

VIRTUAL LABORATORY DEVELOPMENT AS ICT BASED LEARNING MEDIA IN ACID AND BASIC TITRATION LEARNING

1st Febrian Andi Hidayat¹, 2nd Heny Sri Astutik²
{febrianandi12@gmail.com¹, henysriastutik@gmail.com²}

Universitas Pendidikan Muhammadiyah Sorong, West Papua, Indonesia^{1,2}

Abstract. This study used the Research and Development (R & D) method. In this case, the development of a Virtual Laboratory with a Dick & Carey model that is consisted of 10 components which are limited to the formative evaluation stage. The stage consists of the expert judgment stage, small group try out, and field try out to produce an ICT-based teaching material in the form of a Virtual Laboratory on Acid Base Titration learning that is valid, practical and effective. To achieve this goal, this study will be carried out in 1 (one) year starting from the preliminary study then continued with the preparation of a draft of ICT-based learning media in the form of Virtual Laboratory learning media. This draft was validated and trialed on a small scale field, analyzed, and revised. The draft revised on a small-scale trial is then tested on a large scale, revised and refined to produce the quality learning media. The stages of validation are carried out theoretically and empirically along with the expert. The result of this study indicated that the Virtual Laboratory learning media that was developed is suitable to be used as ICT-based learning media in the Acid Base Titration material which is marked by the results of media expert evaluations with the criteria of "good" and by material experts with the criteria of "very good". The Virtual Laboratory that was developed also has an acceptability level with the criteria of the students' responses and lecturers which is "very supportive" and supported by the evaluation data on the average completeness of students (grades A and B) of 87.5%.

Keywords: Virtual Laboratory, Acid-base Titration.

1. Introduction

Learning of Acid Base Titration is not only focusing on concept theory but also to support the student centered learning which give priority to the research process, the discovery of the concepts and theories themselves [15]. Therefore, during the learning process the existence of laboratories becomes important where the purpose of learning in the laboratory is to develop student skills such as observation, using of tools, training students carefully and recognizing the limitation of laboratory measurement skills, practicing accuracy in recording, reporting, experimental results, stimulating the critical thinking analysis through the interpretation of experiments, deepen knowledge, developing honesty and responsibility, training the students to plan and carryinh out experiments.

Laboratories are often interpreted as a space or place to conduct experiments or research but the problems that occur is the study more happening in the class rather than in laboratory because they are pursuing the target of completing material based on the curriculum [18]. The limited costs to provide practical equipment and materials cause the using of laboratory

decrease and the quality of it is getting lower so that it is inadequate in doing the lab work. [11].

The rapid development of information technology and science give big impact in education. One of them is the changing of curriculum, media and technology [1]. The current curriculum requires educators to be more creative in learning, including the ability to modify methods or media that are used as a component of learning. One of the abilities that an educator must possess is the ability to use media / learning resources.

The good media is able to interpret the abstract concepts into the concepts that are easier to understand [3]. As a solution to solve the problems that occur where practicum cannot or difficult to do is using the Virtual Laboratory learning media which is learning with the help of ICT-based media. In this case, the students are given experience like they were practicing in a real laboratory so that Virtual Laboratories need to be developed as media in ICT-based learning that is valid, practical, and effective so that the learning outcomes can improve and suitable with the learning objectives.

Based on the description above, the purpose of this study is to describe the process of developing a Virtual Laboratory as an ICT-based media in learning Acid Base Titration and measure the level of its effectiveness.

2. Research Methodology

2.1. Types of Research

This research is a development research that focused on product development in the form of a Virtual Laboratory as an ICT-based as a learning media that is adapted from the Dick & Carey development model which consists of 10 components [3].

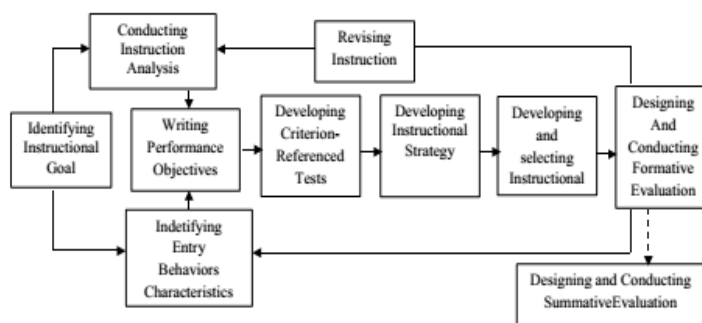


Fig. 1. Dick & Carey Development Model

2.2. Formulation of Development Objectives

The development of a Virtual Laboratory begins with the formulation of objectives by collecting information related to the product that will be developed. The results of the needs analysis and formulation of objectives, then set the indicators of achievement of competencies, determine the scope of the material, formulate tools to measure success, and other things that is related to the preparation of product development.

2.3. Validation of Virtual Laboratory Learning Media

Validation of Virtual Laboratory learning media is done by an expert. This validation involved material experts and practitioners to determine the suitability and feasibility of learning media products [5].

2.4. Product Trial

The product trial is carried out in two stages, namely small scale and large scale trials / field try out.

2.5. Data Analysis process

Data content validation was analyzed by calculating the results of the validators' assessment of teaching materials that is developed with the following equation:

$$\text{Amount of final value} = \frac{N1+N2+\dots+Nk}{\Sigma N} \quad (1)$$

Information:

N1: Amount value of part 1;

N2: Total value of part 2

Nk: Total value of part k; and

ΣN :Total of students

The criteria for interpreting the scores obtained (fulfilling / not fulfilling) are as follows.

Table 1. Score of Virtual Laboratory Validity

Validation Score Range	Criteria	Information
1,00 - 1,50	Poor	Cannot be used
1,60 - 2,50	Fair	Can be used with many revisions
2,60 - 3,50	Good	Can be used with small revision
3,60 - 4,00	Excellent	Can be used with a few revisions

3. Research Result

3.1. The Process of Developing Virtual Laboratory Learning Media

Virtual Laboratory learning media was developed with Coreldraw X7 and Macromedia Flash 8 which consisted of text, images, animation and sound. The minimum hardware needed such as Intel Pentium 200 Mhz, 128MB RAM, and CDROM driver. Virtual Laboratory Design uses Indonesian in accordance with the standards of program requirements in overcoming the limitations of the lessons delivery.

The illustration of initial appearance of the Virtual Laboratory design can be seen in Figure 2.



Fig. 2. The initial appearance of the Virtual Laboratory Learning media

Illustration of the main menu display, subject display, and the experiment simulation display is shown in Figure 3.



Fig. 3. (a) Display the main menu of the Virtual Laboratory learning media, (b) Subject Display, (c) Display of practicum simulation on Virtual Laboratory learning media

The design of Virtual Laboratory learning media was validated by two experts, one lecturer from the Information and Technology education program as an ICT validator and one lecturer from the science education program as a validator in the material section. The results of the evaluation of the feasibility of the Virtual Laboratory by experts can be observed in Table 2.

Table 2. Recapitulation the assessment result of the feasibility the Virtual Laboratory Learning Media by the experts

No	Aspects of learning material	Score	Learning Media Aspects	Score
1	Clarity of learning objectives	3	Effective and efficient in the development and using of learning media	3
2	The relevance of learning objectives with SK / KD / Curriculum	3	Maintainable (can be maintained / managed easily)	3
3	Compatibility of material with learning objectives	3	Usability (easy to use and simple to operate)	3
4	The accuracy of the use of learning strategies	3	Compatibility (learning media can be run on various existing hardware and software)	2
5	Interactivity	3	Reusable (some / all learning media programs can be reused to develop other learning media)	2
6	Providing learning motivation	2	Communicative (according to the target and acceptable to the wishes of the target)	3
7	Contextuality and actuality	3	Creative in ideas and giving ideas	3
8	Material profundity	2	Simple and attractive	3
9	Easy to understand	3	Audio (narration, sound effect, backsound, music)	2

No	Aspects of learning material	Score	Learning Media Aspects	Score
10	Systematic / trace / flow logic is clear	2	Visual (layout, design, typography, color)	1
11	Clarity of description, discussion, examples, conclusions and exercises	3	Moving media (animation)	2
12	Consistency of evaluation with learning objectives.	2	Interactive Layout (navigation icon)	2
Total score		32		29
Average score		2,67		2,42

The design that has been validated by the expert then revised according to the suggestions and input from the two experts. These improvements can be seen in table 3.

Table 3. Revised design of Virtual Laboratory Learning Media

Aspects of learning material	Revision	Learning Media Aspects	Revision
Clarity of learning objectives	Include specific learning goals	Usability	Add a media folder auto run
Contextuality and actuality	Remove the submenu in the form of text	Audio (narrative sound effect, back sound, music)	Add sound effects according to the practical experiment
Profundity of teaching material	Add mathematical equations in determining concentration and volume of solution	Visual (layout design, typography, color)	homogenize the writing position on the main menu
Clarity of description, discussion, examples, simulations and exercises	Using the command sentence on the practical treatment instructions	Moving media (animation)	Remove the initial text animation in the action view before the experiment

3.2. Trial of Virtual Laboratory Learning Media

After the expert review and revision of the Virtual Laboratory learning media design process, it tested on the 3rd semester students of the STKIP Muhammadiyah Sorong Science Education program with the total of 6 students on a limited scale trial. The Virtual Laboratory is stated acceptable if the response data of students who agree reaches ≥ 2.51 . The results of the student responses are shown in table 4.

Table 4. Recapitulation of student responses to limited scale trials

No	Response criteria	Score range	Number of students responding	Percentage(%)
1	Very supportive	3,25 <score \leq 4	4	66,67
2	Supportive	2,50 <score \leq	2	33,33
3	less supportive	1,75 <score \leq	0	0
4	Does not supportive	1 <score \leq 1,75	0	0
The number of students with criteria is very supportive and support			6	100

The average score of student responses can be seen in table 5 below.

Table 5. Average scores for each item of student responses to limited scale trials

No	Response	Average score	Criteria
1	Interest in using media	3,50	Very supportive
2	Media is based on the learning objectives	3,67	Very supportive
3	The media is easy to operate	3,33	Very supportive
4	Media helps understanding material	3,17	Support
5	Attractive media display	3,83	Very supportive
6	Media along with the practice questions and new information	3,00	Supportive
7	Media increases learning motivation	3,67	Very supportive
8	Media is used independently	3,83	Very supportive
9	Media is more effective and efficient	3,67	Very supportive
10	Interest in using media on other materi'al	3,33	Very supportive
	Amount of average score	3,50	Very supportive

The revision of the Virtual Laboratory Learning Media is illustrated in the following figure.

1. The Input related to the background apperence that need to be more varied and bright colors.

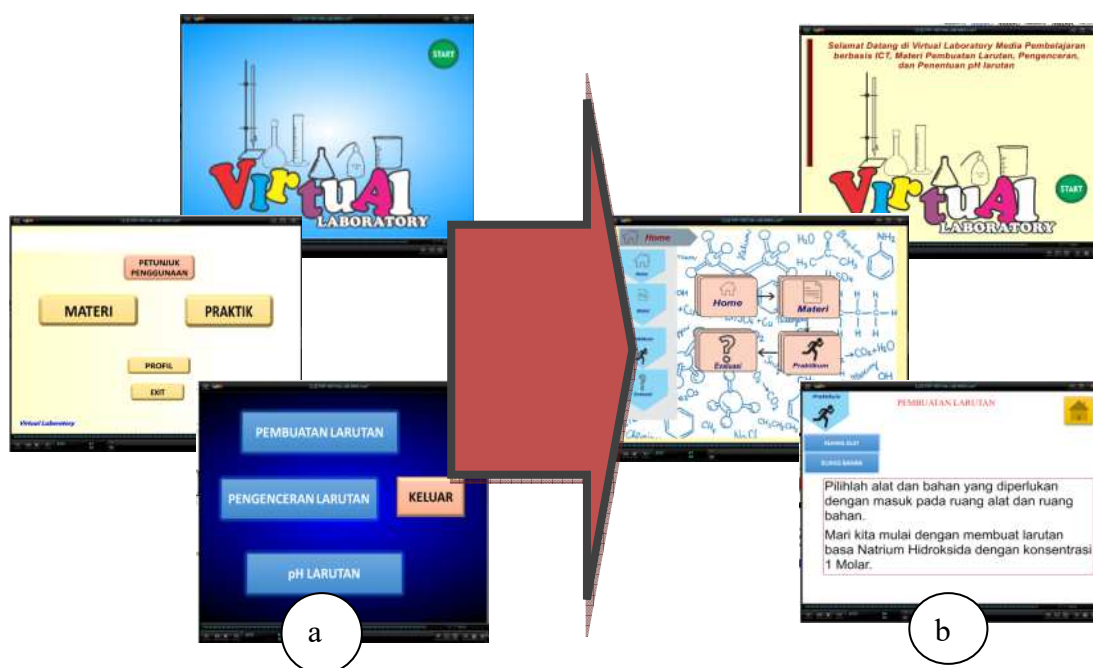


Fig. 4. Display of Virtual Laboratory based on input from students and lecturers before revision and (b) after revision.

2. Input about the number of evaluation questions that need to be added then revised by adding questions and displaying different questions. The evaluation question was then added to 15 questions.

The large-scale trial phase was carried out by testing the revised results of the Virtual Laboratory to 35 students of the STKIP Muhammadiyah Sorong Science Education department. The results of student responses are shown in table 6.

Table 6. Recapitulation of student responses to large-scale trials

No	Response of Criteria	Score range	Total students who responded	Percentage (%)
1	Very supportive	3,25 <score ≤ 4	28	87,5%
2	Support	2,50 <score ≤ 3,25	4	12,5%
3	Not supportive	1,75 <score ≤ 2,50	-	-
4	Does not support	1 <score ≤ 1,75	-	-
The total number of students with criteria is very supportive and supportive			32	100%

The average score of student responses can be seen in table 7.

Table 7. Average scores for each item of student responses to a large-scale trial

No	Response	Average Score	Criteria
1	Interest using media	3,78	Very supportive
2	Media according to learning objectives	3,63	Very supportive
3	The media is easy to operate	3,59	Very supportive
4	Media helps understanding material	3,50	Very supportive
5	Attractive media display	3,72	Very supportive
6	Media accompanied by practice questions and new information	3,38	Very supportive
7	Media increases learning motivation	3,50	Very supportive
8	Media is used independently	3,69	Very supportive
9	Media is more effective and efficient	3,47	Very supportive
10	Interest in using media on other material	3,41	Very supportive
Amount of average score		3,57	Very supportive

The response given by the lecturer was "very supportive" of the Virtual Laboratory with a total average score of 3.81. The results of lecturer response scores can be seen in table 8.

Table 8. Scores for each item of lecturer responses

No	Response	Average Score	Criteria
1	Learning with interesting Virtual Laboratory learning media	4	Very supportive
2	The Virtual Laboratory learning media makes it easy to deliver material	3,75	Very supportive
3	Interest using the Virtual Laboratory on other material	3,75	Very supportive
4	Motivated to make learning media innovations	3,75	Very supportive
5	The use of Virtual Laboratories increases student activity	4	Very supportive
6	Display of interesting Virtual Laboratory Learning Media	3,75	Very supportive
7	The presentation of material is logical and systematic	3,5	Very supportive
8	Practicum with a Virtual Laboratory is effective and efficient	4	Very supportive
Average total		3,81	Very supportive

The recapitulation of the results of the practicum simulation evaluation is presented in table 9.

Table 9. The recapitulation results of the practical simulation evaluation using the Virtual Laboratory learning media

No	Data	Students majoring in science education
1	The highest score	100
2	Lowest score	60
3	Average score	81,7
4	Students who have completed learning (in grades A and B)	28
5	Students who have not finished learning (categories of values C, D, and E)	4
Percentage of completeness		87,5 %
Average completeness		12,5 %

Inputs recorded as improvement material are as follows:

- 1) Input from the students related to the editorial of some evaluation questions that are difficult to understand is corrected by changing the editorial questions to be more communicative and easy to understand.
- 2) Input from the lecturers related to interesting and non-stressful chemistry learning is accommodated by giving some funny animated images and feedback to the users so that it is funnier.

3.3. The final product of the Virtual Laboratory learning media

The revised Virtual Laboratory learning media are then packaged with steps including the provision of covers and using instructions so that the final product of the Virtual Laboratory as an ICT-based learning media is compiled in CD.

4. Discussion

4.1. The process of developing Virtual Laboratory learning media

The development of the Virtual Laboratory fulfills 3 components, namely the development model, development procedure and product trial. Research on the development of Virtual Laboratories as ICT-based media has been carried out using procedural development that follows the steps in the media development procedure from Sugiyono with modifications that are aligned with the objectives and conditions of the actual research [22]. The development of Virtual Laboratories is done to overcome the ineffectiveness problems in the laboratory and the limited time of learning activities in science learning. Material related to abstract concepts such as learning chemistry, especially Acid Base Titration can be visualized through ICT-based applications.

Based on the results of the study, the Virtual Laboratory has passed the validation stage with little improvement, namely (1) the component clarity of learning objectives related to the component consistency of the evaluation with clarity of learning objectives. Experts provide input to include learning objectives specifically so that evaluation questions are adjusted to the

learning objectives. (2) Contextuality and actuality components are improved by removing the submenu in the form of text. The observation section has been found in the experiment animation. Students can use all senses to make observations through experimental animations. (3) Component profundity of material that is improved by the use of the right word editor. (Mustikasari 2008). (4) Components of clarity of description, discussion, examples, simulations and exercises are corrected by adding images and using command sentences according to the general rules of safety working in the laboratory (Wirjosoemarto et al. 2004).

4.2. Trial of small scale Virtual Laboratory learning media

The "very supportive" response can be seen in average score of the students' responses. Most of the students have never used a computer-based Virtual Laboratory in previous learning so the acceptability of the Virtual Laboratory is quite good. Submitting with computers can visualize objects with certain limitations becoming more real. Computer experiments are the link between theory and practice without having to carry out experiments in real laboratories [27]. A "supportive" response to the use of media can help understanding because the use of media can overcome the limitations of student experience, allowing students to understand all objects simultaneously. This is support the results of Huang's (2004) study that the learning with Virtual Laboratories in SUMMIT students can improve understanding of concepts and motivation to learn.

4.3. Product revision

Small-scale testing of Virtual Laboratory shows that ICT-based learning media is well received by students because it has reached an acceptance indicator (score ≥ 2.51). Although it still shows some weaknesses that must be corrected. Less varied and interesting background is one of the things that is improved, by adding attractive colors and more suitable with the recommendations.

Learning outcomes are determined by using evaluation tools in the form of test questions. The Virtual Laboratory provides 10 questions, but the students propose to add the number of questions to 15 or by sub-topics 5 questions. The improvements are made by adding evaluation questions to 15 questions with reasoned multiple choice questions.

4.4. Large scale Virtual Laboratory learning media trials

This stage shows that 100% of students give "very supportive" and "supportive" responses so that they show good and enthusiastic responses from students to the Virtual Laboratory. The percentage (100%) in the large scale trial is the same as the small scale percentage which is equal to (100%), but different in the percentage of students who choose the "very supportive" category which is 87.5% for large scale trials, and 66, 67% for the limited scale test. So, it can be concluded that after the use of Virtual Laboratory, there is an improvement in the percentage number. Virtual laboratories have also been considered to be able to improve the consistency, reliability and quality that they want to convey to the students of Deakin University students that is around 75% of "supportive" responses.

The average score of student responses when the large-scale trial showed that from all student responses, the score is ≥ 2.51 . In item number 1 (interest in using media) the score is 3.50 in a small scale trial and 3.78 in a large scale trial. The score above shows that the Science Education Program students of STKIP Muhammadiyah Sorong have a high interest in

Virtual Laboratories, because these learning media are still classified as new learning media that have never been used before.

The average item score of response number 2 (media according to the learning objectives) in the small-scale trial amounted to 3.67 while the large-scale trial showed a number of 3.63 that is very small decline. It could be occurred because there are still some students who have not too aware the purpose of the questionnaire statement in the student response. The "very supportive" criteria were also obtained during limited and wide scale trials. In the response item no. 3 concerning (the ease operation of the Virtual Laboratory) which proves that the instructions for using the media are clear and it suitable with one of the considerations for choosing the media delivered [22]. In line with the statement Dobrzanski & Honysz, using Virtual Laboratory can be easily accepted by the users.9].

The item response number 4 (media helps understanding material) in small-scale trials get responses "support" while in large-scale trials receive responses "very supportive". A similar response is also shown in item number 5 about the appearance of the media. The interested media "supports" the material understanding in item number 4. The students learn better with animation instructions. It helps them to build the relationships between words and images rather than learning only with text (Saguni 2006). The level of education also affects the level of understanding, so the higher level of education the greater the level of understanding. In line with the statement which id said by Chan (2009) that Virtual Laboratories is suitable to be used by the students with a higher level education (at least high school level / equivalent) [8].

The criteria for "supporting" the small-scale trial, and "very supportive" in the large-scale trials were obtained in item number 6 (complete media with exercise question and new information). Exercise questions on the evaluation menu are used to determine the understanding of material. The exercise question in limited scale trials can give feedback and student motivation. The addition of the number and variety of questions and additional information on CHEMIST have been suitable with the contextual and actuality components.

Item response number 7 (media improve the learning motivation) gets the criteria of "very supportive" when testing scale is limited or broad. It proved that the Virtual Laboratory motivates and stimulates te students to learn [11]. Likewise in item number 8 (media used independently) received a "very supportive" response during small and large scale trials. Virtual laboratories are used independently because the clear instructions and navigation icons allow students to browse the contents of the Virtual Laboratory based on their needs [13 & 9]. Experimental simulations are designed independently to invite the students to experience hands-on activities into real-life science situations [26].

The average item score responses number 9 (media used is more effective and efficient) get the category of "very supportive" in both small scale and large scale trials. However, revisions have been made to the question by adding 15 questions. The results of the student evaluations through evaluation questions can be used as a benchmark for the effectiveness of Virtual Laboratory media.

The last student response item is related to the interest in using the Virtual Laboratory in other material. This response item gets the criteria of "very supportive" in both small and large scale trials because there are still some other materials with abstract concepts and have never been research because of the limitations in terms of time, material objects, laboratory equipment and other materials.

The level of acceptance of the Virtual Laboratory is also measured based on the lecturers' responses. The lecturer gave a "very supportive" response to the Virtual Laboratory. The average score of each item in the lecturers' responses to the eight items of responses showed a

"very supportive" response. In the context of experiments in science learning, Virtual Laboratories is very interested things with logical and systematic presentation of material. The effectiveness and efficiency of the Virtual Laboratory is considered to be important because it is able to overcome the limitations of time, overcome the lack of lab tools and materials provosion, overcome the risk of accidents during the experiment and overcome the presentation of abstract concepts to facilitate the material delivery. The compatibility aspect has also been fulfilled because all users, both lecturers and students, can operate the Virtual Laboratory easily. Based on the advantages that exist in the Virtual Laboratory, the lecturers are very interested in learning other materials using the Virtual Laboratory and are more motivated to make learning innovations such as the Virtual Laboratory. Thus, the Virtual Laboratory is well accepted by students and lecturers who have proven their usefulness.

The results of student practical evaluation at the end of the Virtual Laboratory media can be used as supporting data to determine the effectiveness of Virtual Laboratory in learning. Virtual laboratory is considered effective if $\geq 75\%$ of students achieve completeness scores with criteria A and B (score 70 s.d. 100). Based on the results of data analysis $\geq 75\%$ of students get grades A and B, so the classical completeness is achieved.

The achievement of classical completeness in this study is the role of Virtual Laboratory as an ICT-based learning media that has been tested using aspects of validity, acceptability and effectiveness. Virtual laboratories include enactive representations that integrate text, images, animation and sound to conduct experiments on problem solving material, dilution and pH determination that provide concrete opportunities, hands on activities, high level thinking and problem solving for students.

4.5. Advanced product revisions

The appearance of Virtual Laboratory on a large-scale trial totality received a good and interested predicate so that it could help deliver the material, but showed some weaknesses that must be corrected. The mprovements are made by increasing the level confidence in answering the question give.

The lecturer also gave input that the fun and non-stressful chemical learning must continue to be developed through the use of media such as Virtual Laboratory. Virtual laboratories are expected to be designed based the characteristics of users in creating a pleasant atmosphere. In Virtual Laboratory requires the right learning strategy to always be the center of attention. This is in line with the statement by Suyatna that one of the effective and fun strategies to bridge the relationship between theory and practice is to provide experimental learning experiences through virtual laboratories [26]. Revisions related to evaluation questions were also conveyed by the lecturer, which was related to the addition of short answer questions. A fun evaluation menu design facilitates motivational components through sound effects, text and animation and provides feedback for users with suggesting correct information to the user. The evaluation design causes interactive relationships between stimuli and answers to students and it can help the students gain the feedback and positive reinforcing.[11].

4.6. The final product of the Virtual Laboratory learning media

The final product is produced after the Virtual Laboratory has been revised and validated by expert, accepted by the students and teachers and also the media effectiveness. In this stage, all the files used, including autorun burning use a CD and blank burner CD so that the

learning CD can be used easily. Furthermore, the packaging results of Virtual Laboratory process is carried out, including the provision of covers and the usage instructions on the cover of learning CD. Giving cover is adjusted to the contents of Virtual Laboratory with the clear title and instructions.

Compact Disk Virtual Laboratory learning has several advantages such as (1) interesting attention, (2) easy to operate, (3) helping understanding material, (4) providing motivation to learn, (5) helping students learn independently, and (6) effective and efficient used in learning. These advantages are suitable with the usefulness of the Virtual Laboratory like the results of the previous studies. The accepted of Virtual Laboratory by students and lecturers because it provides knowledge for students, lecturers and other people who want to develop their knowledge (Dobrzanski & Honysz 2010). The use of Virtual Laboratories is not limited to certain places, but can be used anywhere and at any time and it is effective in terms of costs for conducting experiments with limited time, complexity of experiments and risk of accidents. Virtual laboratories can also connect and strengthen the theories, enhance student learning enthusiasm through interactivity, improve the ability to use technology, and be able to provide feedback (Chan 2009). The use of Virtual Laboratory supports learning in the era of the digital industry. With these advantages, the final product of the Virtual Laboratory can be considered suitable to be used as an ICT-based learning media material for pH expert assessment and product testing.

5. Conclusion

Based on the results of the study, it can be concluded that the Virtual Laboratory media that are developed are suitable to be used as ICT-based learning media in the material for making solutions, dilution and determination of pH of the solution. The results of the assessment of media experts with the criteria of "good" and material experts with the criteria "very good" fulfill the feasibility of developing media. Virtual Laboratory has a "very supportive" level of accepted by students and lecturers and is effectively applied to early semester students with an average completeness of 87.5%.

Reference

- [1] Anderson RH. 1994. *Pemilihan dan Pengembangan Media untuk Pembelajaran*. Jakarta: PT Raja Grafindo Persada
- [2] Arnold D. 2000. *Computer Aided Instruction*. On Line at <http://autocww.colorado.edu> [diakses tanggal 10 April 2017].
- [3] Arikunto, S. (2010). *Prosedur Penelitian Suatu Pendekatan Praktik*. Jakarta: Rineka Cipta
- [4] Arsyad A. 2009. *Media Pembelajaran*. Jakarta: PT Rajagrafindo Persada.
- [5] Azwar, S. 1999. *Reliabilitas dan validitas: Seri pengukuran Psikologi*. Yogyakarta: Sigma Alpha.
- [6] Barrante, J R. 2004. *Applied Mathematics for Physical Chemistry*, edisi ke-3. Pearson Prentice Hall: Upper Saddle River.
- [7] Budhu, M. 2002. *Virtual Laboratories for Engineering Education*. Konferensi Internasional di Teknologi Pendidikan Manchester, Kerajaan Inggris.
- [8] Chan, C. 2009. *Evaluating Learning Experiences in Laboratorium Virtual Training Through Student Perceptions: a Case Study in Electrical and Electronic Engineering at The University of Hong Kong*. *Journal of the Higher Education Academy Engineering Subject Centre*. 4 (2): 10.

- [9] Dobrzanski, L.A & Honysz ,R. 2010. The Idea of Material Science Laboratorium Virtual. *Journal of Achievements in Materials and Manufacturing Engineering*. 42 (1-2): 196-203.
- [10] Domingues L, Rocha I, Dourado F, Alves M & Ferreira EC. 2010. Virtual laboratorios in (bio) chemical engineering education. *Journal Education for Chemical Engineers*5 (2010):e22-227. On Line at www.elsevier.com. [diakses tanggal 2 Januari 2011]
- [11] Henlenti., Syamsurizal., Asyhar, R. 2014. Pengembangan Media Praktikum Laboratorium Virtual untuk Pembelajaran Optika Kelas VIII SMP Negeri 1 Tungkal Ulu. *Jurnal Pendidikan IPA Universitas Jambi*. 3 (2): 58
- [12] Istiani W, Asrial, dan Effendi. 2014. Pengaruh Penggunaan Media Laboratorium Virtual Terhadap Hasil Belajar Siswa Pada Materi Sifat Koligatif Larutan Di SMA Negeri 1 Tebo. Jambi: FKIP Universitas Jambi.
- [13] Jian, Brown DJ & Billet E. 2005. Development of a Laboratorium Virtual experiment for biology. *European Journal of Open, Distance and E-learning* 1 (195):1-8. On Line at <http://www.eurodl.org>. [diakses tanggal 1 Januari 2017].
- [14] Kean, E dan Middlecamp, C. 1985. *A Survival Manual for General Chemistry (Panduan Belajar Kimia Dasar)*. Penerjemah: A. Hadyana Pudjaatmaka. Jakarta: Gramedia
- [15] Kertiasta N. 1979. *Petunjuk Pengelolaan Laboratorium IPA SMA*. Jakarta: Depdiknas.
- [16] Klein, D J. 2013. Titrasi Asam Basa! Is It? And if so, What Is It?. *HYLE – International Journal for Philosophy of Chemistry*, Vol. 19 (2013), No. 1, 35-85.
- [17] Mortimer, R G. 2005. *Mathematics for Physical Chemistry 3rd edition*. Elsevier: London.
- [18] Pota, G. 2006. *Mathematical Problems for Chemistry Students*. Elsevier: Amsterdam.
- [19] Purwanti, W. 2012. Pemanfaatan Laboratorium Virtual pada Pembelajaran IPA. *Pelatihan Digitalisasi Perangkat dan Media Pembelajaran IPA Untuk Meningkatkan Kualitas Pembelajaran di Era Baru” di SMP 3 Muhammadiyah Depok*. Yogyakarta. FMIPA UNY.
- [20] Santyasa IW. 2007. Landasan Konseptual Media Pembelajaran. Makalah disampaikan dalam Workshop Media Pembelajaran bagi Guru-Guru SMA Negeri Banjar Angkan. Universitas Pendidikan Ganesha. Banjar Angkan Klungkung 10 Januari 2007.
- [21] Steiner, E. 2008, *The Chemistry Maths Book*, edisi ke-2. Oxford University Press Inc., New York.
- [22] Sugiyono. 2014. *Metode Penelitian Kuantitatif, Kualitatif, dan Kombinasi (Mixed Methods)*. Bandung : Alfabeta
- [23] Suherman, E. 2010. *Media Pembelajaran*. Jakarta: Rajawali
- [24] Sujono. 1998. *Pengajaran matematika untuk sekolah menengah*. Jakarta: departemen pendidikan dan kebudayaan direktorat jendral pendidikan tinggi proyek pengembangan lembaga pendidikan tenaga kependidikan.
- [25] Sutrisno. 2012. *Kreatif Mengembangkan Aktivitas Pembelajaran Berbasis TIK*. Jakarta : Referensi
- [26] Suyatna. 2009. Efektifitas Penggunaan Software Platetec pada Pembelajaran Dinamika Bumi. On Line at <http://pustakailmiah.unila.ac.id>. [diakses tanggal 29 Maret 2017].
- [27] Suyatna. 2009. Pemanfaatan Laboratorium Fisika Virtual. On Line at <http://pustakailmiah.unila.ac.id>. [diakses tanggal 29 Maret 2017].
- [28] Tatli, Z dan Ayas, A. 2012. Virtual Chemistry Laboratory: Effect of Constructivist Learning Environment. *Turkish Journal of Distance Education*. 13 (1): 166.
- [29] Yuniarti, F., Dewi, P., dan Susanti, R. 2012. Pengembangan Laboratorium Virtual Sebagai Media Pembelajaran Berbasis Komputer Pada Materi Pembiakan Virus. *Jurnal Pendidikan Biologi Unnes*. 1(1): 28.