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Development of Reaction Rate Lab Virtual Media in Basic Chemistry Practicum

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Abstract: The Covid-19 pandemic has resulted in learning activities having to be carried out online. However, the practicum implementation was hampered due to the unavailability of virtual practicum facilities. The purpose of this study was to develop a virtual lab media for reaction rate material to determine its validity and see student responses to the media being developed. This research is research and development that adapts the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). The trial was carried out on students in the 3rd semester of chemistry education at UIN Ar-Raniry. Data was collected using interview techniques and questionnaires. Interviews were conducted with chemical laboratory assistants and lecturers supporting basic chemistry practicum, product validity questionnaires were assessed by media, material and language experts, as well as student response questionnaires to find out the level of product practicality. The results showed that the developed virtual lab media obtained a validity percentage of 92.47% with very valid criteria. The test results obtained a very good response with a percentage of 86.66% and the results of the reliability test on student responses obtained a Cronbach's Alpha value = 0.910 which was greater than 0.700 meaning the questionnaire proved to be reliable. With very high validity and very good response, this virtual lab media can be used as a medium for basic chemistry practicum on reaction rate materials.

Keywords: Basic Chemistry; Media Virtual Lab Development; Reaction rate

Introduction

The Covid-19 pandemic entered Indonesia in March 2020. In order to reduce the transmission rate of the Covid-19 virus, the Indonesian government implemented a social distancing policy that required all learning activities to be carried out from home (Pasaribu, 2021). This policy was followed up by the Minister of Education and Culture (Mendikbud) through Circular Letter (SE) Number 4 of 2020 concerning Implementation of Education Policies in the Emergency Period of the Spread of Covid-19 (Pakpahan & Fitriani, 2020). Among these policies contains the procurement of Distance Learning (PJJ) as a substitute for temporarily eliminating face-to-face learning (Salsabila et al., 2020).

In the era of the industrial revolution 4.0, online learning is the right alternative when implementing PJJ. Online or online learning is a learning system without face to face directly by utilizing internet technology. All forms of study material are delivered online through learning platforms such as Classroom, Google Meet, and Zoom (Sari et al., 2020).

Chemistry as a branch of science is based on experimentation. The concepts contained in chemistry material need to be strengthened with practicum to provide meaningful learning. Practicum has a very important function to help theoretical explanations in chemistry learning. Practicum provides factual experience about the material that students learn through a scientific process (Widarti et al., 2021). Therefore, practicum cannot be separated from chemistry learning. Practicum is a way for students to gain an understanding of chemical concepts through the use of chemical tools and materials (Listyarini & Pamenang, 2021).

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Based on the results of the researcher's interviews with the chemistry laboratory assistant and the lecturer in the Basic Chemistry Practicum II course, information was obtained that the practicum activities were carried out using the blended learning method. Blended learning or mixed learning is a learning system that combines face-to-face learning with learning through internet facilities. When using the online method, students carry out practicums by simply watching, observing, and reviewing practicum videos and then writing down the results in report form. However, this method is considered not good because lecturers experience problems in assessing students' psychomotor skills. In addition, not all students easily understand online practicum due to limited discussion regarding the material contained in the video.

The solution offered to overcome this problem is to develop a virtual media lab which is expected to improve students' ability to carry out practicum activities. The virtual lab is a solution because it has a role in chemistry learning which requires proving theories, laws and concepts (Lestari et al., 2023). This is also in line with Vasiliadou (2020) stated that virtual labs can provide powerful solutions for undergraduate and graduate students during the Covid-19 pandemic. Undergraduate students can continue their studies without interruption as important experiments can be carried out online at home.

In addition, the use of virtual laboratories is proven to be able to increase students' understanding, increase scientific literacy, improve critical thinking skills, skills, and scientific attitudes and have an impact on self-efficacy (Sari et al., 2022).

Virtual labs are oriented towards practicality and economy. Practicum can be carried out periodically in a virtual laboratory because there are no space and time constraints. The use of a virtual laboratory also minimizes the cost of procuring laboratory equipment, materials and buildings (Oyewola et al., 2021). In addition, safety and security at work is increasing because they do not interact directly with tools and chemicals.

The development of a virtual laboratory as a medium to support practicum activities has been reported by several researchers. Among them is the development of virtual laboratory media in biochemistry practicum (Sari et al., 2022), chemical kinetics (Listyarini & Pamenang, 2021), analytical chemistry (Widarti et al., 2021), physics (Abdjul et al., 2019; Rani et al., 2019) and important biological laboratory techniques (Miyamoto et al., 2019).

The reaction rate is influenced by several factors, namely surface area, concentration, temperature, pressure, and catalyst. Material characteristics of reaction rates include abstract concepts, mathematical calculations, graphics and involve multiple representations (macroscopic, microscopic, and symbolic). The matter of reaction rates requires a microscopic explanation of the interactions between particles in chemical reactions (Widarti et al., 2022). By using virtual lab media, interactions between particles are practically observed.

Therefore, specifically this research was conducted to develop virtual lab learning media which aims to provide virtual-based practicum that can be accessed via a computer. In addition, this media also aims to reach the concept of presenting visualization down to the sub-microscopic level (Herga et.al, in Muchson et.al, 2019) so as to be able to explain phenomena that occur on a macroscopic scale, especially the matter of reaction rates.

Method

This research and development uses the Research and Development method by adapting the ADDIE model. This development research procedure was carried out based on the stages in the ADDIE model, namely Analysis, Design, Development, Implementation, and Evaluation.

Data collection techniques in this study were carried out by interviewing and distributing questionnaires. Interviews were conducted with chemistry laboratory assistants and lecturers supporting basic chemistry practicum at FTK UIN Ar-Raniry and distributing product validity questionnaires to media, material, and language experts as well as student response questionnaires to find out the level of product practicality. The trial phase was carried out on 12 semester 3 students of Chemistry Education FTK UIN Ar-Raniry who were taken using a purposive sampling technique.

Data analysis was performed using qualitative and quantitative analysis techniques. Qualitative data were obtained from laboratory assistant and lecturer interviews, student needs questionnaires, and comments or suggestions provided by expert validators.

Quantitative data were obtained from product validity questionnaires and student response questionnaires using a Likert scale. According to Sugiyono (2019) the Likert scale is used to measure attitudes, opinions, and perceptions of a person or group of people about a design or product being developed. The Likert scale used is (1) very invalid, (2) invalid, (3) less valid, (4) valid, and (5) very valid. Then the data is processed using the formula 1:

$$V = \frac{TSe}{TSh} \times 100\% \quad (1)$$

Information:
V = Validity
TSe = Total score of the validator
TSh = Maximum expected total score
Adapted from (Sarip et al., 2022)

The product assessment result data is then converted into qualitative data according to the product validity criteria listed in Table 1.

Table 1. Product Validity Test Criteria

Criteria Validity (%)	Validity Level
86.00 – 100.00	Very valid or can be used without revision
71.00 -85.00	Valid or can be used but needs a little revision
56.00 - 70.00	Invalid, it is recommended not to use it because it needs a lot of revisions
41.00 - 55.00	Invalid or may not be used
25.00 - 40.00	Very invalid or should not be used

Adapted from (Sarip et al., 2022)

Student response questionnaires are used to find out feedback from the product being tested. The response questionnaire contains 12 statements with the assessment scores used, namely (1) not good, (2) not good, (3) good enough, (4) good, (5) very good.

The results of student responses are calculated after a reliability test is carried out to determine the consistency of the research instruments used. The reliability test is useful for determining whether the instrument, in this case the student response questionnaire, can produce consistent measurement results when used repeatedly. The reliability test for more than two alternative answers uses the Cronbach's Alpha test with the SPSS 20 program. According to George & Mallery (in Saidi & Siew, 2019) a Cronbach's Alpha value above 0.900 indicates consistency (very good), above 0.800 (good), at above 0.700 (acceptable), 0.600 (doubtful), above 0.500 (poor), and below 0.500 (unacceptable).

According to Gliem & Gliem (in Setyaedhi, 2021) says that the Cronbach Alpha reliability coefficient ranges between 0 and 1. The alpha coefficient can be said to have good reliability if the magnitude is close to 1. George & Mallery (and Setyaedhi, 2021) provides the following practical rules : " > 0.9 = very good; > 0.8 = good; > 0.7 = acceptable; > 0.6 = questionable; > 0.5 = bad; and < 0.5 = unacceptable.

Instrument reliability data that has been obtained is then processed using the formula 2 (Arikunto, 2021):

$$p = \frac{f}{n} \times 100\% \quad (2)$$

Information:
F = Frequency of answers
n = Total number of respondents
p = Large percentage

Data from student responses are then converted into qualitative data according to the product qualification scale in Table 2.

Table 2. Product Qualification Assessment Scale

Percentage (%)	Criteria
81-100	Very Good
61-80	Good
41-60	Enough
21-40	Less
0-21	Very Less

(Kurniasih et al., 2022)

Result and Discussion

This research and development resulted in a virtual lab media that was developed based on the stages of the ADDIE model, namely analysis, design, development, implementation, and evaluation. This research uses formative evaluation, namely the evaluation that is applied to each stage of the research.

Analysis

The first step that must be taken to find out the problems that exist in the field is to identify the problem. Problem identification is done by analyzing educators, students, and the curriculum used. This analysis is carried out so that the product being developed is relevant to the problems found in the field.

Educator analysis was carried out by interviewing Laboratory Assistant and Lecturers of Basic Chemistry Practicum. Based on the results of the analysis, it is known that the implementation of practicum activities in the laboratory is hampered due to the impact of implementing online learning. Problems arise due to the unavailability of virtual-based practicum media that can be used as an alternative to practicum in real laboratories.

Analysis of students is done by distributing questionnaires to students. Based on the results of the analysis, it is known that students need virtual-based practicum media to support online learning activities. And 65% of students find it difficult to understand the interactions between molecules when reacting because when practicing the explanation is only in the form of imaginary theory.

Curriculum analysis was carried out by conducting a review of the Basic Chemistry Practicum RPS. It was found that the reaction rate material studied collision theory which discussed interactions between molecules. However, in practice this material can only be explained in theory because this material is at the submicroscopic level so practice is not observed during practicum. In addition, the sub-chapter on factors affecting the rate of reaction only discusses 4 factors, namely concentration, temperature, surface area of contact, and catalyst without discussing the pressure factor.

Design

Things that are done in the design stage include preparing material and content, making flowcharts and storyboards, initial product design, and pre-validation by the supervisor. The initial design of the virtual lab is made according to the flowchart and storyboard design. The virtual lab is designed using Corel Draw X7 and Adobe Flash CS6 software for computer/PC devices with (.exe) format. Media virtual lab that has been installed can be operated without utilizing the internet network. The initial design that has been made is pre-validated by one of the chemistry lecturers. The aim is to obtain a high validity value from the expert validator because improvements have been made based on criticism and suggestions for pre-validation improvements. The main components composing this Virtual lab media are the introduction section and the content section.

Introduction Section

The initial part of this media consists of several frames, namely loading, cover, instructions, login, and main page. Frame loading will appear automatically the first time the virtual practicum media is run. This view contains the name of the media being developed, the title of the material, and the loading animation. The loading frame display can be seen in Figure 1.

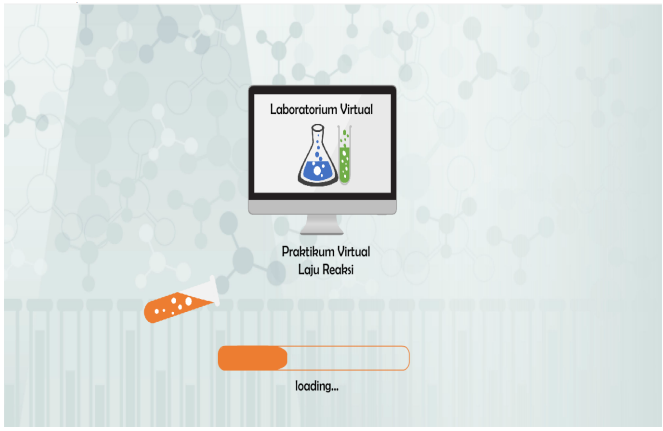

Figure 1. Display of Frame Loading

The display will be redirected to the cover frame after the process in the loading frame is complete. The display frame cover contains the Ar-Raniry UIN logo, faculty and study program names, as well as instructions and login buttons. Users can choose to read the instructions first or directly log into the media. The cover frame display can be seen in Figure 2.

Figure 2. Display Frame Cover

When the user presses the hint button, the display will be redirected to the hint frame. This frame contains information about the menu and navigation buttons found on the virtual lab media. The display of the guide frame can be seen in Figure 3.

Figure 3. Display of Instruction Frame

When the user presses the login button, the display will be redirected to the login frame. This frame functions to enter data in the form of the name and NIM of the user. Users can use this media by filling in the name and NIM correctly and pressing the login button so that the user will be redirected to the main page. The login frame display can be seen in Figure 4.

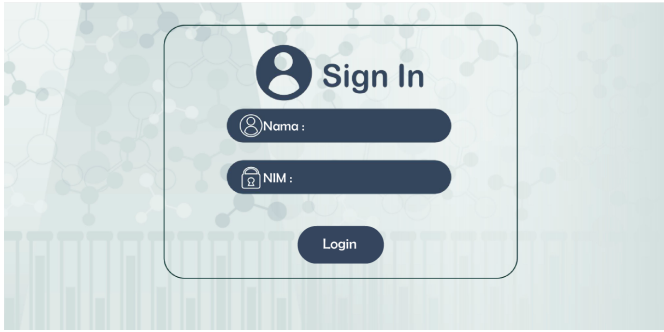

Figure 4. Display of the Login Frame

The main page frame will automatically appear after the login process is complete. This frame displays all of the main menus on the virtual lab media. By pressing the button on the available menu, the page will be redirected according to the menu option pressed on

the media. The main menu contained in this media is Course Learning Outcomes (CPMK) & objectives, materials, simulations, evaluations and bibliography. The display of the main page frame can be seen in Figure 5.

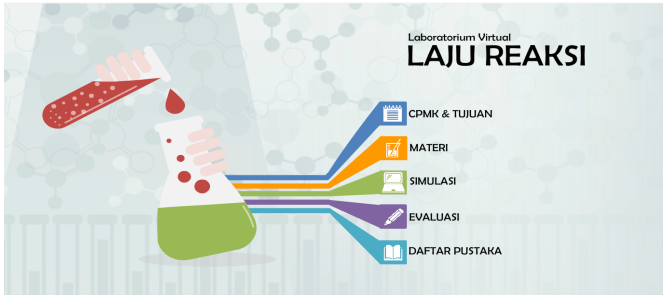

Figure 5. Display of Main Page Frame

Contents section

The contents of the virtual lab consist of CPMK frames & objectives, materials, simulations, evaluations, and bibliography. Users can access these frames by pressing the menu display which is on the left side of the lab virtual media. The CPMK frame and objectives contain the learning outcomes of the course (CPMK), sub-CPMK and the objectives of the reaction rate practicum. The login frame display can be seen in Figure 6.

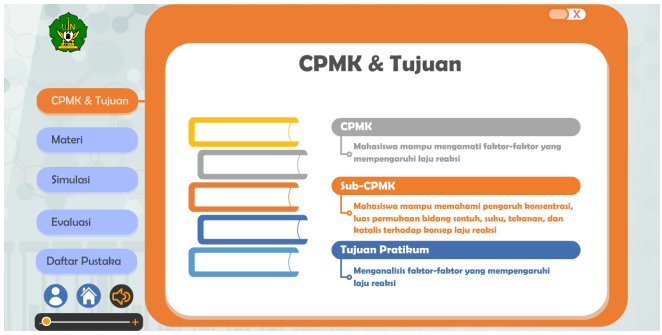

Figure 6. Display of CPMK Frame and Purpose

Furthermore, by pressing the material menu the user will be redirected to a frame which contains reaction rate material. The material on the rate of reaction discusses the factors that affect the rate of reaction, namely concentration, temperature, surface area, pressure, and catalyst. This material is described in the form of writing, animation, and audio so that it can overcome the problems of different user learning methods. The appearance of the material frame can be seen in Figure 7.

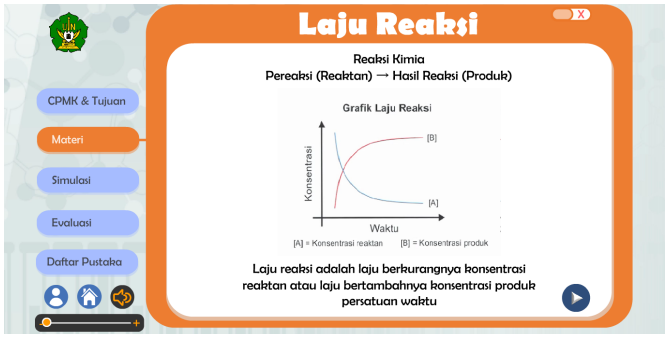

Figure 7. Display of Material Frame Reaction rate

The practicum instruction frame will appear when the user presses the simulation menu. This frame contains instructions that must be carried out before carrying out reaction rate practicum activities. After pressing the start button, you will be directed to the next page which contains practical activities. The display of the practicum instruction frame can be seen in Figure 8.

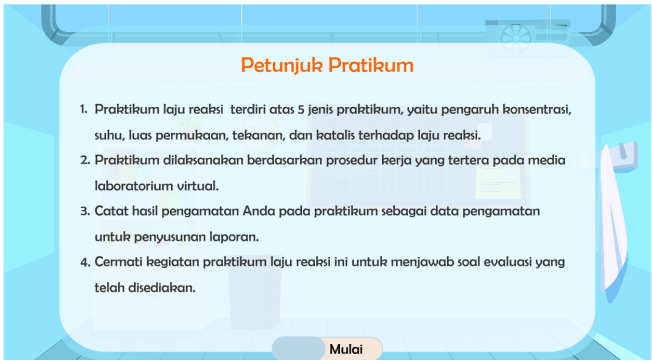

Figure 8. Display of Practicum Instructions Frame

In the simulation menu there are 5 practicum activities carried out, namely concentration, temperature, surface area, pressure, and catalyst. Users can carry out practicum activities by first reading the procedures listed in the practicum procedure column. If the user has finished carrying out the first practicum, another practicum can be continued by pressing the next page button. The simulation frame display can be seen in Figure 9.

Users who have finished carrying out practicum activities can test their understanding by pressing the evaluation menu. The evaluation menu displays the evaluation conditions frame which contains an explanation regarding the questions to be answered. If the user presses the "Start" button, they will be directed to the next page which contains evaluation questions in the form of multiple choices. The display of the evaluation provisions frame can be seen in Figure 10.

Figure 9. Simulation Frame Display

Figure 10. Display of Terms of Evaluation Frame

The evaluation frame contains 10 questions about the reaction rate material. Questions can be answered by pressing one of the answers that the user thinks is the most correct. If the answer is correct then the answer column will turn green and if wrong it will turn red. Questions will automatically go to the next number after the answer is selected. And the score obtained will appear in the upper right corner of the frame. The evaluation frame display can be seen in Figure 11.

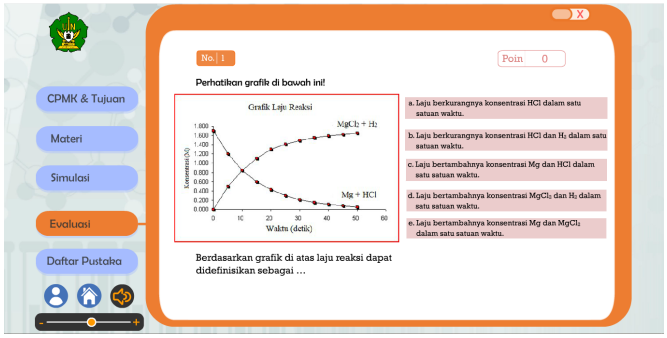

Figure 11. Evaluation frame display

The user has finished answering the 10 questions contained in the evaluation menu, the display will be redirected to the score result frame. If the user gets a score of 80-100 then the sentence "Congratulations you succeeded! Keep your grades up!", if the score is 0-70 the sentence "Re-study the reaction rate material, ok! Keep the spirit of learning!" If you want to return to answering the question, you can press the "Try again" button and the display will return to the question conditions display. The display of the score result frame can be seen in Figure 12.

Figure 12. Display of Score Results Frame

The bibliography menu contains a list of sources or references used to develop virtual lab media. The display of the bibliography frame can be seen in Figure 13.

Figure 13. Bibliography Frame Display

Development

The resulting media was then validated by media, material, and language experts by filling in the reaction rate lab virtual media validity sheet.

Media Expert Validation

The virtual lab media was validated by five design and learning media experts who are lecturers at UIN AR-Raniry. The assessment carried out includes aspects of presentation, graphics, quality, and effectiveness of the developed media. The results of media expert validation can be seen in Table 3.

Table 3. Tabulation of Media Expert Validation Results

Validators	Percentage (%)	Criteria
I	100.00	Very valid
II	80.00	Valid
III	98.18	Very valid
IV	94.54	Very valid
V	100.00	Very valid
Average	94.54	Very valid

Based on the media expert's assessment in Table 3. It shows that an average percentage score of 94.54% is obtained with very valid criteria.

Material Expert Validation

The virtual lab media was validated by four chemical material experts who are lecturers in the Chemistry Education study program at UIN AR-Raniry. The assessment carried out includes aspects of the material content and language of the media being developed. The results of the material expert validation can be seen in Table 4.

Table 4. Tabulation of Material Expert Validation Results

Validators	Percentage (%)	Criteria
I	80.00	Valid
II	93.33	Very Valid
III	96.66	Very Valid
IV	100.00	Very valid
Average	92.49	Very valid

Based on the assessment of material experts in Table 4. it shows that an average percentage score of 92.49% is obtained with very valid criteria.

Linguist Validation

The virtual lab media was validated by five linguists who are lecturers from various universities in Aceh. The assessment carried out includes aspects of the suitability of language rules and the accuracy of sentence construction from the media being developed. The results of the linguist validation can be seen in Table 5.

Table 5. Recapitulation of Language Expert Validation Results

Validator	Percentage (%)	Criteria
I	92.00	Very valid
II	96.00	Very valid
III	88.00	Very valid
IV	92.00	Very valid
V	84.00	Very valid
Average	90.40	Very valid

Based on the assessment of linguists in Table 4, it shows that an average percentage score of 90.40% is obtained with very valid criteria. From the assessment of all expert validators on media aspects, material aspects, and language aspects, an overall validation value of 92.47% was obtained with very valid criteria. Very high percentage with very valid criteria indicates that the developed media can be tested on students in chemistry learning. This is in line with the research results of (Rokhim et al., 2020) which obtained a percentage of material validation values of 95.00% (very feasible) and media validation of 88.50% (very feasible). This finding is also supported by the research of (Listyarini & Pamenang, 2021) which reported that the virtual laboratory media in the developed chemical kinetics material obtained an average material validation value of 97.22% with very good criteria and an average media validation value of 94.31% with very good criteria.

From the results of media, material, and language experts' assessment of the virtual media lab, the reaction rate of the highest average score was obtained in media validation, which was 94.54%. This value indicates that the layout and display format of the media are appropriate and meet the requirements as learning media. This proves that the reaction rate virtual lab media can help the learning process in basic chemistry practicum activities (Delfira & Aldi, 2021). Comparison of the validation results of media experts, materials, and languages can be seen in Figure 14.

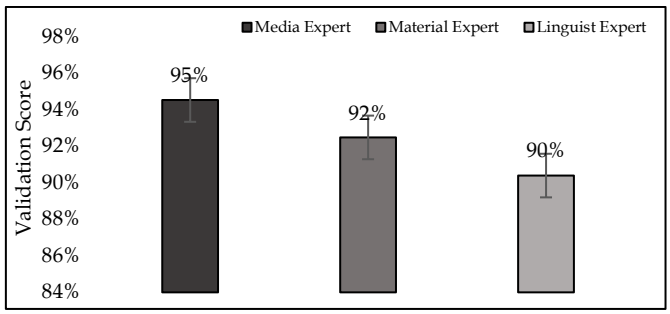

Figure 14. Comparison of Media, Material, and Language Expert Validation Results

Implementation

The virtual lab media was revised first based on criticism and suggestions from expert validators before being implemented. The reaction rate virtual lab media was tested on 12 semester 3 students of the Chemistry Education Study Program. Students fill out a response questionnaire by accessing the Google Form link. The data obtained from the questionnaire were then tested using the Cronbach alpha formula to determine the reliability of the instruments used.

The student response questionnaire instrument was processed using the correlation coefficient formula to calculate the reliability of the instrument. The analysis was carried out using the SPSS application. The result is 0.910 and is more significant than 0.700 so that it can be stated to be reliable based on the analysis of instrument expert agreement data (Ramadhan et al., 2022).

Student response questionnaire data was then analyzed and obtained an average percentage of 86.66% with very good criteria. According to Buanita et al. (2020) the percentage with a range of 81-100% is included in the very high category and when converted it is included in the very practical criteria. This is in line with the results of the research trials by Sari (2020), which reported that the virtual laboratory media in the developed biochemistry practicum were declared valid and practical because they obtained a validation result

of 94.45%. This finding is also in line with the research results of Abdjul et al. (2019) which obtained a response value of 85.55% (very good) meaning that virtual-based laboratories are practically used in learning. Thus it can be concluded that this virtual lab media can be used as a learning medium in the reaction rate practicum. The product trial results can be seen in Table 8.

Table 6. Distribution of Scores for Each Statement in the Questionnaire

Respondent No	Questionnaire Item Number											
	1	2	3	4	5		7	8	9	10	11	12
1	4	5	5	4	4	4	4	5	4	4	4	4
2	4	3	4	4	3	4	3	4	4	4	3	3
3	5	4	5	4	5	5	5	4	5	4	5	4
4	5	5	5	5	5	5	5	5	5	5	5	5
5	4	4	4	5	4	5	3	4	3	4	4	4
6	4	4	4	4	5	5	4	4	4	4	4	4
7	5	4	5	5	4	5	2	4	4	3	4	5
8	4	4	4	4	4	5	4	4	4	4	4	4
9	5	5	5	5	5	5	5	5	5	5	5	5
10	4	4	4	4	3	4	4	4	4	4	4	4
11	5	4	5	4	4	5	4	5	4	5	5	5
12	5	4	5	5	4	5	5	5	4	5	4	5

Table 7. Instrument Reliability

Cronbach's Alpha	N of Items
0.910	12

Of the 12 assessment indicators contained in the questionnaire, it can be seen that the second assessment item obtained the highest percentage. This assessment indicator refers to submicroscopic level chemicals. This proves that virtual lab media can be used as learning in basic chemistry practicum to improve students' conceptual understanding at the submicroscopic level. The results of this study are in line with the research of Widarti et al. 2021) which obtained a response percentage in the range of 81-92% (very valid) in the development of a multi-representational integrated virtual laboratory for analytical chemicals. This shows that the development of a virtual laboratory has the potential to support online practicum activities and provide macroscopic, microscopic, and symbolic level visualization for students to obtain information (Herga et.al, in Muchson, et.al, 2019). The virtual lab display that interprets the submicroscopic level can be seen in Figure 15.

In the student response questionnaire, several criticisms and suggestions were also obtained for the virtual lab media. Therefore, final improvements were made to the virtual lab media, namely in the animation and catalyst graphic sections. Product trials are very important to determine the response of users to the media being developed. Thus it can be repaired again if the response obtained is still low. The purpose of product trials is to obtain data that can be used as a basis for making improvements in order to achieve the level of effectiveness and attractiveness of the product.

Media that is categorized as practical is media that is declared valid by the validator to be used in learning activities and obtains good responses from respondents (Rusdi et al., 2021). In this study the virtual lab media developed was declared very valid by expert validators and received very good responses from students so that the reaction rate virtual lab media developed could be declared very practical for use in basic chemistry practicum learning activities.

Evaluation

The evaluation used in the ADDIE model is a formative evaluation. Formative evaluation is an evaluation carried out at each stage of research starting from analysis, design, development, and implementation. Evaluation at the analysis stage is carried out by reviewing the data from the initial analysis results obtained from the results of the needs analysis. The design stage is evaluated based on pre-validation by the supervisor. The development stage is evaluated according to comments and suggestions from media, material, and language expert validators. The implementation stage is evaluated based on student responses to the media being developed.

Table 8. Reaction Rate Virtual Lab Media Test Results

Indicator Value	Average Score (%)	Criteria
The use of virtual labs piqued my interest in doing reaction rate labs	90.00	Very Good
The display of images and animations of molecular interactions in the virtual lab helped me understand the material concept of reaction rate	95.00	Very Good
The display of images and animations of molecular interactions in the virtual lab helped me understand the material concept of reaction rate	91.66	Very Good

The type of writing or text used in the virtual lab is easy to read	88.33	Very Good
The reaction rate material in the virtual lab is easy to understand	83.33	Very Good
The design and appearance of the virtual lab is interesting to look at	83.33	Very Good
Sounds and music in the virtual lab add to the interest in learning	80.00	Very Good
The language used in the virtual lab is clear and easy to understand The language used in the virtual lab is clear and easy to understand	88.33	Very Good
The virtual lab media makes it easier for me to study and practice independently at home	83.33	Very Good
The virtual lab media used is easy to operate	85.00	Very Good
Reaction rate practicum materials and procedures using a virtual lab are easier to understand	85.00	Very Good
Reaction rate practicum materials and procedures using a virtual lab are easier to understand	86.67	Very Good
Total average score	86.66	Very Good

Figure 15. Display of the Virtual Lab at the Submicroscopic Level

Conclusion

Based on the results of the research and product development developed, it can be concluded that 1) the virtual lab media on the reaction rate material was declared very valid by expert validators with a percentage of 92.47% and obtained very good responses from students with a percentage score of 86.66%; 2) The student response reliability test obtained a Cronbach's Alpha value = 0.910 which was greater than 0.700, meaning the questionnaire proved to be reliable and a value > 0.9 meant very good; 3) Virtual lab media on reaction rate material can be used as learning media in basic chemistry practicum to improve students' conceptual understanding at the submicroscopic level.

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