The Development of Microsoft Excel-Based Computer Simulation to Improve the Student's Concept Understanding on Buffer Solutions

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Abstract: The utilization of computer as a learning media is very important especially in this sophisticated era. With the help of computer, the learning process will run more effectively and efficiently. But in fact, chemistry learning has not been utilizing the IT facilities widely as a medium of learning. The purpose of this study was to determine the feasibility of computer-based simulation learning media on the subject of buffer solution in terms of validity and effectiveness of Microsoft Excel-based computer simulation that was developed to improve the students' conceptual understanding. Media development method in this research used ADDIE model which includes Analysis, Design, Development, Implementation and Evaluation. The results showed that computer-based learning media simulation of Microsoft Excel on buffer solution in terms of validity was feasible to use. The percentage of media worthiness was 81.00% according to the material experts and 81.57% of the media experts. Microsoft Excel-based computer simulation media developed effectively against conceptual understanding of buffer material. The students' conceptual comprehension increased with N-gain value 89.17%.

Keywords: Buffer solution, microsoft excel, interactive

1. Introduction

Buffer solution is one of the subjects in chemistry that include theory and practice. This subject is very useful to be learned as it is closely related to everyday life, such as in the health and pharmacy fields. The prerequisite for understanding the concept of buffer solutions is that learners should have mastered the concept of acid-base, pH concept, acid-base stoichiometry and chemical equilibrium (Chang 2005). The inability of students to understand these concepts will lead to lower learning outcomes and assume the subject of buffer solution is a difficult to understand (Nilawati et al. 2015). Some researchers reported that the students might find difficulties in understanding the buffer solutions (Orgill etal. 2008). They also said that the students assumed that the stronger the base acid of a buffer the greater the capacity of a support and that the buffer solutions can be made from acid-base mixtures regardless of acid or base strength.

Based on the observations' result in several high schools in Banda Aceh, they were found that most schools already have computer lab facilities and wireless internet but unfortunately, chemical learning had not fully utilized the facilities as learning medium. The utilization of computer as a learning media is very important, because with the help of computer the learning process will run more effectively and efficiently and it will make the students become more

happy (Willis 2016; Ibrahim 2009; Rubin2015). In addition, computers are also used for laboratory activities at the senior high school level which is known as dry laboratories. The advantages of dry laboratory compared to wet laboratory are in terms of cost, time, energy, easy to do, and no risk of dangerous chemicals (Morgil et al. 2005; Dobranzki et al. 2010).
The use of interactive virtual chemistry laboratories are as effective as real laboratories in terms of the students' achievement and ability to recognize the laboratory equipments (Tatly et al. 2013). The use of Microsoft Excel-based computer simulations for practicum activities can improve analytical chemistry learning outcomes (Akcay et al. 2006). Based on some of these studies, the authors were interested to develop computer simulation learning media by using Microsoft Excel program for the concept of buffer solution.

2. Methodology

Media development method in this research used ADDIE development model which stands for Analysis, Design, Development, Implementation and Evaluation. This research was conducted in the State Senior High School Number 1 in Banda Aceh (a.k.a. SMAN 1 Banda Aceh) in the class of XI IPA 2 within academic year of 2014/2015.
The analysis stage was conducted on various aspects namely: (a) the analysis of school conditions inorder to determine the completeness of computer facilities, (b) the technology analysis to determine the appropriate software used to develop the media, (c) the curriculum analysis with regards to basic competency and indicators of learning, and (d) the conceptual analysis by analyzing the difficulties faced by learners in the concept of buffer solution. The design stage consists of: (a) compiling the learning path and composing the media content, (b) designing media that supports the concept of buffer solution, and (c) creating a display design media. The development stage, which is done are: (a) create a simulation media using Microsoft Excel program, (b) make Student Worksheet (LKS) as complement to guide usage of media. The implementation stage includes: (a) media validation to see the feasibility of media by requesting assessment from the material and media experts, (b) media effectiveness test toward the understanding of senior high school students on the concept of buffer solution. Media effectiveness test on conceptual understanding was done by using pre-experimental design method through pretest-posttest one group design (Fraenkel et al. 2012).

The validation was done by giving a questionnaire containing media assessment criteria. This questionnaire contains answers such as excellent, good, enough, less, and very less with the scores of 5, 4, 3, 2 and 1 respectively. The percentage of media validation score was obtained by using the following equation (Sugiyono 2011).

$$P = \frac{\sum_i^n X_i}{n.k} x100\%$$

Information:
P = percentage of ratings
ΣX = the number of points of assessment of the test subject
N = number of test subjects
k = highest scoring score

Table 1. Media validity criteria

Percentage (%)	Validity Level	Description
76 – 100	Extremely high validity	Worthy / do not need to be revised
50 – 75	Validity is quite high	Pretty decent / partial revision
26 – 50	Less Validity	Not worthy / partial revision
<26	Invalid	Not worthy / total revision

(Anizar2018)

For the evaluation stage, it was done by giving a questionnaire to students with the aim of knowing their response after using Microsoft Excel-based computer simulation media. The questionnaire analysis was done descriptively in the form of Likert scale with the categories of strongly agree, agree, hesitant, and disagree with the scores of 5, 4, 3, 2 and 1 in a row.

Table 2. The percentage category of the student's assessment feedback

Category	Percentage
Disagree	0% - 25%
Doubtful	25% - 50%
Agree	50% - 75%
Strongly agree	75% - 100%

(Anizar2018)

3. Result and Discussion

3.1. Analysis

Based on the observations, it was known that SMAN 1 Banda Aceh already has facilities such as computer lab, wireless internet, and sufficient electricity. However, chemical learning has not fully utilized these facilities. According to the results of interview to the six chemistry teachers there it was known that one of the chemistry concepts that was difficult to comprehend by the students is the buffer solution. The students are still difficult to distinguish between acid-base reactions that produce buffer solutions with other acid-base reactions. The result of this analysis by far became a reference for researchers to create, to design and to develop the simulation media by referring to the basic competence and the desired indicator of the concept of buffer solution.

3.2 Design

The media design was made based on the learning objectives, basic competencies and desired indicators of the buffer solution. The learning paths of buffer solution in this stage includes:

a) Displaying a list of weak acid solutions, weak bases and conjugate salts which may be prepared as buffer solutions (see Figure 1).

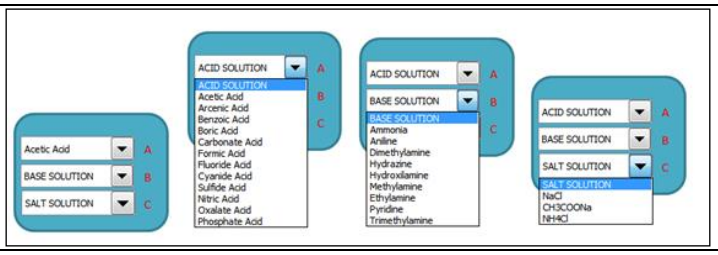

Figure 1. List of weak acid, weak bases and conjugate salts

b) Designing a picture of a measuring cylinder containing a weak acid solution or a weak base or a conjugate salt solution. Both measuring cylinders are equipped with volume adjusting and concentration control buttons.

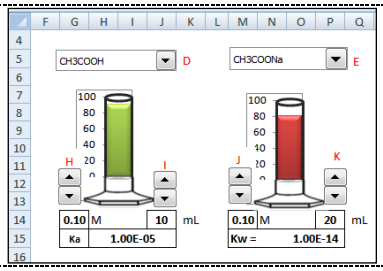

Figure 2. (a) Solution of CH_3COOH 0.10 M and (b) a solution of CH_3COONa 0.10 M

c) Designing an analytical balance sheet to weigh a conjugate salt or a solid-shaped NaOH base.

d) Designing a burette image that contains a strong acid solution (HCl) and a strong base (NaOH).

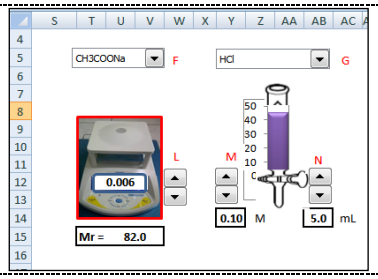

Figure 3. (a) The analytical balance was weighing the crystals of CH_3COONa 0.025 grams (M_r = 82 gram/mol) and (b) burette containing a 0.1 M HCl solution

e) Designing a pH meter image that can show the amount of solution pH.

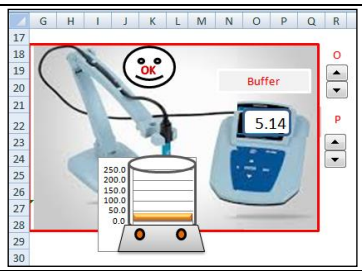

Figure 4. pH meter

f) Designing a graphic.

3.3 Development

The development of learning media was made interactively by using the following steps:

a) Enabling the spin button and combo box used to adjust: the type of chemicals used, the volume of solution and the desired concentration.
b) Creating a stoichiometric reaction chart that serves to calculate the pH of the solution.
c) Incorporating logic formulas into the program to calculate the pH of the solution.

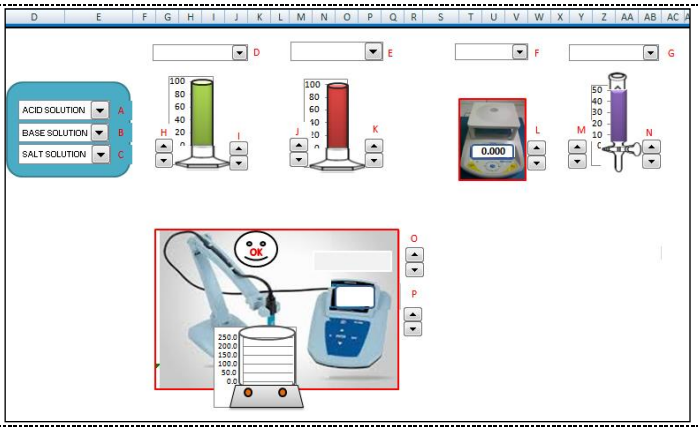

Figure 5. Initial design of interactive learning media based on Microsoft Excel

3.4 Implementation

In this implementation stage, the researchers requested the experts' assessment of the media developed and the media usage trials for the purpose of seeing the effectiveness of conceptual understanding of the buffer solution concepts. This was in accordance with the result of the study by (Altun et.al 2009; Orgill et al. 2008) which stated that virtual labs can improve learning outcomes effectively and significantly.

Media validity test results which was done by media expert obtained an average value of 81.57%. If this result was converted according to Table 1, then it means that this media has a very high validity. Meanwhile, the results of validity test by the material experts obtained an

average value of 81.00% or have a very high validity or in the other words this learning media was feasible to be used as a learning tool.

3.5 Evaluation

One example of Microsoft Excel-based computer simulation validation test was to solve the following problem.

What is the pH of the solution comprising 25 mL of CH_3COOH 0.2 M and 25 mL CH_3COONa 0.1M solutions, when the price of K_a = 1.0 x 10^{-5}?

Answer:

$$[H^+] = K_a x \frac{[acid]}{conjugate\ base}$$

$$[H^+] = 1{,}0\ x\ 10^{-5}\ x\ \frac{0{,}2}{0{,}1}$$

$$[H^+] = 2{,}0\ x\ 10^{-5}$$

$$\text{pH} = 5 - \log 2$$

$$\text{pH} = 4{,}70$$

This problem also can be solved by using the computer-based media designed by selecting CH_3COOH solution and adjust the volume and concentration of each solution according to the question with the controller button. The result obtained is presented in Figure 6 below.

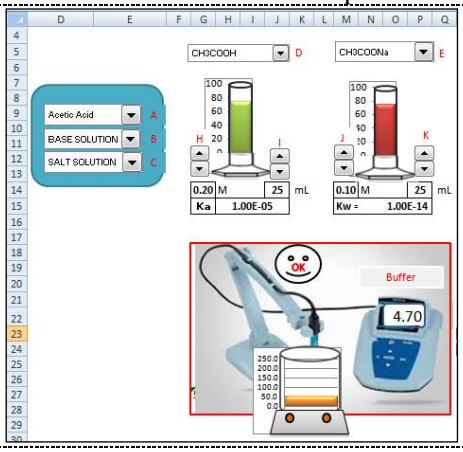

Figure 6. Examples of using Microsoft Excel-based interactive media

4. Conclusion

Computer-based simulation learning media based on Microsoft Excel on buffer solution concept is valid and feasible to be used as a learning tool. In addition, the use of this simulation media is effective against the students' understanding on the concept of buffer solution with a N-gain value of 89.17. The student's response to this media is excellent.

Acknowledgement

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References

Akcay, H., Durmaz, A., Tuysuz, C., Feyzioglu, B., 2006, Effect of Computer Based Learning on Students' Attitudes and Achievements Towards Analytical Chemistry. The Turkey Online Journal Education Technology. 5(1), 1-6.

Altun, E, Demirda, B., Feyziolu, B., Alev, A., and Çobano, I., 2009, Developing an interactive virtual chemistry laboratory enriched with constructivist learning activities for secondary schools, Procedia Social and Behavioral Sciences ,1:1895–1898.

Anizar, 2018, PengembanganModulBerbantuan Media InteraktifBerbaasis Excel UntukMeningkatkanPemahamanKonsepdanKeterampilanBerpikirAnalitisSiswa MA PadaMateriLarutanPenyangga.Tesis. Program StudiPendidikan IPA, Program PascasarjanaUniversitasSyiah Kuala.

Chang, R., 2005, Kimia DasarKonsep-KonsepInti, Edisike 3, Jilid 2, Erlangga: Jakarta.

Dobranzki, L. A., and Honysz, R., 2010, The Idea of Material Science Virtual Laboratory. Journal of Achievement in Materials and Manufacturing Engineering. 42(2), 196-203.

Fraenkel, J. C., Wallen, N. E., Hyun, H. H., 2012, How to Design and Evaluate Research in Education. McGraw Hill, New York.

Ibrahim, D., 2009, Using the excel spreadsheet in teaching science subjects, Procedia Social and Behavioral Sciences.1:309–312.

Morgil, I., Yavuz, S., Oskay, O.O., and Arda, S., 2005, Traditional and computer-assisted learning in teaching acids and bases. Chemistry Education Research and Practice. 6(1), 52-63.

Nilawati, Khaldun, I., and Hasan, M., 2015, Keterampilan Proses Siswa SMAN 2 Banda Aceh padaPenggunaan Media PembelajaranInteraktifBerbasis Microsoft Excel MateriTitrasiAsam-Basa.JurnalPendidikanSains Indonesia. 3(2), 66-70.

Orgill, M.K., and Sutherland, A. 2008, Undergraduate chemistry students' perceptions of and misconceptions about buffers and buffer problems. Chemistry Education Research and Practice. 9, 131–143.

Rubin, S.J., 2015, Teaching Fundamental Skills in Microsoft Excel to First-Year Students in Quantitative Analysis. J. Chem. Educ. ,92, 1840−1845.

Sugiyono, 2011, MetodePenelitianPendidikan: PendekatanKuantitatif, Kualitatif, dan R&D. Alfabeta, Bandung.

Tatly, Z., and Ayas, A., 2013, Effect of a Virtual Chemistry Laborator on Students' Achievement. Education Technology & Society. 16(1), 159-170.

Willis, V.F., 2016, A model for teaching technology: Using Excel in an accounting information systems course, J. of Acc. Ed. ,36, 87–99.