The development of a module with Microsoft Excel-based interactive media on the topic of buffer solution

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Abstract. Topic of Buffer Solution is considered as complex and abstract subject in chemistry because it covers the macroscopic, the microscopic and the symbolic levels. Several studies have shown that interactive simulations using computer technology could help learners to understand abstract concepts. In this research, a module with Microsoft Excel-based interactive media was developed as an alternative to real lab practice on the topic of Buffer Solution. The method used in this research was Research and Development method with ADDIE model. The effectiveness of this media was tested to the second graders of natural science program of a senior high school as the samples with a direct experiment and a response questionnaire regarding the developed media. The samples were chosen randomly. Based on the results, it is indicated that the module with Microsoft Excel-based interactive media received positive responses from the teachers (88%) and the students (86%). The results suggest that the improvement of the students' conceptual understanding was in high category (N-gain = 0,98) and the improvement of their analytical thinking skills was in intermediate category (N-gain = 0,5). Further research with larger class experiment is advisable to be conducted with respective module.

1. Introduction
The rapid development of science and technology resulted in a change of educational paradigm followed by improvements in curriculum, media, and technology. Nowadays, multimedia technology has become a necessity in the efforts made to build and develop learning media. According to Hendra and Siagian [1], one of the examples is an interactive learning media that is based on the development of Information and Communication Technology (ICT).

A multimedia-based learning approach has an ability to move a concept from a static textbook to a more interesting learning style [2]. In addition to increasing interest in learning, it is also able to foster creativity and innovation of learners in producing new technologies for the purposes of learning and education. Improved learning outcomes might be obtained by adding multimedia contents into teaching materials that will become multimedia teaching materials [3]. A computer-based teaching material used in teaching and learning process is also an attempt to improve thinking skills [4].

Several case studies indicated that some students faced difficulties in understanding chemistry concepts. The complexity of chemistry science requires a teaching and learning process including the macroscopic, the microscopic and the symbolic levels [5]. In addition, Laksono, et al.,[6] suggests that chemistry teaching and learning process should involve activities in which the learners interact with the
materials, communicate, and use their mind. One of them is the material of Buffer Solution. The learning process which is still teacher-centered and focuses only on memorization with limited learning resources and the absence of science laboratory facilities in schools make buffer solution become a boring topic.

The topic of Buffer Solution is one of the subjects discussed in chemistry textbooks including theories and practices. The prerequisite for understanding the concept of Buffer Solution is that the learners should have mastered the concept of acid-base, pH, acid-base stoichiometry and chemical equilibrium. The inability to understand the basic concepts leads to many more problems, such as poor learning outcomes and assumption that the topic of Buffer Solution is difficult to understand [7]. Furthermore, Harun et al. [8] stated that most teachers in Banda Aceh and Aceh Besar regions said that the topic of Buffer Solution is rarely delivered with practicum. This happened because of several reasons, such as the target that should be achieved by the teacher according to the syllabus and the unavailability or the incompleteness of laboratory facilities in the schools [9, 10]. Furthermore, Tuysuz [11] added that the obstacles faced by the teachers were (1) the expensive tools and materials, so that they are not affordable for underprivileged schools; (2) a quite long time needed for the preparation and execution of the practicum; and (3) too many students that are hardly monitored by the teacher.

Various kinds of innovative learning media, such as animations, modules, concept maps, comics, virtual labs and others can be used by teachers in order to attract students' attention in the classroom [12]. Good learning media interpret theoretical concepts into easy-to-understand concepts and simulate materials that are difficult to be delivered in classroom[10,13].

The method attempted to overcome the problems faced by the students and the chemistry teachers on the topic of Buffer Solution is using a module as an interactive media of virtual lab. According to Chen et al. [14], using a teaching material developed in accordance with the needs of the learners might improve the learners’ achievement. It is because the module presents adequate exercises for the cognitive development of the learners [15]. This additional teaching materials can support the process of achieving the learners’ competence so that learning materials can be delivered effectively and efficiently. If the module is developed in accordance with the needs, the learning outcomes may be more satisfying.

According to Turkoguz [16] and Alexander et al. [17], by following technological developments, modules can be developed and combined with other teaching materials in the form of audio or video as well as other alternative teaching materials facilitating students in understanding the contents. A module as an interactive media of virtual lab is selected to replace experiments due to some constraints. The use of interactive chemistry multimedia modules, as reported in Azziz et al. [18], showed a positive response and improved the conceptual understanding on the topic of Stereochemistry. Another research conducted by Oktiarmi et al. [19] also obtained the same result, a positive response on the use of interactive multimedia teaching materials. Moreover, it was accepted by learners with different levels of capabilities.

Another advantage of interactive media is by using only a computer program, we are able to simulate a series of experiments without performing the direct activities [20]. Interactive media also helps the learners to interact directly with the experiments, not only by seeing and listening but also by repeating them when needed [21]. With this media, the students can experiment with buffer not only in school laboratories but also at home. Experiments can repeatedly be done without the use of any chemicals. The media makes the experiments cheaper, safer and more suitable to be used and explored by learners who have visual learning styles based on their needs and speeds [22].This study aims to develop viable module with Microsoft Excel based interactive media which can increase understanding concept and analytical thinking skills of the students.

2. Method
Research and Development Method with Analysis, Design, Development, Implementation, and Evaluation (ADDIE) model [23] was employed in this research as follow:
2.1. Analysis
The analysis is a crucial stage in ADDIE model [23]. The process consists of identifying the needs and problems found and setting the goals to be achieved by the development as well as the knowledge and skills needed in the process of obtaining the final product. Feasibility study was done in order to find out the needs and problems at an Islamic Senior High School of Aceh Besar Regency.

2.2. Design
The design stage is in which things related to the desired final product are identified. The module with Microsoft Excel-based interactive media was designed based on the needs for the concept of calculation on the topic of Buffer Solution which is quite complicated. The specific documents of learning objectives, assessment instruments, exercises and content were designed.

2.3. The development
The actual creation of the module is completed in the development phase. A module with Microsoft Excel-based interactive media was developed to make it easier for the students to understand the concept of buffer solution, buffer solution components, buffer solution in acid-base titration graphs and the calculation of the pH of buffer solutions, and its application in daily life. Before the learning tools were used, the validity and reliability of the tools were tested and reviewed by the content experts and instructional media specialists. Then, the tools were then revised. The validity and reliability of the module was tested and reviewed by two content experts and two instructional media specialists prior to its implementation in classroom.

2.4. Implementation of the module with microsoft excel-based interactive media
When the tools were reliable, it was implemented in a small-scale experiment in order to see the response and the effectiveness of the product by distributing questionnaires. Twenty-five students in science program at an Islamic Senior High School of Aceh Besar Regency were selected randomly. The response questionnaires were distributed to five teachers and twenty-five students. The responses were considered in revising the media being developed. The experiment was also designed to identify the students’ conceptual understanding and analytical thinking skills on the topic of buffer solution. The data were collected with pretest and posttest. To measure the improvement of conceptual understanding and analytical thinking skills before and after the use of learning media, the g-factor formula (N-gain) with Hake formula [24] was used.

2.5. Evaluation
After delivery, the effectiveness of the module is evaluated. Formative evaluation runs parallel to the learning process and to evaluate the quality of the module and their reception by the students. Summative evaluation is to prove, once the experiment is finished, that the module had a positive effect.

3. Result and discussion
Feasibility study was done in order to find out the needs and problems at an Islamic Senior High School of Aceh Besar Regency. A module with Microsoft Excel-based interactive learning media was designed to find the best solution for the problems encountered according to the feasibility study. Based on the observation by questionnaires done in the school, an interactive virtual lab media is needed as an alternative to the unavailable real laboratory as well as a complement of limited learning media, and lack of understanding on the topic of Buffer Solution. This is in line with Sutrisno [25], which states that virtual labs might efficiently and significantly improve the learning process and create new experiences providing stimulation to the cognitive dimension of the concepts being learned.

The average score of experts’ judgment on the aspect of the module assessment was 3.42 of 4 maximum score. Based on the score, the module is considered to be implemented. The validity of tested questions was found 0.991 and the reliability was 0.998 with high category. On the basis of statistical analysis, it is assumed that the implemented instrument is valid and reliable.
After several revisions the final display of the interactive media can be seen in Figure 1 and in Figure 2 is shown the cover page of the module.

According to our study, it was also found that most of the teachers gave positive responses (88%) indicating that the product was useful in helping the children to understand the topic of buffer solution and increase the students’ learning motivation. In addition, positive responses were also given by the students (86%). Some of students also found that the topic of buffer solution became more simple, interesting, and detailed with easily-solved problems. Hence, the product has been expected to enhance the students’ analytical thinking skills. The improvement of the students’ conceptual understanding and analytical thinking skills before and after applying the trial module is shown in Figure 3.

In addition, Figure 3 above has also revealed the difference between pretest and post-test average scores of the students’ conceptual understanding and their analytical thinking skills. The students’ average posttest score is higher than their average pretest score. It was because the module with interactive media was equipped with figures and brief materials which could be easily understood. This result is in line with Arsyad [26] who states that giving module and media is a treatment that can help the learners to learn independently. More detailed results of the experiment on the students’ conceptual understanding are listed in Table 1.

| No. | Score   | Average | N-gain | Category |
|-----|---------|---------|--------|----------|
| 1   | Pre-test| 65      | 0.99   | High     |
| 2   | Post-test| 73      |        |          |

Based on the analysis of pretest and post-test scores, there was a difference between the students’ average score in the test regarding their conceptual understanding before and after the use of the module
with interactive media. The average posttest score is 0.99 point (category: high) higher than the average pretest score, which was taken before any treatment was given. Tapilouw [27] and Irianto [28] suggest the same finding in which the conceptual understanding of learners with the use of the module with interactive media is higher than those without any use of the module. The module with interactive media is a tool used to attract the learners’ sympathy and interest in an active and independent process of understanding a particular concept.

Moreover, Sukiman [29] has reported that the module with interactive media can be developed based on the development of science and technology by presenting the material in a sequence that facilitates the learners in understanding the concept. In addition, Chomsin [30] has also reported that by developing a module with interactive media a teacher can overcome the limitations of time, space and sensory power, of both the learners and the teachers. In addition, a research conducted by Trian et al. [31] also concluded that modules and media designed with the principles of increasing motivation would foster the learners’ character. The differences between the pretest and the post-test scores of the students’ analytical thinking skills regarding the trial of the module are shown in the following Table 2.

### Table 2. The improvement of analytical thinking skill indicators.

| No. | Indicators of analytical thinking skill | Average score | Category Pretest | Category Posttest | (N-gain) |
|-----|----------------------------------------|---------------|-----------------|------------------|----------|
|     |                                        | Pretest | Posttest       | Pretest         | Posttest |
| 1   | Arguing                               | 55     | 57             | Medium          | Medium   | 0.2 (Low) |
| 2   | Drawing inferences and conclusions     | 75     | 85             | High            | High     | 0.2 (Low) |
| 3   | Identifying problems                  | 57     | 72             | Medium          | High     | 0.5 (Medium) |

Table 2 shows the results of an experimental analysis of the module with interactive media based on several indicators of critical thinking skills. There was an increase in the average posttest score with the N-gain percentage of 0.5, (category: medium) while the average pretest score got N-gain percentage of 0.2 (category: low). Even though it was not significant, there was an increase which indicates that the module helped the learners to be actively involved in the classroom activities and use their analytical thinking skills. Another study conducted by Nisai [32] obtained the same result. It was found that the direct teaching method with the module trained the learners to learn independently either in the school or at home, so they could optimize their analytical thinking skills in solving various problems provided in the module.

The increase of the students’ critical thinking skills in the three indicators is generally categorized as low-medium. In line with this result, Ismienar [33] also states that analytical thinking skill is a complementary component which is hard to stimulate. It takes a quite long time to stimulate the students’ analytical thinking skills. Table 2 above shows the improvement of several indicators of analytical thinking skill.

The increasing scores of the three indicators of analytical thinking skills in the trial did not show noticeable changes. This probably happened because the learners were rarely trained to develop their thinking skills and to conduct experimental activities [34]. A similar result was also reported by Rahmawati et al. [35], one of the reasons for low level of analytical thinking skills in a school is lack of practice of using thinking skills. Learners were only trained to answer questions by rote so that their high-level thinking was not honed. Teachers play crucial roles in teaching thinking skills during science learning process in the classroom. Analytical thinking skill is a mental process in solving problems. It can be trained through experimental activities in the laboratory, and a module with interactive media might be an alternative to a real experiment [35].

### 4. Conclusion

Based on the results of our research, it can be concluded that the module with Microsoft Excel–based interactive media is feasible and practical as a teaching material on the topic of Buffer Solution.
Positive responses have been shown with high score of statistical analysis by both teachers and the students toward the module in this research. The trial of the module showed that the module was able to improve the students’ conceptual understanding and analytical thinking skills. In addition, this interactive media-based module can be used as an alternative teaching-learning approach to deal with the topic of buffer solution, and as one of virtual laboratory applications in chemistry education.

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