

VIRTUAL LABORATORY BASED ON INQUIRY IN CHEMICAL EQUILIBRIUM AS LEARNING INNOVATIONS

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Abstract

This study aims to develop and determine the feasibility of inquiry-based virtual laboratory media on chemical equilibrium. The development model used in the research was R&D which adopted the phase from Borg and Gall. Phase Borg and Gall used until 5, research and information collecting, planning, developing a preliminary form of product, preliminary field testing, and main product revision. The instruments in this study were questionnaires used to obtain input data for products, and quantitative scores as the value of media feasibility. The results of this study are inquiry-based virtual chemistry laboratory media on chemical equilibrium. Ideality presentations from the results of media assessments by chemistry teachers were 82.50%, peer reviewers were 87.50%, and students ratings were 82.50%. Overall the value of the feasibility of this media presentation was 83% with a very good category. Therefore, the inquiry-based virtual laboratory is worthy of being used as a learning media for high school students.

Keywords: Virtual laboratory, inquiry, chemical-equilibrium, media development.

INTRODUCTION

At present, the development of technology has entered the world of education. Technological developments increasingly encourage efforts to renew the use of technological results in the learning process. This is in accordance with 21st Century which shows that classroom learning using IT-based media is feasible (Lee, 2016). Technology can provide a valuable opportunity to practice new learning techniques (Rajendran, Veilumuthu, & Divya, 2010). Through technology, an educator can improve the quality of education, by opening wide open access to science and information technology (Rusman, 2012). Teachers can adapt teaching methods that are trending to incorporate media into activities in the classroom (Rajendran, Veilumuthu, & Divya, 2010). Utilizing technological developments in the learning process especially computer technology can make it easier for teachers to explain learning material that is far from students' reasoning. In addition, the use of technology and the internet can be done well by students. Students spend more time using digital media in their daily lives (Lee, 2016).

Chemical learning is a complex and abstract process of learning chemistry. Tresna (1998) states that the purpose of chemistry learning is to obtain a long-lasting understanding of the information obtained, problem-solving skills and have the skills to use tools and materials in the laboratory. However, not all students can easily obtain an understanding of the chemical material delivered by the teacher. One of the chemicals that is considered difficult by students and requires high understanding is chemical equilibrium. Chemical equilibrium is one of the material that is considered difficult by students (Solomonidou & Stavridou, 2001), because of its abstract character and the demand for material mastery in large numbers (Pardo & Portoles, 1995) so students at all levels still experience misconceptions (Demircioglu, Demircioglu, & Yadigaroglu, 2013).

In chemical equilibrium material, there are theories about chemical reactions that require practicum because the resulting reactions are related to distinctive color changes (Leal & Leal, 2013). Treagust,

Tyson, and Bucat (1999) say that one of the learning methods proposed to teach better chemical equilibrium is practicum. Laboratories have a very important role in the process of learning chemistry, but not all schools have adequate laboratory facilities. Schools that have laboratories are still not optimal because the availability of laboratory technicians and laboratory staff is still lacking. Based on observations that have been made on 6 schools in Yogyakarta, Indonesia, there are still many limitations that are often experienced by teachers when doing practical activities, including not all schools have laboratory staff who can help teachers, security in practicing activities, limited equipment available in the laboratory, and available materials exceed the deadline for use so they are not suitable.

Teachers can take advantage of the development of information technology in overcoming problems in the classroom. Herga, Cagran, and Dinevski (2016) say that to overcome the above limitations, practicum can be done using a virtual laboratory. Virtual laboratory media is a series of laboratory tools and materials packaged in the form of interactive multimedia-based computer software. This device is operated by a computer and makes the activities in the laboratory as if the user is in the real laboratory.

Virtual laboratories bring many benefits. One of them is students can do dangerous experiments without endangering themselves or others and affordable simulations (Herga, Cagran & Dinevski, 2016). The development of virtual laboratories is expected to be able to solve teacher problems when it is difficult to carry out actual lab work because of the limitations. Multimedia-based learning in the form of virtual laboratories can generally make the learning process more interesting, more interactive, and the teaching and learning process can be done anywhere and anytime. The multimedia display of an experiment helps students reach higher cognitive levels, and reduces the level of abstractness normally encountered when conducting experiments in chemical laboratories (Kirscher & Huisman, 1998; Ambusaidi, Musawi, Al-Balushi, & Al-Balushi, 2018). Previous research conducted by Tuysuz (2010) showed that the use of virtual laboratories increased the level of achievement and had a positive impact on students' attitudes towards chemistry subjects.

Several factors that influence the effectiveness of the learning process are teacher factors, student factors, learning material, media, methods, and learning models. In this study, virtual laboratory media can be combined with learning models. The content of the virtual laboratory is not only equipment for practical activities but there is a syntax of the learning model in it so that it is more focused on conducting the learning process. One student-oriented learning model is the inquiry learning model. Minner (2010) says the teaching strategy that actively involves students in the learning process is through scientific inquiry because it is more likely to increase conceptual understanding. The learning process using the inquiry model involves all students' ability to search and investigate systematically, critically, and analytically. Inquiry learning model directly involves students to think, ask questions, conduct exploration and experiment activities so that students are able to present solutions or ideas that are logical and scientific (Coffman, 2009). Inquiry-based teaching makes learning active by involving students in the learning process and allowing students to learn the contents themselves (Oliver, 2007; Prince & Felder, 2007).

METHODS

Research Design

This study used R&D development model adopted from Borg and Gall. The procedure of development research carried out involves 5 stages, namely research and information collecting, planning, developing the preliminary form of a product, preliminary field testing, and main product revision.

Data Collection

Data collection from 5 stages of development research procedures. First, research and information collecting was the phase of research needs analysis, namely field observations to obtain information about the implementation of the learning process in the classroom, the study of literature relating to

research, in addition to reviewing the curriculum, syllabus, learning resources and teaching materials. Second, planning was the phase of collecting materials and references for making inquiry-based virtual laboratory media products covering the phase of product design and learning design. Third, developing the preliminary form of a product was the phase of combining all the components that have been designed, the products that have been finished are then reviewed by two experts, namely media experts and matter experts. Media experts was lecturer who have experience in the field of research in the development of learning media. Aspects assessed by expert judgement of media were aspects of visual audio display and software engineering. There were 14 indicators for visual and audio aspects and software engineering. Matter experts was lecturer who experts and master the material in the field of chemistry, especially those related to chemical equilibrium. There were 14 items for the learning and material aspects. The instrument used was a questionnaire with 4 scales which was modification of the Likert scales.

Besides being validated by media experts and matter experts, this learning media was also validated or given further evaluation by 7 high school chemistry teachers and 12 peer reviewers in terms of matter and media. Evaluation of media feasibility by teachers and peer reviewers consists of 4 aspects of assessment, namely visual and audio, software engineering, learning, and material. Fourth, the preliminary field testing was a test phase for media readability by 20 students. Fifth, playing product revision is an improvement of learning media based on the results of input and assessment from students after a trial was conducted at the school.

FINDINGS

An inquiry-based virtual laboratory is a series of laboratory tools and materials packaged in the form of interactive multimedia-based computer software. In this virtual laboratory media, there are 4 chemical equilibrium practicum, namely reversible and irreversible reactions, the effect of concentration, temperature, and volume on the shift in equilibrium direction. In virtual laboratory media, there is a syntax of inquiry learning models. The syntax of the inquiry learning model applied in the media were adapted from the results of the synthesis of inquiry steps according to Lou, Blanchard, and Kennedy (2018); Zulfiani and Herlanti (2018); Kambeyo (2017); Wenning (2007); Lukac (2015); Wu and Hsieh (2006); Mumba, Chabalengula and Wise (2007); and the National Research Council (1996). The results of the synthesis of inquiry phase in the media were the introduction which contains problems related to chemical equilibrium, then students are asked to formulate the problem, write the hypothesis of the questions that have been made, design an experiment, conduct experiments, answer questions and give conclusions. The final part of the practicum steps was chemical equilibrium matter which discusses practicum activities that have been carried out. In addition, there are evaluation questions regarding the practice of chemical equilibrium in the form of multiple choice questions. Students can work on evaluation questions after doing practical activities. Virtual laboratory media based inquiry can be seen in Figure 1, 2, 3, and 4.

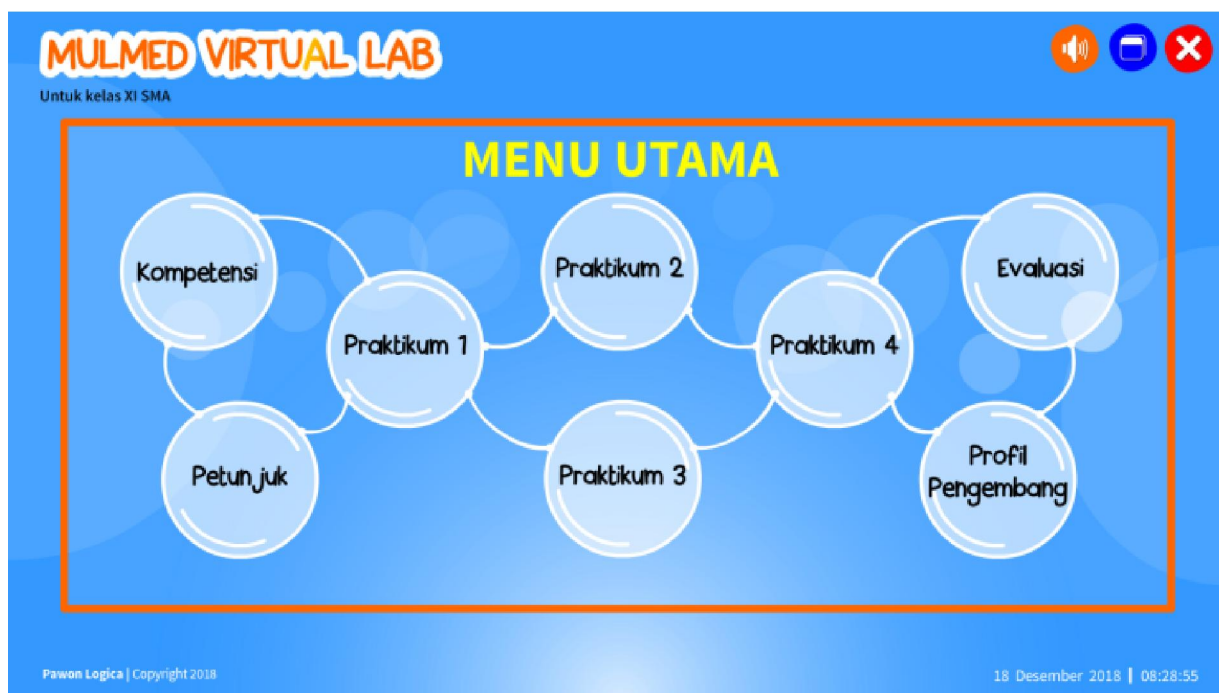
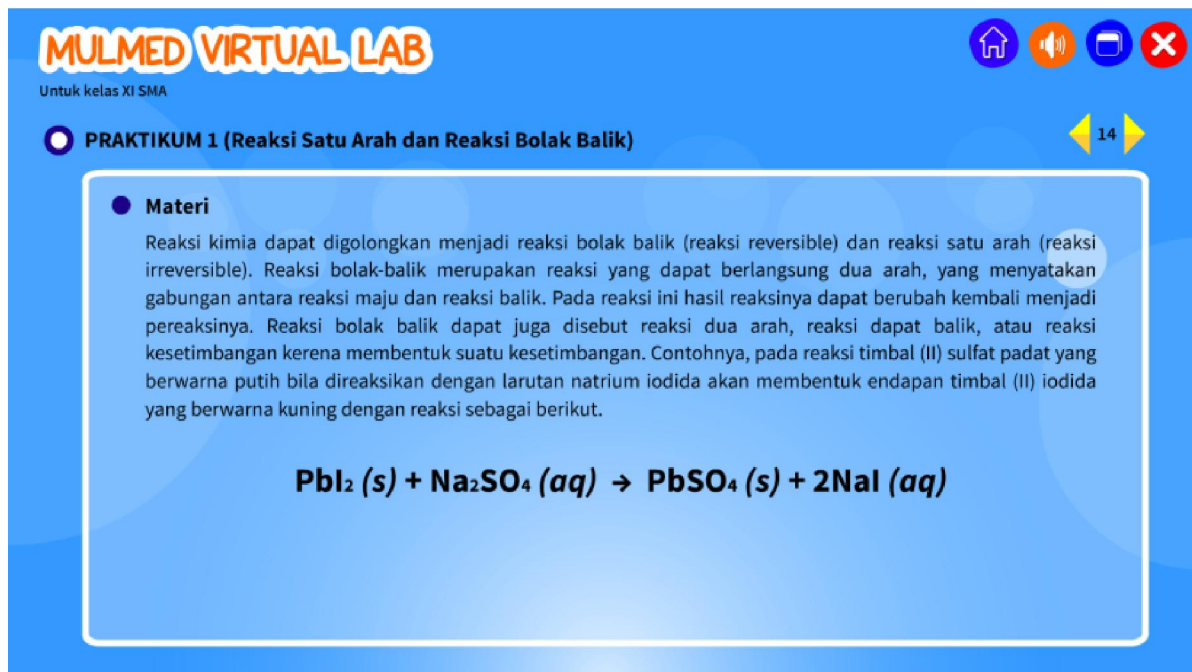


Figure 1: Menu of virtual laboratory media based inquiry



Figure 2: Practicum place activities



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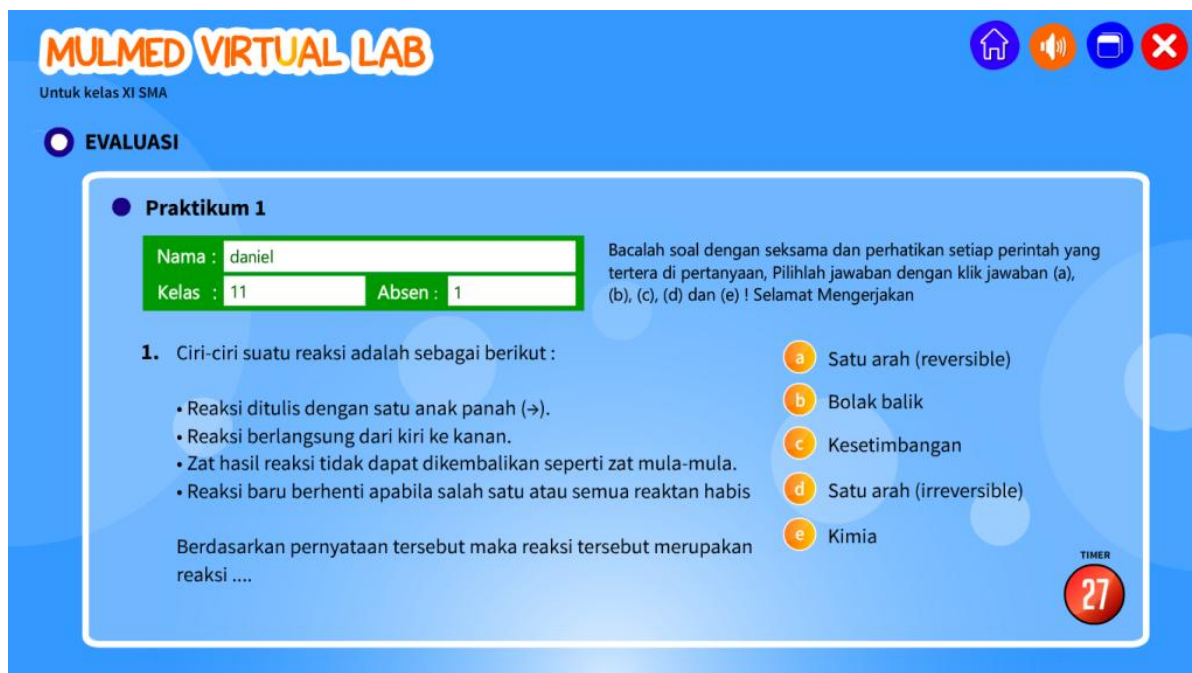
PRAKTIKUM 1 (Reaksi Satu Arah dan Reaksi Bolak Balik)

Materi

Reaksi kimia dapat digolongkan menjadi reaksi bolak balik (reaksi reversible) dan reaksi satu arah (reaksi irreversible). Reaksi bolak-balik merupakan reaksi yang dapat berlangsung dua arah, yang menyatakan gabungan antara reaksi maju dan reaksi balik. Pada reaksi ini hasil reaksinya dapat berubah kembali menjadi pereaksinya. Reaksi bolak balik dapat juga disebut reaksi dua arah, reaksi dapat balik, atau reaksi kesetimbangan karena membentuk suatu kesetimbangan. Contohnya, pada reaksi timbal (II) sulfat padat yang berwarna putih bila direaksikan dengan larutan natrium iodida akan membentuk endapan timbal (II) iodida yang berwarna kuning dengan reaksi sebagai berikut.

$$\text{PbI}_2 (s) + \text{Na}_2\text{SO}_4 (aq) \rightarrow \text{PbSO}_4 (s) + 2\text{NaI} (aq)$$

Figure 3: Chemistry equilibrium material



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EVALUASI

Praktikum 1

Nama : daniel
Kelas : 11 Absen : 1

Bacalah soal dengan seksama dan perhatikan setiap perintah yang tertera di pertanyaan, Pilihlah jawaban dengan klik jawaban (a), (b), (c), (d) dan (e) ! Selamat Mengerjakan

1. Ciri-ciri suatu reaksi adalah sebagai berikut :

- Reaksi ditulis dengan satu anak panah (→).
- Reaksi berlangsung dari kiri ke kanan.
- Zat hasil reaksi tidak dapat dikembalikan seperti zat mula-mula.
- Reaksi baru berhenti apabila salah satu atau semua reaktan habis

Berdasarkan pernyataan tersebut maka reaksi tersebut merupakan reaksi

- a Satu arah (reversible)
- b Bolak balik
- c Kesetimbangan
- d Satu arah (irreversible)
- e Kimia

TIMER 27

Figure 4: Evaluation questions

Developing the preliminary form of a product

Based on the research that has been done, the average score obtained from the assessment of expert lecturers, chemistry teachers, peer reviewers, and students is then compared with the media validation category according to the ideal assessment criteria (Azwar, 2015) described in Table 1.

Table 1: Quality of Validation Media

No	Score Range (i)	Quality
1	$\bar{X} > Mi + 1,5 S_{Bi}$	Excellent
2	$Mi + 0,5 S_{Bi} < \bar{X} \leq Mi + 1,5 S_{Bi}$	Good
3	$Mi - 0,5 S_{Bi} < \bar{X} \leq Mi + 0,5 S_{Bi}$	Fair
4	$Mi - 1,5 S_{Bi} < \bar{X} \leq Mi - 0,5 S_{Bi}$	Poor
5	$\bar{X} \leq Mi - 1,5 S_{Bi}$	Very Poor

Note: \bar{X} = average score; $Mi = \frac{1}{2}$ (ideal max score + ideal min score); $S_{Bi} = \frac{1}{x}$ (ideal max score + ideal min score)

Media eligibility assessments from Lecturers

Table .: Media eligibility assessment by expert lecturer

No	Aspects	Score	Quality
1	Learning	3,8	Excellent
2	Material	3	Good
3	Visual and audio	3	Good
4	Software engineering	3,2	Good

Media eligibility assessments by members lecturers can be seen in Table 2. Based on the assessment of the expert presentation matter the learning aspect was 95% with a score of 3.8 while the aspect of the presentation matter was 75% with a score of 3. The results of the assessment from the matter experts for the learning aspects included excellent categories while the matter aspects included good categories. This can be seen from the input of matter experts regarding some additional improvements to the matter in the media.

The assessment of media experts for visual and audio aspects obtained a present value of 75% with a score of 3 while for the aspects of software engineering the presentation value was 80% with a score of 3.2. The results of the assessment from media experts for visual and audio aspects and software engineering were included in the good category. Inputs obtained from media experts were the background colors that were made more varied, the addition of background sound so as not to be monotonous, the use of laboratory tools and materials when practicum was something that needs to be improved, correcting sentences that were too long in the introduction.

Media eligibility assessments from chemistry teachers and peer reviewers

Table 3: Media eligibility assessment by chemist teacher and peer reviewers

No	Aspects	Chemistry teachers	Peer reviewers	Quality
1	Learning	3,4	3,55	Excellent
2	Material	3,3	3,4	Excellent
3	The visual and audio	3,3	3,45	Excellent
4	The software engineering	3,25	3,5	Excellent
Total Scores		3,3	3,5	Excellent

Assessment by chemistry teachers and peer reviewers can be seen in Table 3. Based on the assessment of media feasibility that has been carried out by the chemistry teacher as many as 7 people, the assessment score for the learning aspect was 3.4 with a presentation of 85%. Matter aspects obtained an assessment score of 3.3 with a presentation of 82.5%. The visual and audio aspects of the score obtained were 3.3 with a presentation of 82.5% and aspects of software engineering were 3.25 with a presentation of 81.25%. The total scores obtained for inquiry-based virtual chemistry laboratory media from chemistry teachers by 3.3 with a presentation of 82.5% and an excellent category. While the media assessment from peer reviewers as many as 12 people

obtained an assessment score for the learning aspect of 3.55 with 88.75% presentation. The matter aspect of the assessment score obtained was 3.4 with a presentation of 85%. The scores for the visual and audio aspects obtained were 3.45 with a presentation of 86.25% and the last score for the software engineering aspect was 3.5 with a total 87.50%. Overall presentation for the media assessment conducted by peer reviewers of 3.5 with a presentation of 87.50% and an excellent category.

Evaluation of media readability

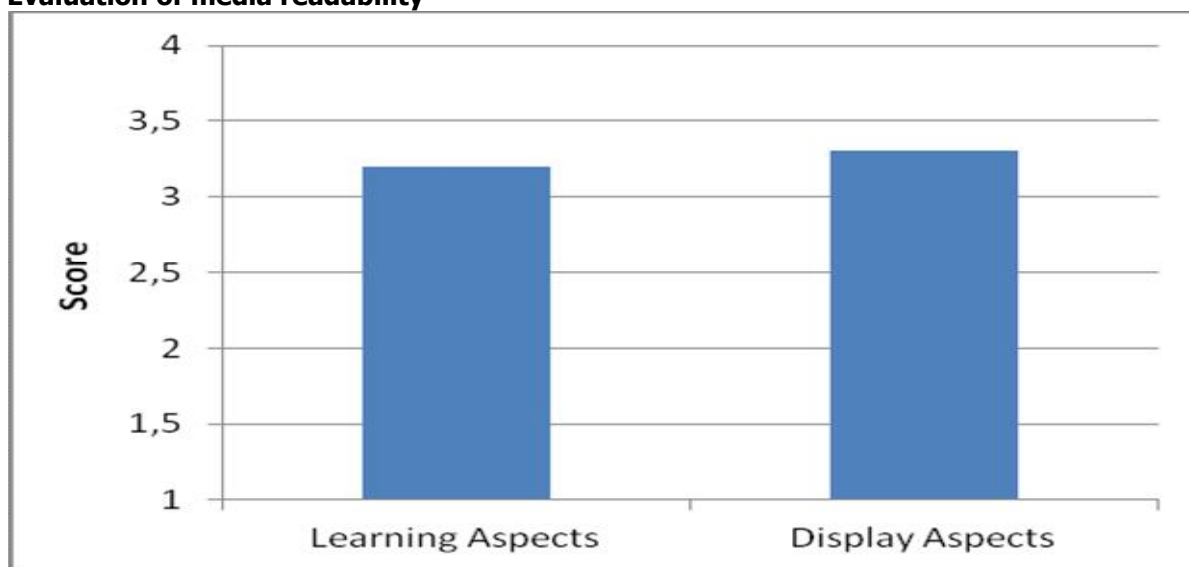


Figure 5: media readability by students

Inquiry-based virtual laboratory media that has been assessed and given input by matter experts, media experts, chemistry teachers, and peer reviewers was then revised. After the media was revised, the media was applied in schools to see students' assessment of the readability of the media. Evaluation of media readability by students can be seen in Figure 5. Based on the results of the assessment of media readability by students for aspects of learning obtained a score of 3.2 with 80% presentation while for the display aspect obtained a score of 3.33 with presentation 83.25%. The total score obtained from the assessment of media readability by students was 3.3 with presentations 82.50% and excellent categories.

A graph obtained for the total score of media assessment obtained from chemistry teachers, peer reviewers, and students can be seen in Figure 6.

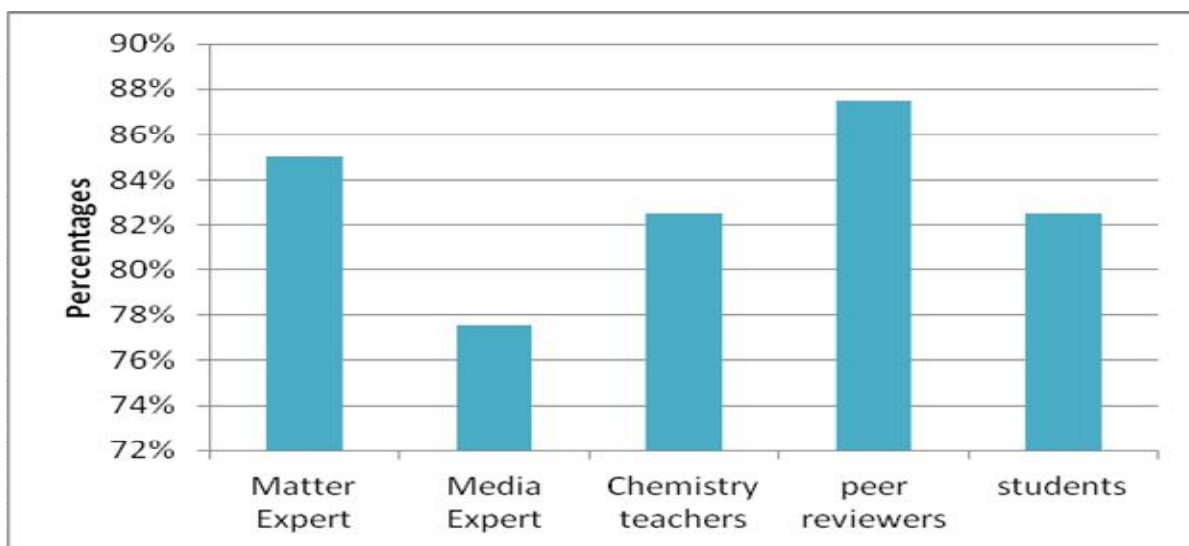


Figure 6: The total score of media assessment

Media scores provided by chemistry teachers, peer reviewers, and students then calculated the percentage ideal to find out the overall inquiry-based virtual chemistry laboratory media assessment. The formula for calculating ideal percentages is

$$\text{Ideal percentage} = \frac{\text{research score}}{\text{ideal maximum score}} \times 100\%$$

The ideal presentation for the inquiry-based virtual chemistry laboratory media as a whole was 83% so that it included an excellent category. Based on the results of the study, the inquiry-based virtual laboratory media is worthy of being used as one of the learning media for chemistry equilibrium in senior high school.

DISCUSSION AND CONCLUSION

The development research that has been carried out obtained an inquiry-based virtual chemical laboratory media product. An assessment carried out by media experts, matter experts, chemistry teachers, peer reviewers and students obtained an overall ideal percentage of 83% which included an excellent category. The results of this study indicate that the inquiry-based virtual chemistry laboratory media developed can be used as one of the learning media for chemistry equilibrium in senior high school.

The use of technology-based media is able to make students more interested in the learning process. In addition, the use of technology for a short period of time in educational programs will make students get more benefits in the long term (Pekdag, 2010). Teachers who integrate ICT into the classroom learning process will attract students' attention because they rarely find these tools in their routine lives (Cereci, 2018). Technology can help teachers to deliver subject matter that is more diverse than using conventional methods. The limitations felt by the teacher in delivering the material can be overcome, one of them is by using technology.

Chemistry learning cannot be separated from practicum, but there are still teachers who cannot do lab work because of limitations in the laboratory. Therefore, teachers can use technology to overcome these problems. Virtual laboratory is one solution that can be done. The development of inquiry-based virtual laboratory media that has been developed can be used by teachers in conducting practicum in class so that it can facilitate teachers in carrying out the learning process. Students think that in the learning process using virtual laboratories, the animations used can help them better understand and remember the information obtained (Ambusaidi et al., 2018). Previous research by Bakar, Zaman, Kamalrudin, Jusoff, and Khamis (2013) regarding the development of

multimedia virtual reality laboratories for chemistry (VLab-Chem), the results of the study showed the level of learning achievement of students using Vlab-Chem was higher than with study groups that use conventional approaches. In addition, research from Bortnik, Stozhko, Pervukhina, Tchernysheva, and Belysheva (2017) shows that the virtual learning approach has the potential to improve the research skills and practices of students in analytical chemistry studies.

Inquiry-based virtual laboratories provide opportunities for students to construct material concepts especially chemical equilibrium through virtual simulation and practicum activities. Learning using inquiry-based virtual laboratories fosters confidence, develops the ability to think creatively and think critically in students (Junaidi, Gani, & Mursal, 2016). Practicum by using inquiry learning model makes students think more openly and critically. Students collect data when conducting research activities, conducting observations and testing data by practicing. Inquiry based science teaching is more interesting and motivates the students (Gibson and Chase, 2002).

The use of various methods, models, or media in the learning process is able to make students not easily bored in learning. However, the teacher must be able to choose the right teaching method for each subject matter delivered so that it is more easily understood by students. Combining different methods can develop students' understanding chemical subjects, especially chemical equilibrium so that they can help change their misconceptions (Demircioglu, 2013). The use of information, communication, and technology can be a good opportunity for chemical education programs, making it an effective tool for developing new methods and techniques in educational programs (Pekdag, 2010).

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