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POGIL-Based Learning Tools to Improve Critical Thinking Skills and Self-Efficacy on Salt Hydrolysis Material

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Abstract

To carry out a learning process that can improve students' skills, appropriate chemistry learning tools are needed. This research aims to determine the characteristics and feasibility of POGIL-based learning tools, analyzing students' critical thinking abilities and self-efficacy before and after using POGIL-based learning tools. The research method used 4-D development model (Define, Design, Develop, and Disseminate). The subjects were 11th grade science student. Design were used pretest-posttest control group design. Learning tools developed are valid with a percentage of 93.7% in the construction aspect, 90% in the content aspect, and 100% in the language aspect. There was an increase in students' critical thinking skills and self-efficacy after using POGIL-based learning tools with the percentage of students' effective contribution in critical thinking skills being 30.5% and to self-efficacy 69.2% (both showed high contribute). This indicates that POGIL-based learning tools are feasible to improve students' critical thinking skills and self-efficacy.

Keywords: critical thinking skills, POGIL-based learning tools, salt hydrolysis, self-efficacy

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1. Introduction

The 21st century needs excellence in all human endeavors and outputs, as well as excellence in human resources, in order to compete on a global scale. Therefore, educational institutions should educate students about a different socioeconomic existence than before. Generally speaking, education is highly vital to ensure students have learning skills and innovation, to become savvy tech users in the field of information technology and media, and belongs survival skills with life skills where those skills demand the young generation in this century to be digital edge people (Salama, 2018; Lubis & Lubis, 2019; Hadinugrahaningsih et al., 2017).

Through the use of technology, information, communication, and collaboration, education provides students with the opportunity to refine and mold their thought processes in order to think critically, creatively, communicatively, and cooperatively (Gupta et al, 2015). Student's education in the twenty-first century must inculcate at least four competencies. The four skills include the capacity for critical and creative thought, effective communication, teamwork, and collaboration (Geisinger, 2016; Kennedy & Sundberg, 2020; Rotherham, & Willingham, 2010).

Based on interview and observation at SMAN 1 Singingi, students' critical thinking skills were still lacking, especially in chemistry lessons, during the learning process in the classroom, students tended to be passive. Besides that, learning with conventional methods makes students only listen and wrote what was explained by the teacher, so students' opportunities to ask questions, develop thinking processes and creativity were limited, which caused a lack of

understanding of the material being studied, resulting in low self-efficacy. Additionally, students also perceived chemistry as challenging and abstract, particularly in the context of salt hydrolysis material (Perdana et al., 2018; Pramesthi et al., 2019; Rohmah et al., 2023).

Chemistry is part of the Natural Sciences. In addition, chemistry mostly consists of abstract material that tends to require thinking skills in analyzing, synthesizing, and evaluating problems (Yerimadesi, 2019). Broman and Simon (2015) stated that students viewed that learning Chemistry was considered less relevant to their lives so it was one of the subjects that was considered difficult for students.

In the learning process, in addition to transferring a number of knowledges to students, fostering the attitudes and skills of students in an excellent and quality learning process also cannot be separated from a method or approach. According to Gupta et al. (2015), self-efficacy and critical thinking skills will develop when students interact with teachers, as well as among students. It can be realized by using learning media prepared with appropriate learning strategies. Besides that, the approach used in carrying out the learning process will also greatly determine the comfort and interest of students in learning.

According to Rusman (2010), learning media are things that must be monitored so that the implementation of learning is more directed to achieve the objective competencies. This means that there are components needed in carrying out learning activities to achieve learning objectives. Teaching without written preparation leads to teaching as lecturing and will result in ineffective learning because the teacher does not think in detail about what to do and how to do it (Dehghani et al., 2011). The success indicators for learning chemistry include teachers, students, lesson plans, student worksheets, supplementary books, learning strategies and methods used.

To be able to carry out a learning process that can improve students' skills, appropriate chemistry learning media are needed to achieve this goal. In developing learning media, an appropriate learning method is needed so that the expected learning objectives can be achieved. One learning model that can enhance critical thinking skills and self-confidence is Process Oriented Guided Inquiry Learning (POGIL). According to Moog et al. (2006) and Hanson (2006), POGIL is a process-oriented and learner-centered learning model in active learning. POGIL requires students to explore and solve problems with interesting applications for students which include the phases of facing problems, collecting data through experimentation, and analyzing data. These phases are expected to be able to improve critical thinking skills (Wulandari et al., 2013).

In this study the researcher chose the material salt hydrolysis. The word "hydrolysis" is derived from the word's hydro, which means "water", and lysis, which means "splitting or decomposition" (Chang, 2004). Hydrolysis is the reaction of decomposing salt by water or the reaction of salt ions with water. The weak base cation or weak acid anion of a salt, or both, can undergo hydrolysis through an equilibrium reaction with water to form H_3O^+ ions, this event is called salt hydrolysis. If hydrolysis produces H_3O^- ions or OH ions then the solution is acidic, but if hydrolysis produces OH^- ions then the solution is basic. The properties of a salt solution depend on the strength of the acid and base that form the salt (Brown et al., 2012; Jespersen et al., 2012; Robinson et al., 2020).

The POGIL-based learning media which will be developed by the researcher are based on the syntax of the POGIL model which is related to everyday life and each syntax includes indicators of critical thinking skills so that students' skills can be better than before, as well as self-efficacy, on devices that will be developed, students are required to be active in discussions and involved in practical activities. Using learning tools based on POGIL that are student-centered will be able to provide a good learning environment and

scientific literacy as a provision to face the 21st-century globalization era (Rahayu, 2018; Mu'minin et al., 2020; Ibnu & Fajaroh, 2018).

2. Research Method

The study was a type of research and development (RnD). Research and development is a research process of developing and implementing a product in learning activities to test the product. The product produced in this study was a learning medium based on POGIL including the form of a syllabus, lesson plans, worksheets, and instruments for students critical thinking skills and self-efficacy. The developed learning media contained salt hydrolysis material for the eleventh-grade students in semester of 2.

The development model used in this study was the 4-D model. According to Thiagarajan et al. (1974), research subjects or validators in media development research were a group of experts comprising chemical subject matter experts, media experts, and educators. Trial of the eleventh-grade students in class XI-MIA 1 as the experimental class, class XI-MIA-2 as the control class. In field trials, learning media were used in classroom learning to determine the percentage of learning implementation using POGIL-based learning tools, increasing students' critical thinking skills through pretest and posttest student learning outcomes, and students' self-efficacy through questionnaires given before and after using the development result learning media. Quantitative product trials were carried out through operational trials such as product implementation. Product implementation was carried out in the learning process in class. Product implementation used a quasi-experimental method with a pretest-posttest control group design. The sampling technique employed was Simple Random Sampling.

Data analysis techniques for the reliability of the developed learning media were gauged based on a questionnaire. This assessment was obtained from expert validation instruments, teacher assessments, peer reviewers, and student readability tests. Theoretical validation of learning media products was descriptive data in the form of input and suggestions from expert lecturers, educators, and peer reviewers as correctors (expert judgment) related to product development. Empirical validation was conducted by testing critical thinking and self-efficacy questions on students out of the trial subject.

The results of empirical validation were used to determine the validity and reliability of critical thinking questions and self-efficacy questionnaires. Data analysis from empirical validation results was carried out with the Winsteps program. To find out which items fitted the Rasch model and their reliability score, the Rasch model was used. Compatibility criteria with the Rasch model can be seen from the MNSQ INFIT score. The items were categorized to fit the Rasch model if the INFIT MNSQ score was at the acceptance limit between ≥ 0.5 to ≤ 1.5. Cronbach's alpha could be used to determine the reliability of the problem. An instrument could be categorized to be reliable if it had a Cronbach alpha value ≥ 0.70 (Gliem & Gliem, 2003).

Analysis of the research questionnaire on the development of POGIL-based learning media was carried out in steps; 1) The scores on the validation sheet questionnaire from each validator were tabulated for each aspect of the component, and 2) the total average score of each component was prepared with the following equation (De-Gale & Boiseelle, 2015):

$$\boldsymbol{X} = \frac{\sum \boldsymbol{X}}{\mathbf{n}} \quad (1)$$

Annotation:
X = Average Score
$\sum X$ = Total Score
n = The number of estimations

The average total score was converted into qualitative data with a scale of 5 to determine the quality of POGIL-based learning media. The reference for converting scores into criteria is in Table 1.

Table 1. Actual Score Conversion Guidelines

No.	Ranges of Score	Rating	Category
1.	X > (xi + 1.80 SBi)	A	Very Good
2.	(xi + 0.60 SBi) < X ≤ (xi + 1.80 SBi)	B	Good
3.	(xi – 0.60 SBi) < X ≤ (xi + 0.60 SBi)	C	Pretty Good
4.	(xi – 1.80 SBi) < X ≤ (xi – 0.60 SBi)	D	Poor
5.	X ≤ (xi – 1.80 SBi)	E	Very Poor

3. Result and Discussion

3.1. Results of Reliability Tests

The Reliability test of the learning media was conducted by three chemist teachers. The results of the assessment of the learning media product developed are as follows:

3.1.1. Syllabus

The syllabus reliability test consisted of construction, material, and language aspects. The assessment of the three validators was averaged for each aspect and then converted from scores to criteria (Widoyoko, 2011). The results of the syllabus assessment are presented in Table 2.

Table 2. Results of Syllabus Reliability Test

No.	Aspects	∑Sub Aspects	Average of Each Aspect	Ideal Percentage	Category
1.	Construction	4	15	93.75%	Very Good
2.	Material/Content	5	18	90%	Very Good
3.	Language	1	4	100%	Very Good

The results of the syllabus Reliability test by the validator have a "very good" category for each aspect. It can be concluded that the syllabus product developed is suitable for field testing.

3.1.2. Lesson Plan

The reliability test of the lesson plan consisted of construction, material, and language aspects. The assessment of the three validators was averaged for each aspect and then converted from scores to criteria (Widoyoko, 2011). The results of the assessment of the learning implementation plan are presented in Table 3.

Table 3. Results of Reliability Test of Lesson Plan

No.	Aspects	∑Sub Aspects	Average of Each Aspect	Ideal Percentage	Category
1.	Construction	7	27.33	97.6%	Very Good
2.	Material/Content	5	18	90%	Very Good
3.	Language	3	11	91.67%	Very Good

The results of the reliability test of the lesson plan by the validator have a "very good" category for each aspect. It can be concluded that the learning implementation plan product developed is suitable for the trial field.

3.1.3. Student Worksheet

The student worksheet reliability test comprised construction, material, and language aspects. The assessment of the three validators is averaged for each aspect and then converted from scores to criteria (Widoyoko, 2011). The results of the student worksheet assessment are presented in Table 4.

Table 4. Results of Reliability Test of Student Worksheet

No.	Aspects	∑Sub Aspects	Average of Each Aspect	Ideal Percentage	Category
1.	Construction	4	15.33	95.81%	Very Good
2.	Material/Content	7	26.67	95.25%	Very Good
3.	Language	4	14.33	89.56%	Very Good

The results of the reliability test of student worksheets by the validator have a "very good" category for each aspect. It can be concluded that the developed student worksheets are suitable for field tests.

3.1.4. Readability Test of Student Work-Sheet

The readability test of the student worksheet consisted of material and appearance aspects. Student worksheet readability test was assessed, because students were product users. The assessments of 30 students were averaged for each aspect and then converted from scores to criteria (Widoyoko, 2011). The results of the student worksheet readability test are presented in Table 5.

Table 5. Results of Readability Test of Student Worksheet

No.	Aspects	∑Sub Aspects	Average of Each Aspect	Ideal Percentage	Category
1.	Construction	4	14.8	92.5%	Very Good
2.	Appearance	6	21.7	90.42%	Very Good

The results of the student worksheet readability test by 30 students had a "very good" category for each aspect. It can be concluded that the developed student worksheets are suitable for field tests.

3.1.5. Results of Dissemination

The learning media which were created ultimately only saw minimal or no distribution, with teachers serving as the main means of distribution to schools. Furthermore, publication activities like compiling scientific journals and presenting them at seminars can be used to carry out the phases of the dissemination process.

3.2. Results of Empirical Test

Empirical validation tests on critical thinking skills and self-efficacy were carried out on 44 students who had received salt hydrolysis material. Then, an analysis of critical thinking skills and self-efficacy questions was conducted by using the Winsteps program. The results of the analysis resulted from critical thinking skills questions which consisted of pretest and post-test questions, each consisting of 10 description questions with the resulting reliability data of 0.94 for pretest questions and 0.95 for post-test questions, both are included in the very high category. The self-efficacy questionnaire also produces reliability data which is included in the very high category with a reliability value of 0.87. The pretest and posttest critical thinking skills questions which consisted of 10 description items were declared fit with the model. The MNSQ outfit score for the pretest is between +0.65 – +1.30 and the MNSQ outfit score for the posttest is between +0.58 – +1.30. The results of the analysis of the 20 self-efficacy questionnaire statements stated that they fit the model and could be accepted with an MNSQ outfit value between +0.52 – +1.46. If the test items meet one of the acceptance criteria for the MNSQ, ZSTD, or Pt Mean Correlation limits, then the items can be declared to fit the model and fit for further analysis purposes (Sumintono & Widhiarso, 2015). From the description, students' critical thinking skills questions and self-efficacy questionnaires can be used to collect field test data.

3.3. Results of Field Test

Data obtained from the results of field tests using the Hotelling T^2 test with the assistance of the SPSS 25 program. Before being analyzed, the data should meet the nine prerequisites of the multivariate assumption test. Then, the Hotelling T^2 test was conducted to test the hypothesis of the first problem formulation. Based on the Hotelling's Trace data obtained, it showed that the significance value was 0.000 which was < 0.05, then H_0 was rejected, so it can be said that there were differences in students' critical thinking skills and self-efficacy before and after using Process Oriented Guided Inquiry Learning-based learning media (POGIL) on salt hydrolysis materials. Moreover, the follow-up test was the Test of Between Subject Effects for critical thinking skills, the significance value obtained was 0.000 indicating that sig < 0.05 then H_0 was rejected, so it can be concluded that there were differences in critical thinking skills before and after participating in learning using learning-based media of Process Oriented Guided Inquiry Learning (POGIL) on salt hydrolysis material. The significance value for student self-efficacy was 0.000 (sig. <0.05), so it can be said that H_0 was rejected, so there was a difference in student self-efficacy before and after participating in learning using learning media of Process Oriented Guided Inquiry Learning (POGIL) on salt hydrolysis material.

Critical thinking skills and self-efficacy of students after participating in learning using Process Oriented Guided Inquiry Learning (POGIL) based learning media resulted in a higher average score than before participating in Process Oriented Guided Inquiry Learning (POGIL) based learning media. In addition, there are differences in students' critical thinking skills in the experimental class using the Process Oriented Guided Inquiry Learning (POGIL) model and the control class using the lecture method. The results obtained from the comparison of the two classes are that the experimental class employs the Process Oriented Guided Inquiry Learning (POGIL) model resulting in a very good category reaching 13%, while the control class using the lecture method does not produce a very good category with only percentage 0%. The control class also produced an average pretest value of 9.83 and a posttest mean value of 11.17.

Comparison of the categories and averages resulting from the experimental class and the control class can be concluded that the experimental class using learning tools based on Process Oriented Guided Inquiry Learning (POGIL) is better than the control class using the lecture method. The improvement of students' critical thinking skills after using Process Oriented Guided Inquiry Learning (POGIL) based learning media is because students are directly involved in the learning process and there is a role for students in solving problems contained in student worksheet so that students are active during the learning process. Harsanto (2005) said that being active in the learning process is a way to optimize all the potential possessed by students so that they can achieve satisfactory learning achievements in accordance with the characteristics they have.

The results of the analysis of the contributions given by learning media based on Process Oriented Guided Inquiry Learning (POGIL) by looking at the partial eta squared value. The results of the analysis (see Table 6) show that the partial eta squared value for the simultaneous contribution of Process Oriented Guided Inquiry Learning (POGIL)-based learning tools to students' critical thinking skills and self-efficacy is 0.741 or 74.1%. From the test results of the Test of Between Subject Effects, the partial eta squared value of critical thinking skills is 0.305. It shows that the percentage of Process Oriented Guided Inquiry Learning (POGIL) based learning tools on critical thinking skills is 30.5%. Meanwhile, the partial eta squared value of self-efficacy is 0.692, indicating that the contribution of learning tools based on Process Oriented Guided Inquiry Learning (POGIL) to the self-efficacy of students is 69.2%.

Table 6. Results of the Analysis of the Contributions Given by Learning Media

No	Treatment	*Partial Eta Squared*
1	Hotelling's Trace	0.741
2	Critical Thingking skill	0.305
3	Self-Efficacy	0.692

This can be seen from the results of the pretest and posttest carried out by students and there is a significant increase after students follow the Process Oriented Guided Inquiry Learning based learning process (POGIL).

4. Conclusion

Before and after employing Process Oriented Guided Inquiry Learning (POGIL) learning media, there are differences in the critical thinking skills and self-efficacy of the students. The effective contribution of Process Oriented Guided Inquiry Learning critical thinking skills 30.5% and self-efficacy 69.2% respectively.

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