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Improving Cognitive Learning Outcomes in Chemistry through Google Forms and Paper-Based Assessment: A Classroom Action Research on Salt Hydrolysis

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ABSTRACT

This classroom action research investigated students' cognitive learning outcomes in chemistry on the topic of salt hydrolysis through different instructional strategies and assessment media. The study involved Grade 11 students at UII High School, Yogyakarta, and followed the Kemmis and McTaggart classroom action research model. Discovery Learning with Google Forms was implemented in the first cycle, followed by the Teams Games Tournament model with paper-based assessment in the second cycle. Both cycles achieved good learning outcomes, while the paper-based assessment provided a more controlled evaluation environment by limiting students' access to external information sources. The findings emphasize that assessment results should be interpreted by considering not only students' scores but also the assessment conditions. Appropriate alignment of instructional strategies, assessment media, and supervision is therefore important for evaluating cognitive learning outcomes in chemistry education, particularly in conceptually demanding topics such as salt hydrolysis.

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1. INTRODUCTION

Improving chemistry learning therefore requires attention not only to instructional content but also to the learning model and assessment conditions. Instructional strategies that actively involve students can support conceptual understanding and participation. Cooperative and student-centered approaches have been widely applied in science education to improve learning outcomes, motivation, and classroom interaction [1-4]. Discovery-oriented learning can encourage students to identify concepts through observation, questioning, and guided problem-solving. Such an approach is relevant to chemistry because students need opportunities to connect observable phenomena, chemical equations, and conceptual explanations. Previous studies on chemistry learning have shown that student-centered instructional approaches can support critical thinking and conceptual understanding [5, 6].

Cooperative learning is another approach frequently used in science education. Teams Games Tournament (TGT) combines group learning, academic games, and competition among teams. This structure can encourage students to work collaboratively, discuss concepts, and support group members during learning activities. Studies in science and related subjects have reported that TGT can improve learning motivation, engagement, collaboration, and learning outcomes [1-4]. Assessment media are equally important because learning outcomes are influenced by how tests are administered. Digital assessment tools such as Google Forms provide practical advantages in terms of accessibility, efficiency, and rapid data collection. However, unsupervised digital assessment may also allow students to access external information sources while answering questions. Under such conditions, high scores may not fully represent independent cognitive performance. Paper-based assessment provides a different testing environment because access to external digital resources can be more easily controlled. Therefore, changing the assessment medium may influence how accurately students' cognitive learning outcomes are represented. In classroom action research, differences between cycles should consequently be interpreted by considering both instructional changes and the conditions under which assessment is conducted.

Based on previous studies [7-10], the present study was conducted in the context of chemistry education at UII High School in Yogyakarta, Indonesia. It focused on salt hydrolysis and compared two classroom action cycles. The first cycle implemented Discovery Learning with Google Forms as the assessment medium, whereas the second cycle implemented TGT with paper-based assessment. The study aimed to improve students' cognitive learning outcomes while examining how different instructional strategies and assessment media influenced the interpretation of those outcomes. The novelty of this study lies in combining classroom instructional intervention with a comparison of assessment conditions in chemistry learning. Rather than interpreting score changes alone, the study considers whether the testing environment may influence the representation of students' actual cognitive abilities. Therefore, the study provides practical insight into the alignment of chemistry instruction, assessment media, and supervision in classroom learning.

2. LITERATURE REVIEW

2.1. Chemistry Learning and Salt Hydrolysis

Chemistry education involves understanding concepts that are often represented at macroscopic, microscopic, and symbolic levels. Students are expected to interpret chemical phenomena, relate them to particle-level processes, and express these relationships through equations and calculations. Salt hydrolysis requires this combination of conceptual and quantitative reasoning because students must identify ionic species, determine hydrolysis reactions, and calculate solution acidity or basicity.

Learning difficulties can arise when students memorize procedures without understanding the chemical relationships underlying the calculations. For this reason, chemistry learning should provide opportunities for active reasoning, discussion, and concept construction. Student-centered learning approaches can assist students in developing deeper understanding rather than relying only on procedural recall [5, 6].

In the present study, salt hydrolysis was selected because it requires both conceptual understanding and computational skills. The topic therefore provides an appropriate context for evaluating changes in cognitive learning outcomes when different instructional and assessment approaches are used.

2.2. Discovery-Oriented and Cooperative Learning

Student-centered learning approaches are frequently applied to improve science learning outcomes. Discovery-oriented learning emphasizes active involvement in identifying concepts through observation, investigation, and reasoning. Such approaches can encourage students to become more independent in learning and can support critical thinking when students are required to interpret evidence and construct explanations [5].

Cooperative learning provides a different but complementary instructional structure. Students learn through group interaction, shared responsibility, and collaborative problem solving. TGT is one cooperative-learning model that combines team activities with academic games and tournaments. Its competitive and collaborative structure can increase participation because individual performance contributes to group achievement.

Previous studies have reported positive effects of TGT on motivation and learning outcomes in biology, mathematics, social science, and science education [1-4]. Similar findings indicate that cooperative learning can improve chemistry learning outcomes when students are actively involved in discussing and solving subject-related problems [6].

TGT is particularly suitable for topics involving repeated conceptual and computational practice. In salt hydrolysis, students need to identify salt types, follow ionization processes, and determine pH. Group discussion and structured academic competition can therefore provide repeated opportunities to practice these processes while receiving support from peers.

2.3. Assessment Media and Cognitive Learning Outcomes

Assessment is an essential component of the learning process because it provides information about students' understanding and achievement. Digital assessment media are increasingly used because they can simplify test administration and data collection. Google Forms is one example of a widely accessible digital platform that can be used for pre-tests and post-tests. However, the interpretation of digital assessment results depends on the testing environment. When students complete online assessments without strict supervision, they may have access to external information sources. In such situations, assessment scores may reflect not only students' own knowledge but also their ability to locate information during testing.

Paper-based assessment limits access to online resources and can therefore create a more controlled testing environment. This does not automatically make paper-based assessment superior in all contexts, but it changes the conditions under which students demonstrate their cognitive abilities. Consequently, differences between digital and paper-based assessment should be interpreted carefully, especially when assessment supervision differs.

The present study uses this distinction as an important component of classroom reflection. Cycle I used Google Forms, whereas Cycle II used a paper-based test. The purpose was not merely to compare two assessment formats but to obtain a clearer representation of students' learning outcomes under different levels of access to external information.

2.4. Classroom Action Research in Science Education

Classroom action research is used to improve teaching and learning through iterative cycles of planning, action, observation, and reflection. The approach allows teachers and researchers to identify classroom problems, implement an intervention, evaluate the results, and use the findings to improve the next cycle.

In science education, classroom action research is useful because instructional difficulties often require context-specific solutions. The approach enables changes in learning models, assessment strategies, and classroom management to be evaluated within authentic teaching situations.

The present study follows this iterative logic. The findings from the first cycle were used to revise the instructional and assessment approach in the second cycle. The change from Discovery Learning with Google Forms to TGT with paper-based assessment was therefore part of the reflection and improvement process rather than a simple independent comparison between two unrelated conditions.

3. METHOD

3.1. Research Design

This study employed Classroom Action Research using the Kemmis and McTaggart model. The research was conducted collaboratively between the researcher and the chemistry teacher. Each cycle consisted of four stages: planning, acting, observing, and reflecting. The study used a descriptive approach to examine the learning process and changes in students' cognitive learning outcomes across the action cycles. Simple quantitative analysis was used to support the descriptive interpretation through calculation of mean scores and classical mastery percentages.

3.2. Research Participants and Setting

The study was conducted at UII High School in Yogyakarta, Indonesia. The participants were 19 Grade 11 students. The class was selected after observations indicated that student engagement and cognitive learning outcomes in salt hydrolysis required improvement.

3.3. Research Procedure

The study was conducted in two cycles.

(i) In Cycle I, the Discovery Learning model was implemented, and Google Forms was used as the assessment medium. The cycle began with a pre-test, followed by the learning activities, and concluded with a post-test. The results and observations from this cycle were used as the basis for reflection and subsequent improvement.

(ii) In Cycle II, the instructional strategy was changed to the TGT model. The activities included forming heterogeneous learning groups, conducting academic games, and implementing an intergroup tournament. The assessment medium was also changed from Google Forms to a paper-based test to reduce students' access to external information sources during evaluation.

3.4. Research Instruments

The research instruments consisted of pre-test and post-test questions. The post-test used a two-tier format designed to assess both answer accuracy and conceptual understanding. The first tier consisted of multiple-choice responses, while the second required a short justification of the selected answer. Scoring was conducted separately for the answer and justification. A correct answer received a score of 1, and an incorrect answer received 0. An appropriate justification received a score of 1, while an inadequate justification received 0. Therefore, the maximum score for each item was 2.

3.5. Data Analysis

Data were analyzed descriptively to evaluate the development of the learning process and students' cognitive learning outcomes in each cycle. Quantitative support was provided through calculation of the class mean and classical mastery percentage. The mean score was calculated using $\bar{x} = \frac{\sum x}{n}$, where $\bar{x}$ is the class mean, $\sum x$ is the total score obtained by all students, and *n* is the number of students. The classical mastery percentage was calculated using $P = \frac{\sum \text{students who passed}}{\sum \text{total students}} \times 100$, where P is the classical mastery percentage. Students were considered to have achieved mastery when they obtained a score of at least 75. The interpretation criteria are presented in **Table 1**.

Table 1. Criteria for evaluating the success of the learning process and outcomes.

PROFICIENCY LEVEL	QUALIFICATION
75-100%	Good (B)
50-74%	Fair (C)
<50%	Poor (K)

The study was considered successful when the percentage of classical mastery reached the Good (B) category, corresponding to at least 75%. Results from the two cycles were subsequently compared to evaluate changes in learning outcomes and to support reflection on the instructional and assessment strategies used.

4. RESULTS AND DISCUSSION

The classroom action research was implemented in two cycles to examine students' cognitive learning outcomes in salt hydrolysis under different instructional and assessment conditions. Cycle I combined Discovery Learning with Google Forms, whereas Cycle II combined the TGT model with paper-based assessment. The learning outcomes obtained in both cycles are summarized in **Table 2**. Both cycles met the predetermined criterion for successful learning because the classical mastery percentages exceeded the minimum threshold of 75%. Cycle I achieved a cycle average of 93.15 with 93% classical mastery, whereas Cycle II achieved a cycle average of 90.52 with 91% classical mastery. Although the numerical values were slightly lower in Cycle II, both cycles remained within the Good (B) category.

Table 2. Summary of student learning outcomes by cycle.

NO	COMPONENT	CYCLE I	CYCLE II
1	Pre-test average	87.36	85.26
2	Post-test average	98.95	95.79
3	Cycle average	93.15	90.52
4	Classical mastery	93%	91%
5	Qualification	Good (B)	Good (B)

The pre-test results also indicate that students entered both cycles with relatively high initial scores. The average pre-test score was 87.36 in Cycle I and 85.26 in Cycle II. These values suggest that the participants already possessed substantial prior knowledge of salt hydrolysis before the instructional activities. Nevertheless, the post-test scores increased in both cycles, reaching 98.95 in Cycle I and 95.79 in Cycle II. Therefore, the learning activities implemented in each cycle were followed by higher post-test performance.

In Cycle I, Discovery Learning was used to encourage students to explore and identify concepts during chemistry learning. This approach is consistent with student-centered learning principles in which learners actively construct understanding through observation, questioning, analysis, and problem-solving [5]. Chemistry topics such as salt hydrolysis require students to connect ionic species, hydrolysis reactions, and pH calculations. An instructional strategy that actively involves students can therefore support conceptual understanding rather than relying entirely on memorization.

The high post-test average obtained in Cycle I indicates that students performed very well after the Discovery Learning activities. Similar student-centered approaches have been associated with improved critical thinking and learning activities in salt hydrolysis and other chemistry contexts [5, 6]. However, the assessment in Cycle I was administered using Google Forms. This condition introduced an important issue during classroom reflection because students could access external online information while completing the test.

This concern does not mean that digital assessment is inherently inappropriate. Digital tools can provide practical advantages, including rapid administration, convenient data collection, and flexibility in learning environments. Online learning media have become increasingly common in educational practice and can support instructional continuity and accessibility [11]. However, when the purpose of an assessment is to measure students' independent cognitive performance, uncontrolled access to external resources can affect interpretation of the resulting scores.

Academic integrity is particularly relevant in this context. Access to outside information during assessment may influence whether responses represent students' independent understanding or information obtained from external sources [7]. Therefore, the very high numerical performance in Cycle I should be interpreted together with the conditions under which the assessment was administered. The classroom reflection did not treat the Google Forms scores as invalid, but it identified the need for a more controlled assessment environment in the subsequent cycle.

Based on this reflection, Cycle II implemented two changes. The instructional model was changed from Discovery Learning to TGT, and the assessment medium was changed from Google Forms to a paper-based test. TGT involves cooperative group activities, academic games, and intergroup competition. These features are intended to increase active participation and provide repeated opportunities for students to discuss and solve academic problems.

The use of TGT is supported by previous studies reporting improvements in motivation, interaction, and learning outcomes across different educational contexts [1-4, 8, 9]. In science education, cooperative activities can encourage students to exchange explanations and assist one another in understanding difficult material [9]. In chemistry, cooperative learning is also relevant because students frequently need to combine conceptual interpretation with calculations and symbolic representations [6, 10].

During Cycle II, students worked in heterogeneous groups and participated in academic games and tournaments. The activities were designed to provide opportunities for repeated practice of salt hydrolysis concepts. This was particularly relevant for identifying types of salts, understanding ionization processes, recognizing hydrolyzing ions, and calculating pH. The classroom observations reported in the original study indicated that students demonstrated active participation, asked questions, and showed greater attention while completing the learning tasks.

The post-test average increased from the Cycle II pre-test value of 85.26 to 95.79. Thus, even under the more controlled paper-based assessment condition, students maintained high cognitive performance after the TGT learning activities. The classical mastery percentage of 91% also remained substantially above the predetermined success threshold.

The difference between Cycle I and Cycle II should therefore not be interpreted simply as evidence that one instructional model was superior to the other. Two variables changed simultaneously: the instructional model and the assessment medium. Cycle I used Discovery Learning with Google Forms, while Cycle II used TGT with paper-based assessment. Consequently, the design does not permit the separate effect of the learning model and assessment medium to be isolated.

This distinction is important when interpreting the lower numerical scores in Cycle II. The cycle average decreased from 93.15 to 90.52, while classical mastery decreased from 93% to 91%. However, these decreases were relatively small, and both cycles remained classified as Good (B). More importantly, the second cycle used a testing environment in which access to external online information was more restricted.

For this reason, the Cycle II scores can be interpreted as outcomes obtained under a more controlled assessment condition rather than as evidence of declining student learning. The paper-based test required students to rely more directly on their own understanding during the assessment. This interpretation is consistent with the main purpose of the classroom reflection, which was to improve not only instructional activities but also the conditions under which students' cognitive outcomes were evaluated.

The comparison between cycles is visually presented in **Figure 1**. The figure illustrates the average results obtained during the initial and final evaluations in each cycle and makes the difference between pre-test and post-test performance easier to observe. Post-test performance exceeded pre-test performance in both cycles. This common pattern is more important pedagogically than the relatively small difference between the cycle averages. It indicates that students demonstrated higher scores after participating in the instructional activities in both Cycle I and Cycle II.

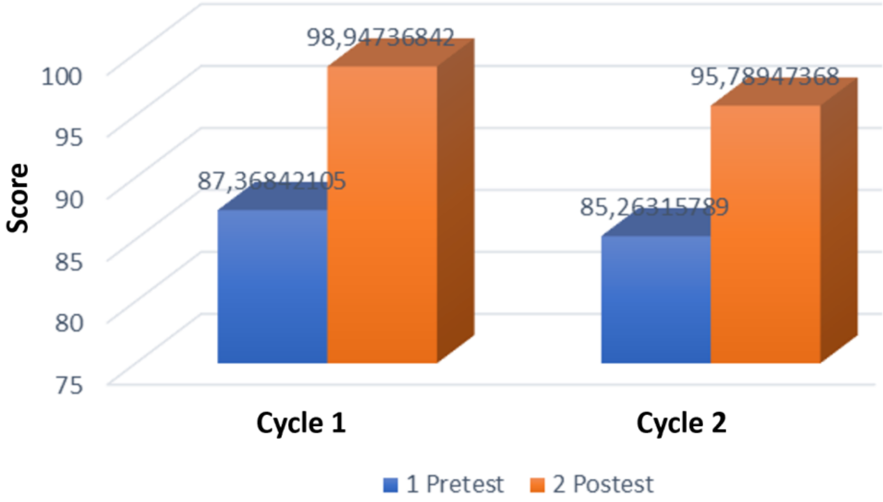

Figure 1. Average student results on the initial and final evaluations in each cycle.

The results also show the importance of considering assessment conditions when interpreting learning outcomes. A numerical score alone does not describe how the assessment was completed. Digital and paper-based assessments can produce different testing environments, especially in relation to access to external information. Therefore, teachers should consider the alignment between assessment objectives, media, supervision, and the cognitive abilities being measured.

This issue is particularly important in chemistry education. Chemistry assessments often require students to demonstrate conceptual reasoning, identify relationships among chemical species, and perform calculations. If students can readily consult external resources during an assessment intended to measure independent cognition, the resulting score may not fully represent their unaided conceptual understanding. Conversely, highly controlled assessment should also be balanced with instructional practices that support meaningful learning rather than simple recall.

The use of TGT in Cycle II provides another important implication. Cooperative learning can make repetitive practice more interactive and may reduce monotony during topics involving multiple calculations and conceptual classifications. Studies of TGT have reported positive effects on learning motivation and outcomes [1-4, 8, 9]. The present findings are consistent with this general direction because students retained high post-test scores and classical mastery after the implementation of TGT. However, the findings should be interpreted within the scope of classroom action research. The study involved a single class of 19 students and was designed primarily to improve classroom practice rather than establish causal superiority among instructional models or assessment media. The simultaneous change in instructional model and assessment medium between cycles is especially important. Therefore, the results support practical classroom reflection but do not demonstrate that paper-based assessment is universally superior to Google Forms or that TGT is inherently more effective than Discovery Learning.

The strength of the study lies instead in the iterative relationship among planning, action, observation, and reflection. The experience in Cycle I identified an assessment-related concern, and the second cycle modified the classroom strategy in response to that concern. This process illustrates the practical role of classroom action research in improving teaching and assessment conditions.

Table 2 and **Figure 1** demonstrate that both action cycles produced high cognitive learning outcomes in salt hydrolysis. Discovery Learning with Google Forms resulted in very high scores, while TGT with paper-based assessment maintained high learning outcomes under a more controlled testing condition. The findings suggest that chemistry teachers should evaluate learning outcomes not only from numerical achievement but also from the conditions under which those outcomes are measured.

The combined evidence also highlights the importance of aligning instructional strategy with assessment practice. Student-centered and cooperative learning can support active participation and conceptual development [5, 6, 8-10], while assessment media should be selected according to the purpose of evaluation. Digital assessment may be highly useful when accessibility and efficiency are priorities, whereas more controlled assessment conditions may be preferable when the objective is to evaluate independent cognitive performance. A balanced use of these approaches can support both effective chemistry learning and more appropriate interpretation of assessment outcomes.

5. CONCLUSION

This classroom action research showed that students achieved good cognitive learning outcomes in salt hydrolysis across both instructional cycles. Discovery Learning with Google Forms produced high achievement, while TGT with paper-based assessment maintained similarly strong outcomes under a more controlled evaluation condition. The findings emphasize that assessment results should be interpreted together with instructional strategies, assessment media, and supervision conditions. Paper-based assessment can reduce access to external online information when independent cognitive performance is being evaluated. Chemistry teachers should therefore align learning models and assessment environments with instructional objectives to obtain meaningful evidence of students' conceptual understanding and learning progress.

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7. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper is free from plagiarism.

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