The effectiveness of an interactive module in improving students’ conceptual understanding of acid-base titration

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Abstract. The results of the previous studies showed that the implementation of acid-base titration module with interactive media which is based on computer technology can assist students to comprehend the concepts taught in the subject. In this study, the module with interactive media was delivered as an alternative in the real practicum for the material of acid-base titration. This study was conducted using a quantitative research method. The sample was collected by purposive sampling and divided into the experiment and control class. Data were analysed by the normalized gain (N-gain) while the student concept understanding data analysed by using percentage techniques. Data was collected through pre-test and post-test in both classes. Based on the result of N-gain average, the improvement of concept comprehension at the control class is 0.50 while it is 0.79 at the experiment class which is in the medium level. The hypothesis test of these two classes shows that the \( t_{\text{score}} (7.405) > t_{\text{table}} (1.996) \) with a significant level of 0.05. It can be concluded that there was a significant difference between control class and experimental class. The implementation of the module is effective in improving students’ comprehension of the concept.

1. Introduction

Chemistry is a branch of natural sciences, which contributes to helping to solve problems in human’s complex life. However, in reality, most of the students learn Chemistry not because they are interested in learning Chemistry, what’s more even after they learn they do not understand the concepts taught in chemistry subject [1]. The low understanding of chemistry has caused students to think that topics taught in chemistry are difficult ones of, especially titration. According to Sheppard [2], students do not comprehend the subject correctly especially in understanding the neutralization process which is regarded as the mix of acids and bases which do not result in the reaction and has no chemical reaction equation.

Based on the observation in a few high schools in Banda Aceh, most schools do not optimally use the facilities provided in the schools such as computer and internet laboratory. All these facilities can be used for the media in the chemistry teaching-learning [3]. The role of computers as a form of advanced technology is important in the teaching-learning process which later can be used to solve problems in
chemistry subject [4,5]. One of the roles of computer technology is as an interactive learning media as a pedagogic strategy in integrating learning and technology [6].

This approach of interactive media aims to let students get the technical knowledge and skills to develop and implement computerized solutions to achieve the important targets in education and motivate their learning [7]. Interactive media helps teachers and students in improving learning interaction as multimedia learning source [8]. Computer-based learning source is used in the teaching and learning process as an effort to improve thinking skills [9].

One of the great resources to use in learning is a module. The module provides the conceptual understanding to be easily comprehended with a more simple way [10]. Therefore, this module with interactive media can solve the issues faced by students, especially in understanding the concept of acid-base titration material. According to Irwansyah et al. [11], this module can be used as a learning material in Chemistry subject. The module is an independent learning material which contains benefits for exercise and evaluations as an assessment to determine students’ ability so wherever there are mistakes, they can be fixed right away. It also can be used to improve learning effectiveness in schools. This module with interactive media can support the process in achieving the students’ competences so that the learning material can be delivered effectively and efficiently. If the module is developed as needed, it is expected that the learning results will be satisfying.

The other benefits of interactive media are cost, size, and performance now handled by the virtual reality that can stimulate a series of experiments without even running the experiments [12,13]. With the interactive media, students can experiment about titration at home and repeat the experiment without using any chemical substance at all. Thus, interactive media become a teaching-learning strategy with high technology simulation in development and use [14]. Interactive media is safer to be used and explored by students who have visual learning style because presenting ideas and concept in visual has been proved to be exceptionally important in assisting the learning process in education [15]. This study aims to determine the effectiveness of acid-base titration module with interactive media that can help to improve students’ comprehension about concepts taught in class.

2. Method
This study was conducted at one high school in Banda Aceh during the second semester. The type of this research was quantitative study with the experimental method. The design used were pre-test, post-test, and non-equivalent control group design [16]. The population of this research was the students of Grade XI- Mathematics and Natural Sciences, in the second semester in the academic year of 2018/2019. The school was chosen based on the low level of comprehension on the material of titration in the National Examination of 2018. The research sample was collected by purposive sampling; sample collection technique was done by choosing the homogenous class. This homogenous class was determined by the quiz score. The sample of the research was Grade XI-1 as the control class and Grade XI-2 as the experimental class. The experimental class implemented the learning by using acid-base titration module with interactive media, while the control class implemented the traditional learning approach without the module with interactive media. This study used a comprehension test as the instrument which is the pre-test and post-test consisting of 20 multiple-choice questions. The concept comprehension test had gone through validation test, after the result of the validation test proven that the content of the test is validated according to the concept comprehension criteria. The student concept understanding data were analyzed by using percentage techniques using equation 1[17].

\[
\text{% Student concept understanding} = \frac{\text{Scores Gained}}{\text{Total Score}} \times 100\%
\]  

(1)

The questions that were used in research that is valid, reliable, and had different power and good difficulty index. The increase in student’s conceptual understanding was determined by the normalized gain (N-gain) formula (equation 2) and interpreted using the Meltzer (2002) classification [18].

\[
N_{gain} = \frac{S_{posttest} - S_{pretest}}{S_{maks} - S_{pretest}}
\]  

(2)
3. Result and Discussion

Acid-base titration module with interactive media can be used as an alternative in school that has laboratory supplied with not enough materials to perform experiments. This kind of situation leads students to comprehend the material of acid-base titration less. This is in line with the opinion of Munawar et al. [19] Direct laboratory experiments constraint in timing, therefore, some things are needed such as tools and ingredients, place, finance, and the inexistence of tools and ingredients for materials being discussed. Thus, the virtual laboratory allows the improvement of the quality of educational technology where students can do practical tasks easily in any place. The research result shows that the virtual laboratory has a significant model to improve students learning and it can be recommended for schools to be implemented. In this study, the treatment given to the experiment group was by implementing the learning with a module of interactive media, while the control group was not given the module. The display of interactive media can be seen at Fig.1 and Fig.2 shown in the cover of Acid-base Titration Module.

Based on Figure.1, it shows that the module of acid-base titration with interactive media applied for the “Acid-base Titration Program”. Acid-base Titration is what the Titrasi Asam Basa stands for. This application is named as “titrasamba”, it consists of two experiment methods which are volumetric titration and potentiometric titration. The potentiometric method is used to determine the endpoint titration through pH meter, while the volumetric titration application is done by using the indicator of changing color when the solution Ph. is changed. Besides, in Figure.2 we can see the picture of a module with interactive media as the learning material that is useful and can be understood by students.

This study was conducted to determine whether acid-base titration with interactive media is effective in improving students’ comprehension of any concept. The data about students’ concepts comprehension can be obtained from pre-test and post-test given in class. The data obtained in the experiment and control class can be seen in Table 1.

| Concept Comprehension | Control Group | Experiment Group |
|-----------------------|---------------|------------------|
|                       | Pre-test | Post-test | N-gain | Pre-test | Post-test | N-gain |
| Minimum Score         | 10      | 50       | 0.16   | 15       | 65       | 0.54   |
| Maximum Score         | 45      | 65       | 0.69   | 45       | 90       | 1      |
| Average Score         | 35.31   | 56.40    | 0.50   | 37.18    | 79.68    | 0.79   |

Based on Table 1, we can see that students’ average score on the pre-test of the control group was 35.31, while in the experiment group was 37.18. After each class was given treatment, post-test was conducted where the results for the control group and experiment group were 56.40 and 79.68 respectively. The average score of N-gain of students’ concept comprehension in experimental class
was 0.79, while in control class was 0.50. It can be concluded that the average score of \(N\text{-}gain\) for students’ concept comprehension in experimental class is higher than in the control class. The average score of \(N\text{-}gain\) in both classes is arguably in a medium category. The comparison of the average score of students’ comprehension of the concept being taught in control and experimental class is shown in Figure 3.

Based on Figure 3, we can see that the comparison between the average score of post-test from experimental class is higher than the control class. This shows that the teaching-learning process by using the module with interactive media is easier for students to understand because it contains pictures and the contents are more comprehensive. In addition to analysing the overall average score of student data, we also analyzed the average score based on each indicator of understanding students' concepts. This was done to find out which indicators of understanding that the concepts developed the most. Comparison of students' concept understanding test scores on each indicator for the control class is depicted in Table 2.

Table 2. Comparison of the average percentage of students’ concept comprehension for each indicator

| No. | Indicator of Concept Understanding for the Material of Acid-Base Titration | Control Class | Experimental Class |
|-----|-------------------------------------------------|--------------|-------------------|
|     |                                                 | Pre-test     | Post-test         | Pre-test     | Post-test     |
| 1.  | Determine the concentration of acid or base by titration | 41.18        | 68.14             | 40.20        | 84.80         |
| 2.  | Determine levels of substances through titration | 19.12        | 27.21             | 23.53        | 63.24         |
| 3.  | Summarizing the right indicators used for acid and base titration | 31.37        | 59.80             | 31.37        | 80.39         |
| 4.  | Apply the pH of the titrated substance | 35.29        | 47.06             | 33.09        | 80.15         |
| 5.  | Interpret the titration graph from the experimental data | 35.29        | 58.82             | 56.86        | 88.24         |

Based on Table 2 can be seen that the comparison of the average score percentage in the increasing of conceptual understanding in the control class and the experimental class shows that the two classes had increased in each indicator, but the comparison of the post-test scores’ percentage in both classes shows that the experimental class had higher percentages than the control class. This finding is in line with the opinion of Parmin and Peniati [20], who said that module can be used in learning and the contents of the module can stimulate students’ intentions to seek for additional information from other learning sources. This is important since the learning environment in school is dynamic. The same result was also shown in the study done by Setiawan et al. [21], that suggested the use of module with interactive-media showed positive result which was improvement in learning outcome. Moreover, the module encourages students to be more engaged during the teaching-learning process. This interactive media application can help students in comprehending the concepts of the material being taught [22].

According to Osman and Lee [23], learning with interactive media-assisted module which comes from communication and information technology as the simulation and animation can stimulate students
to comprehend the chemistry subject better. Moreover, Darus et al. [24], also reported that the module development with interactive media is one of the ways to solve problems and obstacles in the laboratory such as the insufficient number of tools and time discretion to redo the experiment with different substances. Furthermore, Irby et al. [25], concluded that a module with interactive media directs students to have positive learning outcomes.

One of the categories to prove the hypothesis test was by determining the data spread (normality) and data variant (homogeneity) through N-gain pre-test data of control and experiment class. To determine the normality test of students’ concept comprehension, One Sample Kolmogorov-Smirnov Test was conducted to experiment and control class. The result of the normality test through SPSS software with a significant level of $\alpha= 0.05$ can be seen in Table 3.

**Table 3.** Data of normality result test

| Data Source          | Class          | Significant Score |
|----------------------|----------------|-------------------|
| N-gain               | Control Class  | 0.147             |
|                      | Experiment class| 0.316             |

Data is normally distributed

The normality test was conducted to determine the data distribution and students’ concepts comprehension in both groups. Table 3 shows the normality test result of N-gain data from experiment and control class, and it is significantly bigger than $\alpha$. It can be concluded that N-gain data distribution is normal.

Homogeneity test of test score data of students conceptual understanding was done to determine whether both groups have similarity invariance or not. Homogeneity variance and N-gain data were conducted through the Levene Test (Test of Homogeneity of Variances) with the significance level of 0.05 at control and experiment group. The result of the homogeneity test can be seen in Table 4.

**Table 4.** Homogeneity test result

| Data Source                 | F       | Significance level |
|-----------------------------|---------|--------------------|
| N-gain of control and       | 3.184   | 0.147              |
| experiment groups           |         | Homogenous         |

Table 4 shows that N-gain data of the two groups have a significance level higher from 0.05. Thus, it can be concluded that both groups have the same variants (homogenous). After the prerequisite analysis test which was the normality test and the homogeneity test, it showed that pre-test and N-gain data of both groups were homogenous and distributed normally. Therefore, the average difference test of both groups used the Independent Samples Test with the significant rate of ($\alpha$) at 0.05. The result of the hypothesis test (t-test) with SPSS version 20 to determine the implementation of the acid-base module with interactive media to improve students’ comprehension can be seen in Table 5. At the experiment class, the module was used, while in the control group, the module was not used. The learning period was 90 minutes per meeting. At the first meeting, students in both classes were given pre-test. Besides, students at the experimental class were taught early knowledge about acid-base titration through acid-base titration module with interactive media while the control class was given the regular module. Then, for the experimental class, the laboratory activity was implemented by relying on the instructions on the module; while for the control group, the laboratory activity was done conventionally. The learning process was conducted in a group discussion so that the teamwork can be initiated in the learning.

**Table 5.** Hypothesis test result

| Data Source                  | T-test | df  | Mean Difference | Hypothesis test  | Result         |
|------------------------------|--------|-----|-----------------|------------------|----------------|
| N-Gain of control and        | 7.405  | 64  | 28.32176        | $t_{\text{score}} (7.405) > t_{\text{table}} (1.996)$ | Significance   |
| experimental group           |        |     |                 |                  |                |

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The result obtained on Table 5 shows that the $t_{\text{score}} (7.405) > t_{\text{table}} (1.996)$ at the significance level of 0.05. In this case, the provision applies that, if $t_{\text{score}}$ is greater than $t_{\text{table}}$, $H_a$ is accepted and $H_0$ is rejected. The conclusion is that there are significant differences between the control and experimental class, meaning that the use of acid-base titration module with interactive media in the experimental class can improve students' understanding of concepts in acid-base titration.

The practicum activity process at the control class was conducted without using the acid-base titration module with interactive media. The practicum was done like a conventional practicum at school, the laboratory activity was only on the steps of the experiment. The experiment done in the class was the same as the one done in the experimental class which were two experiments. In this learning process, teachers focused more on students' skills and analysis result of students and group. Based on the data analysis result of the practicum activity, students did not grasp the concept being taught the material of acid-base titration. Therefore, the teacher was the one who explained the data analysis. The teacher motivated students by asking questions, then reviewed the materials of acid-base titration back in with a more simple way. In the last meeting, students evaluated the learning by doing a test of students' comprehension.

The implementation of learning with and without acid-base titration module with interactive media and without this module at each of the class has shown that there was a significant difference in students' behavior as well. In the control class, the students did not fully understand the way to analyze the experimental data, so that the teachers needed to explain the subject which later led students to be less involved in the learning process. However, in the experimental class where acid-base titration module with interactive media was used in learning, students learned to be independent in their studies. It made each student learn to deepen their understanding. Students were able to relate the concept they learned with the result of observation they did. They are also actively involved in the learning process. Therefore, the learning turned out to be more interesting that led students to have high motivation in studying. This turned the learning in class to be more interactive to the discussion between teacher and students went well.

The effectiveness of using this module can be measured by the existence of significant differences in students' understanding of concepts between the experimental and control classes. According to Sugiono [26], testing the effectiveness of aspects of learning outcomes is measured through tests with valid and reliable instruments. When testing products such as acid-base titration module with interactive media using the pre-test post-test control group design (there were experimental and control groups), then to measure the effectiveness and efficiency is done by comparing the significance of the group taught with acid-base titration module with interactive media to groups that remain taught without modules assisted by interactive media. The results of the statistical test in the form of t-test obtained the score of $t_{\text{score}} (7.405) > t_{\text{table}} (1.671)$ at a significant level of 0.05 There were significant differences in the control and experimental class. It can be concluded that learning with interactive media-assisted modules “titrasamba” effectively and significantly increased students' understanding of concepts.

Based on Herlinah's research [27], the use of ICT in teaching and learning process assisted by computers can accommodate students who are slow in accepting lessons, because computers are never tired and bored in carrying out instructions according to what they are instructed. According to Davenport, et al. [28], students experienced an increase in learning as evidenced by statistically increased learning outcomes from pre-test to post-test with interactive media used in activities after initial exposure to the material provided. Sari, et al. [29], also showed that Microsoft Excel-based interactive media was effective in the science process skills of students in chemical material. In addition, Elfariyanti, et al. [30], suggested that Microsoft excel-based computer simulation media are effective for enhancing students' understanding of concepts and critical thinking skills in chemical materials. Then, the use of interactive learning media based on Microsoft Excel can reduce the level of high school students’ misconceptions [31].
4. Conclusion
It is proven from the difference of N-gain average score of concept comprehension of acid-base titration material which was 0.79 in experimental class and 0.50 in the control class (medium category). Moreover, from the hypothesis test, both classes show that the \( t_{\text{score}} (7.405) > t_{\text{table}} (1.996) \) with a significant level of 0.05. In other words, it can be stated that there is a significant difference in the control and experimental class. From these results, it can be concluded that the implementation of acid-base titration module with the help of interactive media is effective to be used as a learning tool as it can increase students’ concept comprehension. Moreover, it can also act as a learning application through a virtual laboratory in the chemistry lesson.

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