp://eprints.ums.ac.id/8389/1/A410060208.pdf

Wahyuni, I., Slameto, S., & Setyaningtyas, E. W. (2018). Implementation of PBL Model Assisted by Role Playing to Improve Motivation and IPS Learning Outcomes. *J. Ilm. Sekolah Dasar, 2*(4), 356. doi:10.23887/jisd.v2i4.16152

Wulan. (2018). Implementation of Problem Based Learning (PBL) Model to Improve Student Learning Outcomes in Social Studies Subjects of Class IV MI Islamiyah Sumberrejo Batanghari in the 2017/2018 Academic Year. *Universitas Islam Negeri Maulana Malik Ibrahim*, 1-100.