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Development of Android-Based Virtual Laboratory to Improve Critical Thinking Ability on Reaction Rate Materials

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Abstract

Virtual laboratories can be used as an alternative to practicum activities in online learning during the COVID-19 pandemic. This study aims to develop an android-based virtual laboratory to improve critical thinking skills on valid, effective, and practical reaction rate materials. The development model used is Research and Development according to Sugiyono with stages namely potential and problems, data collection, product design, design validation, design revision, product testing, product revision, usage trial, product revision, and final product. The respondents of this study were students of class XI-IPA as many as 90 students of SMA Negeri 2 Unggulan Tanah Grogot. Data collection techniques have been used in the form of tests and non-tests, research instruments for pretest and posttest, as well as validation questionnaires and student responses. The data analysis technique used qualitative and quantitative analysis. The results of the analysis show that the validation of the expert team's assessment is an average of 95.98% with very valid criteria, effectiveness based on the results of the analysis of the pretest and posttest scores, the average N-Gain score is 0.77 with high or effective criteria, practicality based on the results of questionnaire analysis The average student response is 94.11% with very practical criteria. Thus the android-based virtual laboratory developed is feasible to improve critical thinking skills and as a medium for learning chemistry class XI-IPA.

Keywords
virtual laboratory; android; critical thinking

I. Introduction

Facilities and infrastructure in education units are absolute things to be fulfilled, including laboratory facilities as a support for teaching and learning activities, training students' skills in practice, and experimenting. This supports science learning which has a positive impact on the learning process (Jagodziński & Wolski, 2015). The laboratory also has a strategic role in science learning where it can attract the interest and attention of students as well as a meaningful learning experience (Bortnik *et.al.2017*). One of the uses of technology as a learning medium is the application of virtual laboratories as a substitute or support for real laboratories (Fabregat-Sanjuan *et al* ., 2017 Dwiningsih *et al* ., 2018).

Several previous studies on the use of virtual laboratories, namely their use still use computer devices as media and require *software* installed on computer devices and internet facilities *(online)* so that they are not effective because their mobility is very low and impractical in terms of their use, so in this study, a laboratory will be developed. Android-based virtual reality for practicum activities (Dwiningsih, *et al*., 2018) is based on the fact that most students have Android phones and have become part of the needs that are attached to daily learners. Virtual laboratories have many advantages, including practicality in use, effectiveness in terms of time and can be repeated as well as practical

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and efficient in terms of the use of tools and materials because they do not use original materials that are not available or in small quantities (Wulandari & Vebrianto, 2017). In addition, the use of virtual laboratories can represent material that is abstract, macroscopic, and microscopic which cannot be explained in detail in a real laboratory (Ambusaidi *et al.*, 2018).

In this regard, efforts have been made to innovate learning media that are interactive, educative, fun, and flexible without space and time limits by utilizing information and communication technology, to overcome various shortcomings or obstacles faced in real laboratories. In addition, the developed virtual laboratory is integrated with critical thinking skills instruments, so it is expected to grow and improve students' critical thinking skills (Widowati *et al*., 2017). Based on this, an android-based virtual laboratory will be developed to improve critical thinking skills on the reaction rate material.

The laboratory is a means of supporting science learning which is closely related and cannot be separated or stands alone between theory and practical activities. On that basis, its existence in schools is very important and vital, because the laboratory is a place to train students' skills in terms of practice, demonstration, experiments or experiments, and the development of science. Practicum is one of the activities to provide students with an understanding of the material (Muchson *et al* ., 2018). The ideal condition of a laboratory is to have a special and specific room, for example, a chemical laboratory, the availability of laboratory equipment and materials that are well arranged on shelves or storage cabinets, equipped with safety standards, and the existence of quality assurance management for the laboratory.

A virtual laboratory is a laboratory used by students to conduct experiments without the need for real laboratory equipment (Sugiana *et al* ., 2017). The function of a virtual laboratory is as a learning medium, but in general, there are three functions of a virtual laboratory in chemistry learning, first, a virtual laboratory is an alternative to a real laboratory for schools that do not have laboratory facilities and are constrained by the limitations of inadequate tools and materials. More specifically, virtual laboratories serve as a means to assist students in pre-lab preparation, strengthen students' conceptual understanding, and as a substitute or complement to real laboratories because students can repeat practicum simulations that are not understood (Hawkins & Phelps, 2013; Tatli & Ayas, 2010). From the several functions of the virtual laboratory, it is hoped that the learning process will continue without reducing the essence of the material being studied and even foster a deep and memorable concept understanding for students.

Android is an operating system for Linux-based mobile devices that includes an operating system, middleware, and applications. Nazrudin (2012). According to Kasman (2016), Android is an operating system for mobile phones and touch screen tablet computers *based* on Linux. Based on this understanding of Android, it can be concluded that Android is a Linux-based operating system and is *open source* on touch-layer mobile devices such as cellular phones and tablet computers.

Education is one of the efforts to improve the ability of human intelligence, thus he is able to improve the quality of his life (Saleh and Mujahiddin, 2020). In the 21st century, critical thinking skills are seen as very important to be trained for students and become one of the main goals of Indonesian education. (Suryanti *et al* ., 2018) . Critical thinking is one of the 21st-century skills as a provision for students to face the challenges and demands of the times. By equipping critical thinking skills, students are expected to be able to make the right decisions when needed, get the best solution to a problem, and as part of an individual character who is visionary towards the future. According to Cottrel (2005), critical thinking is defined as a disciplined process that is intellectually active and skilled at conceptualizing, applying, analyzing, synthesizing, and evaluating the information gathered resulting from observation, reflection experience, reasoning, or communication as a guide for belief and action. Ennis (2011) states that critical thinking is thinking rationally and reflectively by emphasizing making decisions about what to believe or do.

Based on the opinions of the experts above, it can be concluded that critical thinking is someone who can think logically, rationally and think that is used to investigate, identify, study and develop in a more perfect direction both towards a statement and to assess certain qualities so that someone The person can assess things starting from simple things to complex ones and finally able to draw conclusions and make decisions from a statement or assessment of certain qualities.

The reaction rate is the change in the concentration of reactants (reactants) and reaction products (products) per unit time. For a reaction with reactants A and B to produce products C and D as shown in the following equation: A + *b* B *c* C + *d* D

Over time the number of reactant molecules A and B will decrease and the number of product molecules C and D will increase, and the formula for the rate of reaction (v) is written as follows:

$\rightarrow$

$$\frac{\Delta[A]}{\Delta t} = \frac{[A]2 - [A]1}{t2 - t1} \; dimana \; t2 > t1$$

$$v = -\frac{1}{a}\frac{\Delta[A]}{\Delta t} = -\frac{1}{b}\frac{\Delta[B]}{\Delta t} = +\frac{1}{c}\frac{\Delta[C]}{\Delta t} = +\frac{1}{d}\frac{\Delta[D]}{\Delta t}$$

A measure of the amount of a substance in a chemical reaction is generally expressed as the molar concentration or molarity (M). Thus, the reaction rate expresses the decrease in the concentration of the reactants or the increase in the concentration of the reaction products every one unit of time (seconds). The unit of reaction rate is generally expressed in units of mole dm $^{-3}$ s $^{-1}$ or mol/liter second. The unit mole dm $^{-3}$ or molarity (M) is the unit for the concentration of the solution.

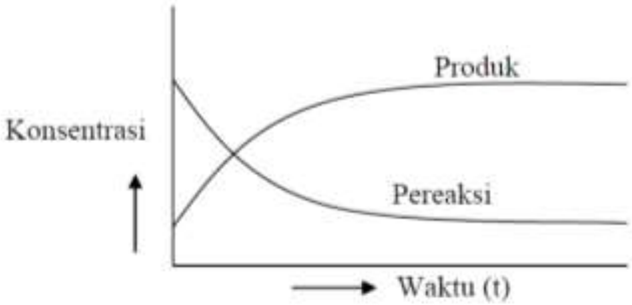

Figure 1. *Relationship of concentration changes with time*

II. Research Method

This research is development research that produces a product in the form of an android-based virtual laboratory to improve critical thinking skills on the reaction rate material, using a Research and Development (R & D) research model or research and development that produces certain products and tests the effectiveness of these products (Sugiyono, 2017). Development research is a process used to develop and validate educational products. The purpose of this development research is to produce a product where the resulting product already exists but still has shortcomings and the product is made to be perfected so that it can be used to support or assist learning process activities in schools.

This research produces a learning media in the form of an android-based virtual laboratory. At this stage, the researcher makes a virtual laboratory design, the main components displayed in the product design are KD and GPA, concept maps, materials, virtual labs, practice questions, and evaluations. The data analysis technique used in this research is quantitative and qualitative analysis.

III. Results and Discussion

The effectiveness of the virtual laboratory developed in this research is to determine the extent of the role of the virtual laboratory to assist students in understanding the material and concepts being studied, and to improve critical thinking skills. in terms of increasing students ' *pretest* and *posttest scores on the reaction rate material.* The effectiveness of the virtual laboratory is carried out in small-scale trials and large-scale trials. Specifically what is seen in these two tests is how virtual laboratories can be used to help students achieve learning goals. The small-scale trial amounted to 6 students while the large-scale trial amounted to 84 students, while the results of the trial are as follows:

Table 1. Virtual Laboratory Effectiveness Analysis Results

Aspect	Critical Thinking Ability			
Group	Average *pretest*	*Posttest* average	N-Gain	Criteria
Small Scale	29.17	82.50	0.76	High / Effective
Large Scale	29.79	84.47	0.78	High / Effective

Based on the data in Table 1 the results of the analysis of the effectiveness of the virtual lab, the results of the small-scale trial showed that the data had an increase in the results of the *pretest* and *post-test* N-Gain scores of 0.76 with high criteria and the percentage of N- *Gain* scores of 75.65 in the effective category, while the results of the large-scale trials large data shows an increase in the results of the *pretest* and *posttest* N-Gain scores of 0.78 with high criteria and the percentage of N- *Gain scores* of 77.73 effective categories.

The practicality of the virtual laboratory in this study was obtained from the results of student response questionnaires after the learning process. The virtual laboratory is said to be effective if the results of the student's response give a positive response seen from the student response questionnaire sheet and the comments given. The practicality test was carried out in two groups, namely a small-scale group and a large-scale group. The first trial was carried out on a small scale group to see if there were still weaknesses and shortcomings that could be revised as needed, then after being revised a trial was carried out on a large scale. The results of the student response questionnaire analysis were as follows:

Table 2. Results of Virtual Laboratory Practicality Analysis

N o	Group	Percentage	Criteria
1	Small Scale	93.56	Very Practical
2	Large Scale	94.76	Very Practical

Based on the data in Table 2 the results of the analysis of the practicality of the virtual laboratory, the use of the virtual laboratory obtained 93.56% of data in the small-scale group with a very practical category, while in the large-scale group data obtained 94.56% in the very practical category.

3.1 Description of Android-Based Virtual Laboratory Development Design

This study aims to produce a product in the form of an android-based virtual laboratory on the reaction rate material. The development of an Android-based virtual laboratory has fulfilled the main stages, namely the development model, development procedures, and product trials. Research on the development of a virtual laboratory as an android-based learning media is carried out using a procedural development model that follows the steps of the media development procedure with modifications that are aligned with existing goals and conditions.

The development of a virtual laboratory is carried out to overcome practical problems during distance or online learning. All materials and practicums with abstract concepts and objects can be visualized through the android application. One such application is a virtual laboratory which is a series of applications in the form of text, images, animation, and sound that are integrated as an experimental simulation or practicum.

The virtual laboratory is designed and made in such a way according to the curriculum and the needs of students in learning. Android is one of the operating systems on mobile phones that are most widely used today, so it can be used as a digital learning media that has a strategic role in the learning process that can help convey messages in learning and understanding material to students effectively and efficiently, so it is expected to foster trust self and stimulate cognitive ability in critical thinking.

3.2 Description of Android-Based Virtual Laboratory Validity

A product is said to be valid if it has gone through an assessment process carried out by a team of experts or validators. Validator is to provide suggestions, feedback, and comments for improvement and refinement of a developed product and conduct an assessment by filling out an expert validation sheet or assessment instrument so that it can then be tested. Aspects are assessed based on the quality of content and objectives, instructional, and technical. However, before validation, a validation instrument has been prepared which has been consulted and validated by the supervisor so that it can then be used for the validation process with the validator. The validation process is carried out by a team of experts, namely material and learning experts, media experts, and practitioners.

3.3 Description of Android-Based Virtual Laboratory Effectiveness

The effectiveness test is to determine the extent to which the role of an android-based virtual laboratory can improve critical thinking skills on the reaction rate material. The virtual laboratory is said to be effective if the activities of students during learning are more active, able to solve problems and provide solutions and experience an increase in learning outcomes *(pretest and post-test)*. Effectiveness refers to the degree that the experience and results obtained are in accordance with the expected goals (Akker, 1999).

The effectiveness test was conducted on small and large-scale groups with the same treatment in learning. The research was conducted in three meetings with online mode using *Microsoft Teams Learning Management System* (LMS). In the first meeting of students working on the *pretest questions* on the link that has been distributed in the class group, the *pretest questions* aim to determine the student's initial ability to the reaction rate material, then proceed with the learning process.

The learning process is focused on exploring concepts and students are asked to work on student worksheets (LKPD) in groups and then the results of the work are presented. In the implementation of the learning process, students begin to get used to virtual learning conditions and are very enthusiastic about participating in learning, which can be seen from the seriousness of learning. The instructions given are very clear and the student's responses are in accordance with the instructions given. The critical thinking ability of students can be seen from the activities during the learning process, the teacher observes and fills out the critical thinking observation sheet. The results and notes in this first meeting are that critical thinking skills are still in the average category enough and time management needs to be controlled, considering that online learning time is limited (60 minutes).

The activity of the students at the second meeting was to do a virtual practicum using an android-based virtual laboratory application that had previously been installed on the student's mobile device. Practical activities include student worksheets (LKPD) to guide learning activities and are carried out in groups and are required to collaborate in groups.

Students when working on LKPD are guided to identify/analyze problems or questions, make hypotheses, design experiments, collect data and information (opinions and arguments), analyze data and solve problems to make conclusions, and then communicate through presentations. It follows a step in the critical thinking process. According to Angelo (1995), critical thinking is applying rational, higher thinking activities, which include analyzing, synthesizing, recognizing problems and solving them, concluding, and evaluating.

The practicum activity itself is part of the critical thinking process where students carry out an experimental activity by linking theories and concepts by answering questions that stimulate critical thinking. The application of critical thinking skills is done by using the questions contained in the student worksheets (LKPD) related to the practicum activities carried out. This is in accordance with the concept of critical thinking (Ennis, 1986) that in the implementation of the test there needs to be mental involvement, strategies, and representations used to analyze, solve problems, make decisions, and learn new concepts.

The learning process at the second meeting was also carried out with critical thinking observations, where the results obtained were quite significant in increasing critical thinking skills with a good average category. In addition, the application in measuring critical thinking skills is also carried out using a multiple choice model but with a higher level of difficulty in other words the ability measured by C3 and C4. The importance of measuring critical thinking skills according to the opinion (Travis, 2015) that critical thinking is an essential ability that can be used as an indicator of learning success in achieving learning objectives and competency standards.

The results of previous research on the use of virtual laboratories can help students learn independently (Saputra & Priyambodo, 2018. Other research is the application of virtual laboratories to improve students' understanding of concepts (Hikmah *et al* ., 2017). Based on these results, it is directly proportional to the results of current research, where learning using virtual laboratories can effectively improve students' critical thinking skills.

Based on the results of small-scale trials, the data showed an increase in the results of the *pretest and posttest N-Gain* scores of 0.74 with high or effective criteria. At this stage, it aims to determine the extent to which students can experience an increase in critical thinking skills in the learning process by using an android-based virtual laboratory. In addition, this stage also aims to find weaknesses and shortcomings to be revised before a large-scale trial is carried out. In the large-scale group trial, the data also showed an increase in the results of the *pretest* and *posttest* N-Gain scores of 0.75 with high or effective criteria. This shows that the learning process using a virtual laboratory can help students understand the material being studied and lead to expression and exploration. The use of virtual laboratories also gives a meaningful impression to students (Picture *et al.*, 2018) so that the material learned can be remembered in long-term memory, fosters self-confidence, and is able to think critically about an issue. In the last part of the research, students were asked to fill out a student response questionnaire to find out how easy, comfortable, and interested the product was.

3.4 Description of Practical Android-Based Virtual Laboratory

The level of practicality of the resulting product refers to users or other experts considering that the product used is interesting and useful for teachers and students. (Akker, 1999). In addition, the practicality referred to in this development research is that the products developed can and are easy to use by students and teachers (Nieveen, 1999). The product developed can be said to be practical if the respondent states that the product developed can be applied in the field and the level of product implementation is included in the good category (Haviz, 2013). The virtual laboratory is said to be effective if the results of the student's response give a positive response seen from the student response questionnaire sheet and the comments given and the learning objectives are achieved.

The practicality of the product is measured using a student response questionnaire with two aspects of assessment, namely the learning or material aspect and the media display/operational aspect. An Android-based virtual laboratory is said to be practical if it is easy to install and use, easy to operate (complete with instructions for use) and the application runs normally and smoothly.

Practical trials of android-based virtual laboratories are carried out in the final stages of the learning process with the same treatment in small-scale trials and large-scale trials. Students are given a link *(link)* to the student response questionnaire to be filled in based on the use of an android-based virtual laboratory application that has been used during the learning process. Small-scale trials are more focused on student responses and comments for improvement and

Based on the results of the student's response questionnaire to the use of virtual laboratories, the data on a small-scale trial of 93.56% with very practical criteria, shows that students are very interested and like the products developed, besides that the class atmosphere is active and more lively even in virtual space. In general, there are no obstacles or problems in its use, it can be seen from the responses or comments that most of the students stated that the product developed was very good so that there were no improvements and revisions to the application. Suggestions in the future are that there is a similar application that can accommodate any material in practical activities using an android application.

Based on the results of the student response questionnaire to the use of the virtual laboratory, the data on a large-scale trial was 94.67% with very practical criteria. This shows that in the use of android-based virtual laboratory applications there are no obstacles and obstacles, but non-technically in the online learning process it is very dependent on network conditions, this becomes an obstacle for students when doing face-to-face *online*, the rest runs smoothly according to the instructions has been planned so that learning guides students in understanding the material and practicing critical thinking skills through virtual practice. This has an impact on the interest of students in learning to use the products developed, besides that the use of virtual laboratories is more *flexible* and effective on android *phones* (Manikowati & Iskandar, 2018). From the analysis of the student response questionnaire data, it is stated that it is very practical to use in the chemistry learning process on the reaction rate material

IV. Conclusion

This development research produces a product, namely an android-based virtual laboratory to improve critical thinking skills on the reaction rate material through the main stages, namely validation, and product testing until the product is declared final. Based on the research that has been done, the validity, effectiveness, and practicality are concluded as follows:

1. The android-based virtual laboratory development design has features or menus, namely KD and GPA, concept maps, materials, virtual labs, practice questions, and evaluations.
2. The validity of the android-based virtual laboratory is reviewed from the validation sheet of material experts, media, and practitioners with very valid criteria so that they are suitable for use and meet the assessment criteria, and are in accordance with the needs and conditions of the Covid-19 pandemic.
3. The effectiveness of an android-based virtual laboratory that was developed based on the results of *pre-test* and *post-test* with high or effective criteria means that the product can improve students' critical thinking skills.

The practicality of the android-based virtual laboratory that was developed in terms of student response questionnaires with very practical criteria means that the android-based virtual laboratory does not experience obstacles and obstacles, it can even guide students in understanding the material and practicing critical thinking skills.

References

Ahmed, S., Shehata, M., & Hassanien, M. (2020). Emerging Faculty Needs for Enhancing Student Engagement on a Virtual Platform. MedEdPublish, 9(1).

Akker, J. van den. 1999. Principles and Methods of Development Research. In Plomp, T; Nieveen, N; Gustafson, K; Branch, RM; and van den Akker, J (eds). *Design Approaches and Tools in Education and Training.* London: Kluwer Academic Publisher.

Ambusaidi, A., Al Musawi, A., Al-Balushi, S., & Al-Balushi, K. (2018). The impact of virtual lab learning experiences on 9th-grade students' achievement and their attitudes towards science and learning by the virtual lab. *Journal of Turkish Science Education*, 15(2), 13–29.

Angelo, Thomas A. & Cross, Patricia (1995). Classroom Assessment Techniques: A Handbook for College Teachers, 2nd edition

Arikunto, Suharsimi. 2010. Research Procedures A Practical Approach. Jakarta: PT. Rineka Cipta.

Azzahra, SF (2019). Improving Students' Critical Thinking Ability Through Experimental Learning on Electrolyte and Non-Electrolyte Solutions. *Journal of EduMatScience*, 4(1), 77–88.

Bortnik, B., Stozhko, N., Pervukhina, I., Tchernysheva, A., & Belysheva, G. (2017). Effect of Virtual Analytical Chemistry Laboratory on Enhancing Student Research Skills and Practices. *Research in Learning Technology, 25* , 1-20

Bujeng, B., Kamis, A., Hussain, MAM, Rahim, MB, & Soenarto, S. (2019). Validity and reliability of multimedia interactive making clothes (MIMP) module for home science subjects. *International Journal of Innovative Technology and Exploring Engineering*, 8(8 S), 593–596.

Chen, C., Jones, KT, & Xu, S. (2018). The association between students' style of learning preferences, social presence, collaborative learning, and learning outcomes. *Journal of Educators Online*, 15(1).

Dwiningsih, K., Sukamin, Muchlis, & Rahma, PT (2018). Development of Chemistry Learning Media Using Virtual Laboratory Media Based on the Learning Paradigm in the Global Era. *Kwangsan: Journal of Educational Technology*, *06* (02), 156-176.

Elisa, E., Wiratmaja, IG, Nugraha, INP, & Dantes, KR (2021). Development of Engineering Chemistry Virtual Laboratory to Improve Students' Critical Thinking Skills and Science Process. *In Journal of The Indonesian Society of Integrated Chemistry* 12 (2), 55–61.

Ennis, RH 1996. *A Critical Thinking*. New York: Freeman.

Ennis, RH 2015. Critical Thinking Assessment. *Taylor and Francis.* 32 (3) pp.179-186.

Fabregat-Sanjuan, A., Pàmies-Vilà, R., Piera, FF, & De la Flor, S. (2017). Laboratory 3.0: Manufacturing technologies laboratory virtualization with a student-centered methodology. *Journal of Technology and Science Education*, 7(2), 184–202.

Facione. (2013). Critical Thinking: What It Is and Why It Counts. Millbrae, CA: Measured Reasons and The California Academic Press

Firmyanti, Lilis. 2011. The Effect of Using Virtual Physics Laboratory in Different Group Sizes on Student Learning Outcomes on the Concept of Static Electricity. Thesis. Surabaya: PPs Unesa.

Fisher, A. 2008. Critical Thinking. Jakarta: Erlangga.

Gambari, AI, Kawu, H., & Falode, OC (2018). Impact of Virtual Laboratory on the Achievement of Secondary School Chemistry Students in Homogeneous and Heterogeneous Collaborative Environments. *Contemporary Educational Technology*, *9* (3), 246–263.

Ghavifekr, S., & Rosdy, WAW (2015). Teaching and learning with technology: Effectiveness of ICT integration in schools. *International Journal of Research in Education and Science*, 1(2), 175–191.

Hake, R, R. (1999). Analyzing Change/Gain Scores. AREA-D American Education Research Association's Division. D, Measurement and Research Methodology.

Harlinda Fatmawati, et al. 2014. "Analysis of Students' Critical Thinking in Solving Mathematical Problems Based on Polya on the Quadratic Equation material". *Electronic Journal of Mathematics Learning*. ISSN 2339-1685. Vol. 2, No. 9.

Hawkins, I. & Phelps, AJ 2013. Virtual laboratory vs. traditional laboratory: which is more effective for teaching electrochemistry? Chemistry Education Research and Practice, 14, 516–523.

Herliandry, LD, Nurhasanah, N., Suban, ME, & Kuswanto, H. (2020). Lessons Learned During the Covid-19 Pandemic JTP - *Journal of Educational Technology,* 22(1), 65–70.

Hikmah, N., Saridewi, N., & Agung, S. (2017). Application of Virtual Laboratory to Improve Student Concept Understanding. *EduChemia (Journal of Chemistry and Education)*, *2* (2), 186.

Jagodziński, P., & Wolski, R. (2015). Assessment of Application Technology of Natural User Interfaces in the Creation of a Virtual Chemical Laboratory. *Journal of Science Education and Technology*, 24(1), 16–28.

Kahveci, M., & Orgill, MK (2015). Affective dimensions in chemistry education. Affective Dimensions in Chemistry Education, 1-318.
Karlinda, DF 2013. Comparison of Science Process Skills (Kps) and Learning Outcomes between Learning Using Real and Virtual Laboratory Experimental Methods on Students' Initial Ability in Dynamic Electrical Materials. (Thesis). Lampung University. Bandar Lampung.
Kasman, AD 2015. Android Collaboration Tricks with PHP & MySQL. Jogjakarta: Loko Media
Lutfi, A. (2017). Development of Computer-equipped Virtual Laboratory Media to Practice Critical Thinking in Acid, Base, and Salt Learning. *Unesa Journal of Mathematics and Science Education Research*, 1(1), 27–33.
Mahanta, A.; Sarma, KK. (2012). Online Resource and ICT Aided Virtual Laboratory Setup. *International Journal of Computer Applications*, 52(6), 44-48.
Makransky, G., Thisgaard, MW, & Gadegaard, H. (2016). Virtual simulations as preparation for lab exercises: Assessing learning of key laboratory skills in microbiology and improvement of essential non-cognitive skills. PLoS ONE, 11(6), 1–11.
Manikowati, & Iskandar, D. (2018). Development of Mobile Virtual Laboratory for Practicum Learning for High School Students. *Kwangsan: Journal of Educational Technology*, *06* (01), 23–42.
Mataka, LM, & Kowalske, MG (2015). The influence of PBL on students' self-efficacy beliefs in chemistry. Chemistry Education Research and Practice, 16(4), 929–938.
Muchson, M., Munzil, M., Winarni, BE, & Agusningtyas, D. (2018). Android-Based Virtual Lab Development on Acid-Base Materials for High School Students. *J-PEK (Journal of Chemistry Learning)*, 4(1), 51–64.
Musyaillah, D., Muhab, S., & Yusmaniar. (2017). The Effect of Virtual Laboratory Integration in Problem Solving Learning Models on Students' Critical Thinking Skills on Dual Electrolyte and Non-Electrolyte Solutions. *Journal of Chemical Education Research*, 7(1), 38–51.
Nazar, M., Oktarina, A., & Puspita, K. (2020). Development of Android-Based Interactive Learning Applications to Assist Students in Studying Electrolyte and Nonelectrolyte Solutions. *Indonesian Journal of Science Education*, 8(1), 39–54.
Nieveen, N. 1999. Prototyping to Reach Product Quality. Jan Van den Akker, Robert Maribe Braneh, Kent Gustafson, and Tjeerd Plomp (Ed), London: Kluwer Academic Publisher.
Prasetyowati, EN, & Suyatno. (2016). Improving the Mastery of Concepts and Critical Thinking Skills of Students through the Implementation of the Inquiry Learning Model on the Main Material of the Buffer Solution. *Journal of Chemistry and Chemistry Education* (JKPK), 1(1), 67–74.
Putratama, F., & Efkar, T. (2019). The Effect of Experimental Methods on Improving Critical Thinking Skills and Mastery of Thermochemical Concepts. 1, 25–37.
Putri, A., Syakbaniah, & Yulkifli. 2013. Development of Virtual Laboratory on Kinematics Material with Vector Analysis in Physics Learning in Class XII SMA. *Pillars of Physics Education*. 1(1), 23-29.
Raharjo, SB 2016. Experimental-Based Chemistry 1 for SMA and MA Class X. Solo: PT Tiga Seragkai Pustaka Mandiri
Saleh, A., Mujahiddin. (2020). Challenges and Opportunities for Community Empowerment Practices in Indonesia during the Covid-19 Pandemic through

Strengthening the Role of Higher Education. *Budapest International Research and Critics Institute-Journal (BIRCI-Journal)*. Volume 3, No 2, Page: 1105-1113

Saputra, P., & Priyambodo, E. (2018). Development of an Android-Based Virtual Laboratory on Acid & Base Materials as a Source of Independent Learning for SMA/MA Students. *Journal of Chemistry Learning*, 7(2), 94–102.

Solihah, Attus, Yektyastusi, R., Prasetyo, YD, Sugiyarto, KH, & Ikhsan, J. (2015). Development of Android-Based Chemistry Learning Media as a Supplement to Acid-Base Materials Based on the 2013 Curriculum. Proceedings of the National Seminar on Science Education, 2015–2457.

Sugiana, IN, Harjono, A., Sahidu, H., & Gunawan, G. (2017). The Influence of Virtual Laboratory Media Assisted Generative Learning Model on Students' Mastery of Physics Concepts on Momentum and Impulse Materials. *Journal of Physics and Technology Education*, 2(2), 61.

Sugiyono. (2017) Research and Development *Research and Development Methods* ", Bandung: Alfabeta.

Suprapto, N., Abidah, A., Dwiningsih, K., Jauhariyah, MNR, & Saputra, A. (2018). Minimizing misconceptions of ionization energy through a three-tier diagnostic test. Periodico Tche Quimica, 15(30), 387–396.

Suryanti, Arifin, ISZ, & His Majesty, U. (2018). The Application of Inquiry Learning to Train Critical Thinking Skills on Light Material of Primary School Students. *Journal of Physics: Conference Series*, 1108(1).

Shukri, S. 1999. Basic Chemistry Volume 2, Bandung: ITB Publisher.

Tatli, Z. & Ayas, A. 2010. Virtual laboratory applications in chemistry education. Procedia Social and Behavioral Sciences, 9, 938–942.

Wahyuni, TR, & Atun, S. (2019). Development of Virtual Laboratory Media Based on Inquiry for Electrolyte and Non-Electrolyte Solutions. *Journal of Education: Theory, Research, And Development*, 4(5), 674–686.

Widowati, A., Nurohman, S., & Setyowarno, D. (2017). Development of Inquiry-Based Science Virtual Laboratory for Improving Student Thinking Skills of Junior High School. *Journal of Mathematics Education And Science*, *5* (2), 170±177.

Wulandari, N., & Vebrianto, R. (2017). Literature Study of Problem-Based Chemistry Learning in terms of Ability to Use Virtual Laboratory. National Seminar on Information, Communication and Industry Technology (SNTIK) 9, 709