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The Effectiveness of Guided Discovery Learning-Based Salt Hydrolysis E-Module in Improving Higher-Order Thinking Skills (HOTS) of Students

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Abstract. This study is a part of educational design research on guided discovery learning (GDL) based e-module on the topic of salt hydrolysis. The e-module had passed the test of validity and practicality after the development. Quasi-experimental research using a control-group pretest-posttest design was done to analyze the effectiveness of the GDL-based salt hydrolysis e-module on higher-order thinking skills (HOTS) of students. The population of the research consists of all grade XI students at one of SMAN in Padang City, Indonesia in the academic year of 2021/2021. The sample was selected by the purposive sampling technique. Research data obtained with a multiple-choice test were analyzed through the N-gain test and t-test. Results of the N-gain test showed that the HOTS of students in the experimental class (0.64) were higher than those in the control class (0.55). Results of the t-test showed that the value of the hypothesis testing was less than 0.05 (2-tailed). Therefore, it can be concluded that the salt hydrolysis e-module which is based on the GDL model is effective in improving the HOTS of grade XI students at SMAN 14 Padang. The e-module is suggested to be used for senior high school learning.

INTRODUCTION

Chemistry learning in high school offers topics that are quite difficult for students to understand as they involve calculations, chemical reactions, and abstract concept[1]. One of the topics considered difficult by students is salt hydrolysis. To learn and understand this topic students must master the essential prerequisite concepts such as acids and bases, reaction equations and mole concepts, as well as formulas to calculate pH of solution[2]. Results of preliminary research regarding chemistry learning-processes in several senior high schools in Padang showed that (1) 63% of students stated that salt hydrolysis was a difficult topic (2) the learning model used had not fully guided students to find concepts, and (3) teaching materials used were mainly in the form of printed teaching materials such as student worksheet.

To help students learn the topic, we need learning models that are not only scientific but also can increase students' learning outcomes in understanding concepts. One of which is the guided discovery learning (GDL) model. In GDL, students are guided and directed to find concepts independently, so their knowledge is the result of their finding[3]. Previous studies state that the GDL model can improve students' motivation and understanding in the learning process[4], cognitive outcomes[5], the ability to solve problems[6], and achievement in chemistry learning[7]. One of several teaching materials that can guide students to learn independently to find new knowledge, factual, conceptual, procedural, and metacognitive knowledge to use in implementing GDL is a module. Several studies show that modules

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that are based on GDL have been practically and effectively used in learning the topics of acid-base[8], chemical equilibrium[9], colloids[10], redox reactions, and electrochemical cells [11].

In the 2013 curriculum, students are supposed to be skilled in using media, technology, information, and communication technologies (ICT) required in the 21st century and the industrial revolution 4.0 12. The use of technology in learning aims to improve the efficiency and effectiveness of learning. So that the industrial revolution 4.0 is the digitalization era in various fields, especially in the field of education, which can be an opportunity to develop innovations in teaching materials to be more practical and more interesting. Teaching materials in the form of modules that have been developed into e-modules (electronic modules).

E-modules have information as videos, animations, diagrams, texts, and practice questions (quizzes) that can be answered directly by students13. E-modules are interactive and helpful for students to understand learning materials 14. In addition, e-module is so easy to go anywhere, has lower production costs, and is eco-friendly [15-16].

The e-modules can improve students' motivation in learning science, such as physics [12], mathematics [17], and biology[18]. E-modules are very effective and practical to use in supporting the independence of higher-order thinking skills (HOTS) students [19-20-21]. However, teachers' knowledge of HOTS, the ability of teachers to improve students' HOTS, solve HOTS-based problems, and measure students' HOTS are still low[22]. The application of the e-module-assisted inquiry model contributes to the students' science process skills. However, the contribution was only 29.16% in the low category[23]. Teachers needed to select appropriate learning models according to the characteristics of the subject matter and learners. Therefore, in this study, a GDL-based salt hydrolysis e-module was developed.

A valid and practical GDL-based hydrolysis e-module had been developed by the previous researchers[24]. The effectiveness of the e-module in improving the HOTS of students has not been tested yet. Therefore, this study aims to analyze the effectiveness of the GDL-based salt hydrolysis e-module in improving the HOTS of senior high school students.

METHODS

This study is a part of educational design research on guided discovery learning (gdl) based e-module on the topic of salt hydrolysis. The e-module had passed the test of validity and practicality after the development. The study used a quasi-experiment with a pretest-posttest control group design to analyze the effectiveness of the gdl-based salt hydrolysis e-module on hots of students. The study was conducted in one of sman in padang city, indonesia. The population in this study was all grade xi students at the research site in the academic year of 2020/2021. The sampling technique used in this study was the purposive sampling technique and sample classes of this study consisted of the control class (xi mipa 1) and the experimental class (xi mipa 3) having the same person as the teacher. The experimental class was taught using the gdl-based salt hydrolysis e-module, while the control class was taught conventionally. Both sample classes were given a pretest and a posttest in the form of multiple-choice questions. The test consisted of 18 questions possessing the criteria of good questions; they were valid and reliable, had distinguishing power, and had a good difficulty index25. The e-module effectiveness test was analyzed using the n-gain (g) formula with the criteria; value (g)<0.3 = low, 0.7>(g) 0.3 = medium, and (g)>0.7 = high[26]. Furthermore, the hypothesis testing using an independent sample t-test was done after normality and homogeneity tests had been completed. The normality testing was done through the kolmogorov-smirnov test, while the homogeneity testing was done through the levene test. All of these effectiveness testing were done using spss 23 software[27].

RESULTS AND DISCUSSION

The effectiveness of GDL-Based Salt Hydrolysis E-module

The determination of the N-gain value was done based on the pretest and posttest values that had been given to the two sample classes. The N-gain test was conducted to state the effectiveness of the GDL-based salt hydrolysis e-module in improving the HOTS of students. The results of the N-gain test for two sample classes are shown in Table 1.

TABLE 1. Results of N-gain test of sample class

Class	N	Mean			Criteria
		pretest	*posttest*	*N-Gain*	
Experimental	36	17	70	0.64	Medium
Control	36	17.3	63	0.55	Medium

As can be seen in Table 1, the N-Gain value of the experimental class (0.64) is higher than the N-Gain value of the control class (0.55). However, the two-sample classes have the same medium category of N-gain. To prove whether this value is significantly different or not, hypothesis testing was carried out. The requirement of doing hypothesis testing is that the data must pass the test of normality and homogeneity[27].

Normality Testing

The normality testing was carried out to determine whether the data in the study were normally distributed or not. The decision criteria was based on the significance value (probability). Results of the normality testing are shown in Table 2.

TABLE 2. Results of normality test of sample class

Class	α	Sig.	Distribution
Experiment	0.05	0.12	Normal
Control		0.20	Normal

Table 2 shows that both of class samples were normally distributed, because the Significance is higher than 0.05. Therefore, the homogeneity testing was done to determine whether the data had homogeneity variance or not.

Homogeneity and Hypothesis Testing

Results of the homogeneity testing for the sample class are shown in Table 3. The significance is higher than 0.05; data in both classes were distributed homogeneously. Because the data were normally and homogeneity distributed, the hypothesis testing was done through a t-test.

TABLE 3. Results of homogeneity test of sample class

Class	α	Sig.	Distribution
Experiment Control	0.05	0.65	Homogeneity

The results of the hypothesis testing in the sample classes can be seen in Table 4. Table 4 shows that the hypothesis of the study is accepted, because the value of Sig. (2-tailed) is less than 0.05. These results indicate that the HOTS of students in the experimental class is significantly higher than HOTS of students in the control class.

TABLE 4. Sample class hypothesis test results

Class	α	*Sig.(2-tailed)*	Distribution
Experiment Control	0.05	0.001	H_1 accepted

Analysis of Student Answers during the Effectiveness Test

The results the effectiveness of the e-module was proven by the percentage of student's ability to correctly answer the questions in the GDL-based salt hydrolysis e-module. The results of the analysis of student answers can be seen in Table 5.

TABLE 5. Results of the analysis of student's answers in the GDL-based salt hydrolysis e-module

No.	Syntax	% of Students Answered Correctly			Mean
		LA 1	LA 2	LA 3	
1	*Problem presentation*	76	80	80	79
2	*Data processing*	85	89	81	85
3	*Verification*	87	87	87	87
4	*Closure*	89	89	86	89
5	Average LA	84	86	83	84
6	Category	high	Very high	high	high

Note:
LA1: Learning activity 1 (understanding and reaction of salt hydrolysis)
LA2: Learning activity 2 (Determination of the nature of the pH of salt solution by experiment)
LA3: Learning activity 3 (calculate the pH of a salt solution)

As can be seen in Table 5, the mean percentage of students' abilities to answer the questions in the e-module is 84 % (which falls in the high category). It can also be seen from the increase of student scores in each syntax of the GDL model, starting from the problem presentation, data processing, verification, and closure. The improvement in the mean score of students who were taught with e-module occurred in almost all learning activities, except learning activity (LA) 3 where the decrease of mean score of students in the e-module happened. One concept given in LA 3 was the pH calculation of a salt solution. This finding indicates that students' ability in chemical calculations was not optimal and needed to be improved

Discussion

Both sample classes in this study have almost the same capabilities. An increase in learning outcomes occurred in the two sample classes. The experimental class has an average pretest value of 17 and the control class of 17.3. After the learning process, the posttest average value for the experimental class was 70 and the control class was 63. However, the students in the experimental class showed a higher improvement in HOTS as compared to students in the control class. Therefore, the use of salt hydrolysis modules that are based on GDL is proven to be effective. The research findings indicate that the use of the GDL-based salt hydrolysis e-module is effective in increasing the HOTS of students in the medium category. From the learning process, it can be seen that HOTS is a thinking process, that is not just memorizing and passing on information, but students are expected to be able to connect and transform their knowledge with things or problems that have never been taught in learning[28]. The students who used e-modules can solve problems in several parts, then look for relationships, evaluate (a combination of the ability to judge, examine, and criticize), and finally create (creating new ways or modifying something that already exists and solving problems)[29]. Based on previous research, the use of e-modules based on the T-test also showed differences in students' critical thinking skills between before and after being taught with e-modules[30.]

The effectiveness of e-modules is due to the components of the e-module that can help students in finding the concepts. Questions in the e-module lead students to learn independently. In addition, with the key answers provided, students can also measure their understanding ability in learning and can repeat the subject matter according to their needs. It also fulfills the self-contained characteristic of e-modules, which means that e-modules are user-friendly and contain all learning materials needed (helping and facilitating users)[12]. In line with this study, found that learning outcomes of students learning chemical bonding using e-modules are higher[31]. The use of e-modules can improve

skills in the material science process on the topic of heat and temperature[32], and students' cognitive outcome on the topic of material human digestive system[33]. However, when compared to similar researches, the effectiveness of the e-module in this study is in a medium category level. This is because the ability of some students is still low in analyzing questions, curiosity in finding information is still low, student feel embarrassed to ask questions and do not dare to express opinions[34]. This is probably due to the limited availability of infrastructure at the school. Facilities and infrastructures including computers, laptops, and android were available, but the internet connection was not very good[35]. In addition, students are still not used to e-modules. Previously, students were learning by printed books. This can be seen from some students who find it difficult to use e-modules sequentially[30]. In line with the previous study that the obstacle in implementing e-modules is that students are not used to e-modules so that when teachers ask students to use e-modules, there are several steps that students miss when using them. The solution is to provide explanations and video tutorials to use of e-modules when learning continues[36].

The improvement of HOTS of students when learning with GDL-based e-module proves that HOTS can be trained and taught at schools. The syntaxes of GDL namely motivation and problem statement, data collection, data processing, verification, and closure[37] can guide students to be active like thinking critically, gathering information, observing the objects, providing explanations and making conclusions from the material being studied[10]. In GDL model, the teacher acts as a motivator, mentor, and facilitator for students in learning. Then, the students are guided and directed to find the concept independently so that the knowledge they obtain is the result of their invention themselves. GDL leads students through demonstration, discussion, and experiment activities[38]. GDL has a very significant effect on students' confidence, motivation, and achievement by increasing students' self-confidence and science process skills[39]. Students are also directed to be able to answer questions correctly by asking questions that have been prepared in advance, so that simple to complex questions can be discussed [40]. Furthermore, the students are supposed to be active in learning through a variety of experiments so that they are qualified to solve problems[41]. This is because in the learning process, the teacher provides more opportunities for students to think, search information that's wider from the books, internet and can find their concepts that are used to solve the problems that have been presented, so that students can process the data that has been collected through problem discussions with a group of friends[42].

The improvement of HOTS of students is also due to the use of e-modules. E-modules are organized in systematic language, communicative, attractive, and suitable to student's abilities; so the students do not get confused in understanding the materials. E-modules can also make learning fun for students because e-modules are completed with multimedia such as images, animations, audios, videos, and interactivity[43]. As can be seen during the learning process, students are very active in asking and enthusiastic in learning the materials contained in e-modules[44]. Besides that, it is also seen in the process of working on questions before and after learning to use e-modules. Before learning, students still have difficulty in solving questions that contain indicators of analyzing, evaluating, and creating. However, after learning to use e-modules students begin to be able to solve questions that contain these indicators. E-modules have several advantages, including; (1) the concepts contained can be visualized in the form of animations; (2) the presentation of materials is more interactive and dynamic; long verbal elements in the printed module can be reformed to visual elements in videos or animations; (3) e-modules can be used repeatedly and can be accessed anywhere and anytime using facilities that students have[45]. Besides improving the HOTS of students, it is also effective in increasing students' interest in understanding the materials presented[46], stimulating students to think critically, and improving students' learning outcomes[19].

Due to the Covid-19 pandemic, learning has turned into online learning (learning using modern information and communication technology) at various levels of education. Thus, teaching materials must also be switched into electronic formats, one of which is the e-module. E-modules are also effective for distant learning[47], because they can create more interactive learning [48].

The high effectiveness of the e-module can be seen from students' ability to answer questions and get high scores in almost all LAs. In the section where formulas and calculations were used, however, the activity was still low, and some students still did not understand how to apply those formulas to solve the questions asked. Nevertheless, in line with previous researches, in GDL-based learning, the students discussed actively, collect data, analyzed data, answer questions, and write conclusions with the teacher's guidance [11].

Activities through experiment videos also lead students to collect data, analyze data, and draw conclusions. Students are generally able to discover and understand the concepts by applying the syntaxes of the GDL model. It is verified by the average activities of students at each meeting [49]. We can conclude that students could understand learning materials presented in the e-module well, which in turn got high learning outcomes in each lesson. In this study, the overall students' learning was good because it got increased from time to time. Students were actively involved in finding the concepts independently. The material learned will remain in students' memories longer than

they will when reading passively every time they learn. At the closure stage, the students were helped by the auxiliary sentences, so students' scores increased after concluding the concept[48] Based on the result of the effectiveness test, it can be concluded that the GDL-based salt hydrolysis e-module is effective in guiding the students to find and understand the concepts in the salt hydrolysis topic in SMA/MA.

The e-module has been effectively used in learning, yet this study has some limitations. Covid-19 pandemic has led to the limited time of learning and shifts of students' learning into online and offline modes. 45 minutes for one-hour learning is now shortened to 30 minutes. Therefore, it is reasonable that students could not get the optimal score. Nevertheless, the GDL-based salt hydrolysis e- module is proven to be something that can be used to improve HOTS of students and learning outcomes of students as well. The e-module can be used for online learning and blended learning. Therefore, students' HOTS abilities can still be developed further.

CONCLUSIONS AND SUGGESTIONS

Based on the results of the study and data analysis, it can be concluded that the use of the salt hydrolysis e-module which is based on GDL is effective in improving HOTS of students (with medium criteria). Therefore, this e-module can be used as an alternative teaching material for studying salt hydrolysis in senior high school.

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