Application of Microsoft Excel as an interactive learning media of acid-base titration

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Abstract. Senior high school students in Banda Aceh find Acid-base titration is challenging to learn as it requires knowledge and many concepts such as acid-base reaction, acid-base strength, pH solution, buffer solution, and salt hydrolysis. This study aimed at developing a Microsoft Excel-based interactive learning media program on the topic of acid-base titration. It employed ADDIE model of development design. The study was conducted at one of senior high school in Banda Aceh, Indonesia. The participants of this research were year 11 students. Interview, questionnaire, and test were employed to collect the data in this study. Data were analyzed using a descriptive quantitative technique. The results of validation from two learning media experts revealed that 79.41 were categorized into the very good category. Furthermore, two chemistry experts revealed that the 77.94 of the instrument met the very good category. In addition, in the implementation phase, the result showed the skill of science process for the students who were in the experimental class was better than students in the control class.

1. Introduction
Titration is a common laboratory method of quantitative chemical analysis that can be used to determine the concentration of an identified analytic. Acid-base titration is one of challenging topics to be learned by senior high school students. It is required knowledge or such supportive concepts as stoichiometry solution, pH of acid solution, pH of base solution, pH of buffer solution, and pH of hydrolysis solution [1]. Apart from these ones, it is also needed a laboratory practice to prove the concept [2]. It can also be done by using computer-based interactive program media other than in the laboratory. From the research finding obviously showed the use of virtual media was better than the traditional method [3,4]. Nowadays, the use of computers in learning is highly recommended by the government since it is accordance with the Strategic’s Plans of Indonesia Government which hopes there is the use of technology, information, and communication within a learning activity.

This study aimed at developing an interactive learning media of acid-base titration-based Microsoft Excel-based. Microsoft Excel is not solely used in the field of statistics [5] as well as business [6], but it is also used as a medium of learning in related chemical matters to data processing from the result of chromatographic analysis [7], titration [8,9], spectroscopy [10], pharmaceutical or medical field [11].

It was a Research & Development. It purposed to make and produce a particular product then test the advisability of produced product. Advisability test is given for both media and material experts, teachers, and students as the user [12].
2. Method
The development of titration media used ADDIE model which stands for Analysis, Design, Development, Implementation and Evaluation. This research was carried out at one of Senior High School in Banda Aceh on grade 11 with the number of samples was 70 students. The following steps of research were:

- Analysis, on this step there were some matters observed such as the school condition particularly the availability of computer facility in school, curriculum analysis, difficulties analysis encountered by students on the learning material of acid-base titration.
- Design, arraying of learning cycle and media content outline, designing a media that supported the understanding of titration concept, and making a media display design were some things done on this step.
- Development, this step focused on making a Microsoft Excel-based interactive titration media and students' work sheets as the complement of the guide of media use.
- Implementation, meanwhile on this step media validation was conducted to look at the media advisability by distributing the questionnaires for both material and media experts. Afterward, it was done a trial test for senior high school students to know the skill of science process on the learning material of titration. Titration media validation was done by administering the questionnaires that contained media assessment criteria and optional responses i.e. very good, good, enough, less, very less with weight score respectively 5, 4, 3, 2, and 1. The calculation of score percentage of media validation used the equation (1) [11]. Moreover, validity criteria of media are presented in Table 1 and criteria of students’ responses are presented in Table 2.

\[
P = \frac{\sum_{i}^{n} x_i}{n \cdot k} \times 100\%
\]

Note:
P : assessment percentage
\(\Sigma X\) : number of assessment point
N : number of subjects
K : highest assessment score

| Percentage (%) | Validity Level | Description            |
|----------------|----------------|------------------------|
| 76 - 100       | very high      | proper/no revision     |
| 50 - 75        | high enough    | proper enough/partial revision |
| 26 - 50        | less           | pess proper/partial revision |
| <26            | Invalid        | improper/total revision |

| Categories               | Percentage |
|--------------------------|------------|
| Disagree                 | 0% - 25%   |
| Hesitate                 | 26% - 50%  |
| Agree                    | 51% - 75%  |
| Strongly agree           | 76% - 100% |

- An evaluation was conducted by giving a number of questionnaires to know their responses having used titration media. The questionnaires were descriptively analyzed with the following of some categories was Strongly Agree (SA), Agree (A), Hesitate (H), and Disagree (D) weight score respectively 5, 4, 3, 2, and 1.
3. Result and Discussion

3.1 Analysis
The result of observation revealed that Senior High School in Banda Aceh has had computer laboratory facility which can be used for 40 students. The practice related to acid-base titration was conducted by the chemistry teachers; however, it was only restricted on HCl – NaOH titration. Moreover, it solely used one indicator type namely phenolphthalein. While, other chemical compounds were not done because there was a chemical substance. From the above finding, the researcher made an acid-base titration program which was more complete by using such solution as HCl, CH$_3$COOH, NaOH and NH$_4$OH; whereas, as its indicator used phenolphthalein, methyl red and bromothymol blue solution.

3.2 Design
Media design which was made in line with learning objectives, basic competency and the needed indicator from the learning material of acid-base titration. Design a burette picture with the volume was 25 mL and Erlenmeyer flask picture was completed with a magnetic stirrer. Burette bar picture was made from the chart graph, while; other pictures were taken ChemDraw program Ultra 8 (Figure 1).

![Figure 1. Burette 25 mL, erlenmeyer flask, and magnetic stirrer](image)

Design a titration program chart that was completed with titration type, indicator type, pH range, and table of information. The information table functioned to show solution volume (cell D11 and D20), solution concentration (cell D12 and D21), $K_w$ water equilibrium constant (cell D13), and the weak acid or the weak base equilibrium constant (cell D22).

![Figure 2. Design acid-based titration program](image)

3.3 Development
Activating combo box which can set up both titration and indicator type. The titration that was used consisted of 4 types namely HCl – NaOH, HCl – NH$_4$OH, NaOH – HCl, and NaOH – CH$_3$COOH. Meanwhile, the indicator contained 3 types namely phenolphthalein, bromothymol blue, and methyl red. The change of titration type was controlled by the cell F5 and; whereas, the change of indicator type was controlled by the cell K5 which its data included into data combo box (Figure 3).
Making a stoichiometric reaction chart is functioned to calculate the concentration. The reaction equation that appeared on this program is in accordance with the selected titration. The following example is the type of (Figure 4) HCl – NH\textsubscript{4}OH titration.

Inserting the logic formula (IF) into Stoichiometric Reaction Chart on the following cells respectively are T6, T7, T8, V6, V7, V8, and X8:

\begin{align}
= & IF(D20*D21>0,(D11*D12)/(D11+D20),"") \\
= & IF(D20*D21>0,MIN(T6,V6),"") \\
= & IF(D20*D21>0,T6-T7,"" ) \\
= & IF(D20*D21>0,(D20*D21)/(D11+D20),"") \\
= & IF(D20*D21>0,MIN(T6,V6),"") \\
= & IF(D20*D21>0,V6-V7,"" ) \\
= & IF(D20*D21>0,MIN(T6,V6),"")
\end{align}

The next step was inserting the logic formula (IF) into the cell H25 to calculate pH of solution. The logic formula was used for each titration type can be written severally within the equation (9–12).

\begin{align}
\text{Titr ation of HCl – NaOH} \\
= & if (F5 = 1, if (V8 > T8,14 + \log(V8), if (V8 = T8, −\log(D13^{0.5}), if (V8 < T8, −\log(T8)))) \right)
\end{align}

(9)
Titration of HCl – NH₄OH

= \begin{cases} 
2, if (V8 > T8, or(D11 = 0, D12 = 0)), 14 + \log((D21 \cdot D22)^{0.5}), if (D11 > 0, V8 > T8), 14 + \log(D22 \cdot \left(\frac{V8}{X8}\right)^{0.5}), if (D11 > 0, V8 = T8), -\log(X8^{0.5}), if (V8 < T8, -\log(T8)) \end{cases} 

(10)

Titration of NaOH – HCl

= \begin{cases} 
3, if (V8 > T8, -\log(V8)), if (V8 = T8, -\log(D13^{0.5}), if (V8 < T9, 14 + \log(T8))) \end{cases} 

(11)

Titration of NaOH – CH₃COOH

= \begin{cases} 
4, if (V8 > T8, or(D11 = 0, D12 = 0)), -\log(D21 \cdot D22)^{0.5}, if (D11 > 0, V8 > T8), -\log(D22 \cdot \left(\frac{V8}{X8}\right)), if (V8 > T8), -\log(D13 \cdot D22)^{0.5}, if (V8 < TT8, 14 + \log(T8)) \end{cases} 

(12)

The next step is inserting the logic formula (IF) into the cell G21 change solution color based on indicator type (cell K5) and pH of solution (cell H25). The logic formula was used as on the following equation.
Based on the equation (13), for each change of indicator type that occurred (cell K5) and pH of solution (cell H25); as a result; within cell G21 will emerge the following letters are A, B, C, D, E, F, G, H, or I. After that those letters changed became the color by using “conditional formatting”. The color of the letters of A, B, C, D, E, F, G, H, and I from left to right as presented respectively on figure 5.

3.4 Implementation
From the result of validation employed by both media and material experts it was respectively gained its percentage was 79.41% and 77.94%. According to the criteria presented in Table 1, it can be concluded the validity of titration media can be categorized very high and it is proper to be used in the teaching and learning process.

3.5 Evaluation
Based on the result of program trial test toward the students of Senior High School in Banda Aceh attained N-gain value was 0.38 on the experimental class was higher than the control class with N-gain value was 0.12. Generally, the students’ science process skill who was in the experimental class increased having followed the learning process through Microsoft Excel-based titration learning media. The result of this study was pertinent to the previous research findings undertaken by Tatly and Ayas [2] as well as Tuyuz [3]. From the result of statistic test, both of N-gain value were significantly different. It indicated that the students who used the interactive titration media better than the other
group. Thus, the use of titration learning media by using Microsoft Excel is effective to advance the students’ science process skill on the learning material of acid-base titration.

4. Conclusion
Microsoft Excel-based interactive learning media on the learning material of acid-base titration which is developed it is appropriate to be used because of its validity, practicality, and effectiveness. In addition, it can enhance the skill of students’ science process at Senior High School in Banda Aceh. It suggests that this learning media is suitable as an alternative to replace laboratory-based experiment for teaching and learning of acid-base titration.

References
[1] Harvey D 2000 Modern Analytical Chemistry (New York: McGraw Hill)
[2] Tatly Z and Ayas A 2013 Educ. Tech Soc. 16 159
[3] Tuysuz C 2010 Int. Online J Educ. Sci. 2 37
[4] Morgil I, Yavuz S, Oskay O O, and Arda S 2005 Chem. Educ. Res. and Pract. 6 52
[5] Spellman R 2011 J. Access Serv. 8 150
[6] Hargreaves B R and McWilliams T P 2010 Comp. Statis. and Data Anal. 54 1190
[7] Fasoula S, Nikita P, and Pappa-Lousi 2017 J. Chem. Educ. 94(8) 1167-1173
[8] Burnett J and Burns W A 2006 J. Chem. Educ. 83 1190
[9] Forgacs A, Balkay L, Tron L and Raics P 2014 Appl. Rad. and Isotop 94 77
[10] Zhang Y, Huo M, Zhou J, and Xie S 2010 Comp. Met. and Prog. and Biomedic. 99 306
[11] Sugiyono 2011 Metode Penelitian Pendidikan: Pendekatan Kuantitatif, Kualitatif, dan R&D (Bandung: Alfabeta)