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DEVELOPMENT OF A VIRTUAL CHEMISTRY LABORATORY AS A MEDIUM FOR PRACTICUM ACTIVITIES BASED ON COMPUTER APPLICATIONS ON ACID-BASE TITRATION MATERIAL CLASS XI SCIENCE HIGH SCHOOL 1 SURAKARTA

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ABSTRACT

This study aims to develop virtual chemistry laboratory media and determine the feasibility of developing it as a medium for computer application-based practicum activities on acid-base titration materials. This research is a development research or Research and Development (R&D). This research adapts the design of ADDIE development research, which includes five stages, namely analysis, design, development, implementation, and evaluation. The data source was obtained from the assessment of research subjects: two material experts, two media experts, one subject teacher, and 12 students. Data collection techniques are carried out through documentation, interviews, and questionnaires. Data analysis is based on assessment results from validation instruments of material experts, media experts, subject teachers, and limited trials on learners. After analyzing the data of the results of validation and limited trials, the scores of the results of validation and limited trials are translated into the eligibility criteria for virtual chemistry laboratory learning media. The results showed that the virtual chemistry laboratory media obtained the criteria of "feasible" from the assessment of media experts and "very feasible" from the assessment of material experts. Virtual chemistry laboratory media received a positive response from both teachers and students. This study concludes that the media is suitable for use in learning Chemistry.

Keywords*: Development, Virtual Laboratory, Media, Lab Work, Acid-Base Titration*

INTRODUCTION

Learning as a process of interaction between teachers and students is carried out continuously to manage students' potential in obtaining knowledge. As a process that takes place dynamically, learning only sometimes goes well according to the plan that has been prepared. The COVID-19 pandemic, which is massively sweeping the world today, has emerged as a new external factor affecting education implementation in Indonesia [1]. The implementation of learning in every school was stopped nationally by the Central Government. For this reason, learning is replaced with a learning system in the network (online) or Distance Learning. The online learning system is a learning system without face-to-face directly between teachers and students but is carried out through an *online platform* that uses the internet network.

Teaching theoretical concepts in teaching and learning activities is most efficiently transferred to online systems, especially in institutions that have embraced *e-learning*. Significant challenges exist in the planning and implementation of practicum classes in this online learning period. This is because the practicum class requires students to practice proving the truth of a theory and then providing conclusions based on the results obtained. In practicum classes, students also need teachers or practicum assistants to guide the practicum [2].

The implementation of online practicum is a challenge in science subjects where the implementation of

online practicum should be able to provide students with real experience and understanding of concepts as in real or actual practicum. Watson, Prieto, and Dillon in Adisedjaja (2009) also emphasize the importance of laboratory skills in providing direct experience, students' first experience, and changing students' perceptions of essential concepts. [3]

The implementation of distance learning at High School 1 Surakarta uses *Microsoft Teams* 365 media and *WhatsApp* groups, and the material is delivered using *PowerPoint* slides. In chemistry subjects, learning materials that require practicum activities are not carried out directly but are replaced with watching videos from the *YouTube platform related to the practicum and* then making practicum reports based on the video. The use of media devoted to online practicum activities has yet to be implemented at High School 1 Surakarta.

Acid-base titration material is a sub-material of the acid-base chapter, and if not carried out, practicum activities are only taught in symbolic and mathematical calculations. To support students' understanding of acid-base titration material, practicum activities [4] are needed. Studying acid-base titration material should provide opportunities for students to have direct experience in observing titration-related phenomena. Through experience and direct observation, students are expected to be able to build concepts and relate them to the knowledge that the next student will acquire [5].

The impact of the rapid development of technology and information in education, one of which is the integration of technology into learning media. A virtual chemistry laboratory is a form of learning media that uses a simulation environment generated by computer programs that can simulate activities in the real laboratory [6].

Virtual chemistry laboratories are very beneficial in distance learning, as they are flexible and allow unlimited space and time for the simulation of chemical experiments. Virtual chemistry labs allow students to conduct experiments many times without the cost and risk of accidents. Virtual chemistry labs also enable students to explore tiny, large, or dangerous chemical objects inaccessible in normal real-world situations [7]. In addition, the research of Muchson et al (2018) found that students' understanding of the details of experimental procedures being carried out in the laboratory increased when real laboratory learning was facilitated with virtual labs. [8]

RESEARCH METHOD

Virtual chemistry laboratory media was developed using *research and development* methods using the ADDIE research and development model (*Analysis, Design, Development, Implementation and Evaluation*). At the analysis stage, a literature review and field study are carried out to collect data to analyze media needs based on the characteristics of students. The design stage is carried out to design or design virtual chemical laboratory media in accordance with the analysis of the needs that have been obtained. This stage includes making *a storyboard* that contains an overview of the contents of the virtual chemistry laboratory application to be developed. This stage consists of the development of virtual chemistry laboratory products and expert validation. Product development using *Adobe Illustrator software* and *Adobe Flash Professional Cc 2015*. The implementation phase was carried out on a limited-scale product trial on 12 students of class XI Science High School 1 Surakarta. The evaluation stage is carried out by analyzing the results at the implementation stage. Namely, the results of the assessment of subject teachers and student responses to the media developed to revise and perfect the final product produced.

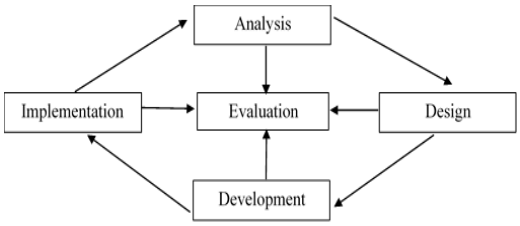

Figure 1. ADDIE Development Model [9]

Research data collection techniques using documentation, interviews, and questionnaires. Media feasibility assessment based on media expert validation questionnaires, material expert validation questionnaires, and teacher and student response questionnaires to virtual chemistry laboratory media. Data from expert validation sheets and teacher and student response questionnaires were analyzed using quantitative analysis techniques. Quantitative analysis uses a Likert scale based on a predetermined score and then interprets it in qualitative terms according to **Table 1.**

Table 1. Eligibility Criteria for Virtual Chemistry Laboratory Learning Media

Score Range	Criteria
> Mi + 1,5 SBi	Highly Eligible
Mi + 0,5 SBi < s.d ≤ Mi + 1,5 SBi	Eligible
Mi – 0,5 SBi < s.d ≤ Mi + 0,5 SBi	Quite Eligible
Mi – 1,5 SBi < s.d ≤ Mi – 0,5SBi	Less Eligible
< Mi -1,5 SBi	Not Eligible

RESULTS AND DISCUSSION

This research aims to develop products in virtual chemistry laboratories and determine the feasibility of using media in learning activities.

1. **Analysis Stage (*Analysis*)**

   The analysis stage is carried out to determine the existence of problems so that the development of new learning media is needed [10]. Further stages of analysis are carried out by conducting literature reviews and field studies.

   The results of the literature review show that no literature develops virtual laboratories specifically for acid-base titration materials, and the most widely used software to create virtual laboratories or other multimedia is Adobe Flash Professional. This is one of the bases for selecting materials and software used in development. In addition, acid-based titration material was chosen because practicum activities [4] are needed to support students' understanding of acid-based titration material. Studying acid-base titration material should provide opportunities for students to have direct experience in observing titration-related phenomena.

   Field studies consist of student needs analysis and teacher needs analysis. Data analysis of teacher needs was obtained by conducting interviews with subject teachers; there were four indicators of questions asked, namely related to the importance of learning media supporting online practicum activities, school characteristics associated with the implementation of teaching and learning activities during a pandemic, the availability of supporting media for online practicum activities, and responses to the development of virtual chemistry laboratory media. The results of the analysis of teacher needs, namely teaching and learning activities at High School 1 Surakarta are still carried out online with one hour of lessons is 25 minutes, and chemistry lessons consist of 4 hours of lessons; teachers strongly support the implementation of online practicum for material that requires practicum activities but are hindered by the availability of media and the limitations of teachers themselves in the development of supporting media, Teachers support the development of virtual chemistry laboratory media, especially for alternative implementation of online practicum activities, such as the current pandemic situation.

   The results of the analysis of student needs show that most students have laptops to support the implementation of learning, students consider it essential to have to learn media to support the implementation of online practicum for material that requires practicum activities during online learning, students are interested in learning with media that

can show how to work, animation, and simulation of practicum activities, most students have never used simulation media such as Virtual Laboratory When carrying out online practicum. Also, for the existence of supporting media for online practicum activities, some students answered that it was adequate, but not a few answered inadequately, and the development of this virtual chemistry laboratory media received a positive response from students. Overall, at the analysis stage, it was found that the development of a virtual chemistry laboratory was needed to support the implementation of practicum activities during the online learning period (online).

2. Planning Stage (*Design*)

At this stage, a storyboard design is carried out that contains menus or features that will later be in the virtual chemistry laboratory application. At this stage, the design of the application interface (User Interface) includes collecting or creating the required assets, such as buttons, sounds, and supporting images. The initial design of the virtual chemistry laboratory application consists of a start page containing an introduction menu, an acid-base titration simulation menu, and an exit button. The introduction menu contains a material summary, instructions for use, and a developer profile.

The acid-base titration simulation menu consists of a submenu of acid-base titration simulation and pH change simulation in acid-base titration. The acid-base titration simulation submenu consists of 3 experiments: strong acid titration with a strong base, weak acid titration with a strong base, and weak base titration with strong acid. The pH change submenu in acid-base titration consists of 2 experimental options: strong acids with strong bases and weak acids with strong bases, and an exit button. An example of the initial design of the media is in Figure 2.

Figure 2. Initial Design of Virtual Chemistry Laboratory

3. Development Stage (*Development*)

The development stage in the ADDIE model contains product design realization activities. Development stages using Adobe Flash Professional Cc 2015 software. After going through the development stage, the resulting media enters the validation stage; media validation is carried out by two media experts and two material experts.

Media expert validation to see the feasibility of media consists of two aspects: software engineering and visual communication. The validation data is presented in Table 2. The average score of the software engineering aspect of the two media experts was 38.5, where this score was included in the “eligible" criteria; in the visual communication aspect, the average score of the two media experts was 31, where this score was included in the "eligible" criteria. This means that the media is 'appropriate' for use after improvements have been made based on the advice of media expert validators.

Table 2. Hasil Validasi Ahli Media

No	Assesement Aspect	Media Expert Validator		Avg	Criteria
		I	II		
1	Aspect of Software Engineering	38	39	38,5	Eligible
2	Aspect of Visual Communication	30	32	31	Eligible

Media feasibility is assessed from the material's learning and substance aspect of the material by material expert validators, from the validation data presented in Table 3. The average score of the learning aspect by both material experts was 30.5, and this score was included in the "Highly eligible" criterion. Then, regarding material substance, an average score of 18 was obtained, and this score included the "eligible" assessment criteria. This means that the media is 'appropriate' for use after improvements have been made based on the advice of material expert validators.

Table 3. Material Expert Validation Results

No	Assesement Aspect	Material Expert Validator		Avg	Criteria
		I	II		
1	Learning Aspects	30	31	30,5	Highly Eligible
2	Material Substance Aspects	18	18	18	Eligible

4. Implementation Stage (*Implementation*)

The implementation phase was carried out as limited media trials to 12 students of grade XI Science 9. Test subjects were selected through purposive sampling by paying attention to students' abilities on Acid-Base material based on the average value of Quiz of Acid-Base material. The results of the limited student trial showed an average score of 89.36, which falls under the "Highly Eligible" criteria.

At the implementation stage, subject teachers also carry out media reviews. The results of the teacher's response to the virtual chemistry laboratory media developed obtained a score of 80 where this score showing the criteria "highly eligible." Based on the results of limited-scale trials, the media was declared suitable for use with notes on some suggestions put forward by teachers and students.

5. Evaluation Stage (*Evaluation*)

At the evaluation stage, a final revision is carried out to perfect the product that has been developed. Feedback and suggestions from students and teachers serve as the basis for improving the product. The final design of the media consists of a start page consisting of an Introduction menu, a Virtual Trial menu, and an exit button. The Introduction menu contains a developer profile, instructions for use, KD (Basic Competencies) and

learning objectives, and a summary of acid-base titration material. The Virtual Trial menu contains a selection of submenus for acid-base titration virtual experiments and pH change virtual experiments in acid-base titration. The submenu design of the acid-base titration virtual experiment consists of 3 experiments: strong acid titration with a strong base, weak acid titration with a strong base, and weak base titration with strong acid. The virtual experiment submenu design for pH changes in acid-base titration consists of 2 experimental options: strong acids with strong bases and weak acids with strong bases and exit buttons. In the final revision, a fix was also made for the problem of errors in the application, namely, the inability to input the letters d, f, j, q, x, and z on the experimental data input menu. An example of the final design of the media is in Figure 3.

Gambar 3. Desain Akhir Laboratorium Kimia Virtual

Virtual chemistry laboratories have the potential to be used further, and further research can be done on their effectiveness in learning. As in the results of research conducted by Hawkins & Phelps (2013) shows that the use of virtual and traditional laboratories provides relatively similar learning outcomes in electrochemistry learning so that virtual laboratories can be used instead of conventional laboratories [11]. Similar results were also revealed by Tatli & Ayas (2013) who stated that virtual chemistry laboratory applications are as practical as real laboratories regarding learning outcomes and students' ability to recognize laboratory equipment [12]. According to the results of research by Arista & Kuswanto (2018), Virtual laboratories can even increase students' learning independence and understanding of concepts [13]. The results of Tüysüz's (2010) Research shows that virtual laboratories positively affect student achievement and attitudes [14].

About online learning, virtual chemistry laboratories can be used as a substitute for offline practicum activities in face-to-face learning. It also potentially can be used in hybrid learning, which is a combination of online and face-to-face learning as in research conducted by Nais et al (2019).

CONCLUSION

This research produced a product as a computer application of the Virtual Chemistry Laboratory of acid-base titration material with (.exe) specification. Virtual chemistry laboratory media has been tested for feasibility in terms of material and media. The average score of the media expert assessment covering the software engineering and visual communication aspects of the media falls under the "eligible" criterion. The average score of material expert assessment, which includes aspects of learning and material substance from the media, is included in the criterion "highly eligible." As well as virtual chemistry laboratory media received a positive response from subject teachers and students.

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REFERENCE

[1] Mansyur, A. R. (2020). Education and Learning Journal, 1(2), 113.

[2] Zunaidah, F. N. (2020). Jurnal Pendidikan Nusantara, 6(1), 103–115.

[3] Adisedjaja, Y. H. (2009). Peranan Praktikum Dalam Mengembangkan Keterampilan Proses Dan Kerja Laboratorium. MGMP Biologi Kabupaten Garut, 1–7.

[4] Kartika, H et al.,(2019). Phenomenon, 09(2), 190–205.

[5] Sari, R. P., & Seprianto, S. (2018). Jurnal Pendidikan Sains Indonesia, 6(1), 55–62.

[6] Wibawanto, W. (2020). Laboratorium Virtual Konsep Dan Pengembangan Simulasi Fisika. In W. Hardyanto & Fianti (Eds.), Azka SaturnLab & Izzan Artwork (1st ed.). Semarang: Penerbit LPPM UNNES.

[7] Ali, N., & Ullah, S. (2020). Journal of Chemical Education, 97(10), 3563–3574.

[8] Muchson, M., Munzil, M., Winarni, B. E., & Agusningtyas, D. (2018). J-PEK (Jurnal Pembelajaran Kimia), 4(1), 51–64.

[9] Branch, R. M. (2009). Instructional Design: The ADDIE Approach. New York: Springer.

[10] Mulyatiningsih, E. (2011). Riset Terapan Bidang Pendidikan dan Teknik. Yogyakarta: UNY Press.

[11] Hawkins, I., & Phelps, A. J. (2013). Chemistry Education Research and Practice, 14(4), 516–523.

[12] Tatli, Z., & Ayas, A. (2013). Achievement. Journal of Educational Technology & Society, 16(1), 159–170.

[13] Arista, F. S., & Kuswanto, H. (2018). International Journal of Instruction, 11(1), 1–16.

[14] Tüysüz, C. (2010). International Online Journal of Educational Sciences, 2(1), 37–53.

[15] Nais, M. K., Sugiyarto, K. H., & Ikhsan, J. (2019). Journal of Physics: Conference Series, 1156(1).