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Development of Laboratory Virtual Learning Media on Alkene Submaterial

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Abstract

This study aims to develop virtual laboratory learning media for the alkenes subtopic and determine the feasibility, practicality, and effectiveness of its use in chemistry learning. This study used the Research and Development (R&D) method with the ADDIE model, which includes the stages of analysis, design, development, implementation, and evaluation. The study was conducted in the Chemistry Education Study Program, State University of Medan, with students from class PSPK 25 C as the experimental class and class PSPK 25 E as the control class. The research instruments consisted of validation sheets from media experts and material experts, student response questionnaires, and learning outcome tests in the form of pretests and posttests. Data were analyzed descriptively quantitatively using percentages and N-Gain calculations. The results showed that the virtual laboratory media achieved a media feasibility percentage of 83.93% and a material feasibility percentage of 83.67%, categorized as very feasible. The media's practicality level reached 86.24%, categorized as very practical. The effectiveness test results showed that the experimental class achieved an N-Gain score of 0.80, categorized as high, while the control class achieved an N-Gain score of 0.67, categorized as moderate. Based on the research findings, the developed virtual laboratory media is effective for learning the alkenes subtopic.

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INTRODUCTION

Education in the era of the industrial revolution 4.0 demands the integration of digital technology in the learning process, both in the classroom and in the laboratory, through the use of interactive and innovative virtual media. The use of educational technology is expected to improve the quality of learning and help achieve educational competency goals and standards (Sabaruddin, 2022). One form of using technology in learning is the use of laboratory-based virtual learning media.

Chemistry is a branch of natural science that studies the structure and properties of matter, changes in matter, and the energy that accompany those changes (Artini & Wijaya, 2020). Learning chemistry is often considered difficult because it has a wide scope of abstract material and concepts, causing students to have difficulty understanding the material and potentially experiencing misunderstandings (Afrianti et al., 2025). One of the materials that is considered difficult is hydrocarbons. Hydrocarbon materials include various concepts, such as molecular structure, nomenclature of compounds, properties of compounds, isomerization, and hydrocarbon reactions so that they require a relatively long learning time (Rico & Fitriza, 2021).

The implementation of practicum in hydrocarbon courses still faces various obstacles, such as limitations in tools and materials, limited

practicum time, long practicum procedures, and the risk of work accidents in the laboratory. This condition causes students to be unable to understand the concept of chemical reactions optimally and lack independence in carrying out practicums. Therefore, learning media is needed that can help students understand abstract concepts and support practicum activities more effectively.

Virtual laboratory is a learning media based on computer technology that is able to simulate practicum activities virtually so that students can do practicum without having to be in a physical laboratory (Suhadah & Mufit, 2023). The use of virtual laboratories is considered effective in improving students' reasoning skills, concept understanding, and learning outcomes compared to conventional practicum (Sudirman & Hindriana, 2023). In addition, virtual labs can help students understand abstract concepts through interactive visualizations and provide opportunities for independent learning anytime and anywhere (Kurniati et al., 2024).

Several previous studies have shown that the use of virtual laboratories is able to improve the quality of learning. According to Elisa et al., (2020) stated that the virtual laboratory received a very high response from students and was able to improve problem-solving skills. Research by Andriani et al., (2024) it also shows that the use of virtual labs results in higher mastery of concepts than learning using PowerPoint and animation. However, most previous research is still developing a virtual laboratory in general and has not been specifically focused on alkene submatter, specifically on bromine test reactions and potassium permanganate assays as double bond identification. Based on previous research, the novelty of this research lies in the development of laboratory virtual learning media that focuses on alkene submatter through a simulation of bromine test practicum and potassium permanganate test adapted to the characteristics of chemistry education students at the State University of Medan.

Various problems in the implementation of practicum cause learning on alkene submatter not to run optimally. The limited practicum time, the use of conventional learning media, and the risk of work accidents in the laboratory cause students to be unable to understand the concept of bromine test reactions and potassium permanganate tests in depth and do not have independence in carrying out practicums. Therefore, this study aims to develop virtual laboratory learning media for alkene subtopics and to evaluate its feasibility, practicality, and effectiveness in improving student learning outcomes.

METHODS

This study uses a quasi-experimental design with a pretest-posttest control group design to test the effectiveness of laboratory virtual media. The design was used to compare the improvement of student learning outcomes in the experimental class and the control class through the provision of pretest and postest. The two classes were given different treatment during the learning process, such as the experimental class was given treatment using laboratory virtual learning media, while the control class used PowerPoint learning media. Observe Table 1 to see the design of this study.

Table 1. Research Design

Classes	Remarks	Quantity Students	Treatment
PSPK 25 C	Experiment	33	Virtual Lab.
PSPK 25 E	Control	29	Powerpoint

The sampling technique in this study uses purposive sampling, meaning the determination of the sample based on certain considerations according to the needs of the research (Sugiyono, 2018). The research sample consisted of the PSPK 25 C class as the experimental class and the PSPK 25 E class as the control class. The selection of the two classes was based on the consideration that both have relatively similar characteristics, such as learning the same material, being taught by the same teaching lecturer, and using learning methods and Powerpoint learning media in the initial learning process. The difference in the number of students in each class is due to the research using classes that have been available in the Chemistry Education Study Program, State University of Medan.

The type of research applied is research and development using the ADDIE model. This study uses the ADDIE model because the model has systematic stages and is suitable for the development of digital-based learning media. The ADDIE model consists of five stages, namely Analysis, Design, Development, Implementation, and Evaluation. Based on research and development, a product will be produced, namely

a laboratory virtual learning media on alkene submatter. Each stage of research and development with the ADDIE model can be seen in Figure 1.

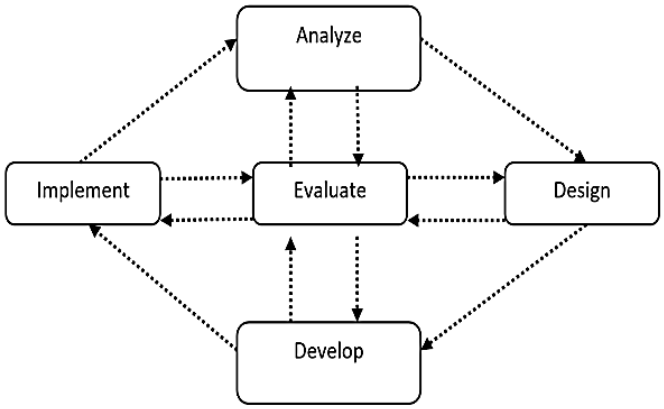

Figure 1. ADDIE Model Stages

ADDIE's development procedure consists of five stages (Mulyatiningsih, 2013), among others:

Analysis

The initial stage is to analyze several journals as well as virtual laboratories on the internet. The analysis of media needs developed by conducting interviews with lecturers majoring in chemistry and students who have completed the course aims to find out the state of learning at UNIMED. In this process, focus on identifying every problem that occurs in class activities, then analyzing the problems and needs needed for learning.

Design

The second stage is the design stage, a virtual laboratory is designed using a powerpoint application which will be filled with the concept of alkenes and tests to determine alkene compounds. The virtual laboratory will be presented with pictures of practicum tools which are then added animations to create movements in the simulation, there is text that helps convey information and work procedures, the addition of audio to the bromine and potassium permanganate test simulations, especially in the display of practicum tools and materials, and equipped with pretest and posttest questions that will be added to the ppt slides before and after the implementation of the practicum simulation that moves according to the procedure work. The laboratory's virtual media will be developed in an interesting way so that students can carry out online practicum easily, practically, and interestingly. Through the media developed and given to students, it is hoped that it can increase independence and interest in learning.

Development

The third stage in this research is development, which is the process of making and purifying products according to the prepared design. This stage aims to produce laboratory virtual learning media that is feasible, practical, and effective to use during the learning process. Through this development stage, a laboratory virtual product is produced which is then validated by materials experts and media experts to assess their feasibility. The results of this validation are used to identify the advantages and disadvantages of the developed media. If improvements are still needed, the researcher will revise the media to obtain a quality product.

Implementation

The fourth stage is the implementation of laboratory virtual media for students. A virtual laboratory trial was carried out for students majoring in chemistry PSPK 25 C to find out the feasibility, practicality and effectiveness of learning media. Based on the trial, it is known to what extent the media plays a role and is useful for students, if there are no benefits or obstacles for students when using the virtual laboratory, revisions can be made.

Evaluation

The fifth stage is media evaluation which aims to get input and suggestions as a basis for media improvement. At this stage, the virtual improvement of the laboratory is carried out based on data obtained from expert validators and students who have participated in media trials, so that valid, practical, and effective learning media is produced. Thus, these media can be used during the learning process to support more effective learning achievements.

This study uses non-test instruments and test instruments to measure the feasibility of media, practicality and effectiveness of laboratory virtual learning media. The non-test instruments used were media validation questionnaires and material validation questionnaires aimed at measuring the feasibility of media, while student response questionnaires were used to measure the practicality of media in the learning process. The media and material validation questionnaire will be filled out by media expert validators and material experts, each questionnaire has a score adjusted to the likert scale, which is in the range

of 1-4, the score given by the validator shows how appropriate the media is to be implemented in learning. The media expert validation questionnaire has 14 statements consisting of 2 aspects, namely graphics and media techniques. The material expert validation questionnaire has 25 statements consisting of 3 aspects, namely the feasibility of content, material presentation, and language. The student response questionnaire consists of 18 statements that students will answer with assessment criteria, namely strongly disagree (score 1); disagree (score 2); agree (score 3); strongly agree (score 4) that has been adjusted to the Likert scale in the range of 1-4. The test instrument is used to measure the effectiveness of the media, the test is in the form of multiple-choice questions as many as 10 question items that have been validated by instrument experts and have been tested for validity, reliability, differentiation, difficulty level and constructor in each question item.

After obtaining scores from the media validation questionnaire, student response questionnaire and multiple-choice test questions, the data processing and analysis continued. The data analysis in this study was carried out in a quantitative descriptive manner using Microsoft Excel. Media and material feasibility data were analyzed using the percentage of expert validation scores, while practicality data was analyzed based on the percentage of student response questionnaires. The media effectiveness analysis was carried out using N-Gain calculation based on pretest and posttest results to determine the improvement of student learning outcomes in the experimental class and the control class.

The criteria in the assessment scale for media eligibility use the Likert scale in Table 2 are as follows.

Table 2. Assessment Criteria for Learning Media Questionnaire with Likert Scale

Criteria	Score
Not Eligible	1
Less Worthy	2
Worthy	3
Highly Worth It	4

Then the collected data is processed into the calculation of the feasibility percentage using the following formula (Damayanti et al., 2018).

$$\text{Percentage (\%)} = \frac{\text{Score obtained}}{\text{Maximum score}} \times 100\ \%$$

The percentage results obtained are adjusted based on the table of learning media feasibility test criteria in Table 3 (Arikunto 2010).

Table 3. Learning Media Eligibility Test Criteria

Percentage of Eligibility (%)	Category
76%- 100%	Highly Worthy
50%- 75%	Worthy
26%- 50%	Less Worthy
< 25%	Very Unworthy

The criteria in the media practicality assessment scale use the Likert scale in Table 4.

Table 4. Likert Scale Assessment Criteria on Student Response Questionnaire

Criteria	Score
Strongly Disagree	1
Disagree	2
Agree	3
Strongly agree	4

Based on the data obtained, data processing is carried out to obtain the value of media practicality. The value of practicality is given using the following formula:

$$\text{Value practicality} = \frac{Total\ scores\ obtained}{Highest\ Total\ Score} \times 100\ \%$$

After the percentage is obtained, grouping is carried out according to the modified criteria in Table 5. Follows (Purwanto, 2012).

Table 5. Percentage of The Practicality Value of Learning Media

Interval	Category
86%- 100%	Very practical
76%- 85%	Practical
60%- 75%	Quite practical
< 59%	Very impractical

The calculation of N-Gain is obtained from the student's pretest and posttest scores. The increase in competence that occurs before and after learning is calculated by the formula g factor (N-Gain) with the formula according to Meltzer as follows:

$$\text{N} - \text{Gain} = \frac{\text{Posttest score} - \text{Pretest score}}{\text{Maximum score} - \text{Pretest score}}$$

Hake's interpretation of N-Gain is presented in Table 6 as follows (Riduwan, 2009).

Table 6. N-Gain Value Criteria

N-Gain Value	Category
$g > 0{,}7$	Height
$0{,}3 \leq g \leq 0{,}7$	Medium
$g < 0{,}3$	Low

The division of the N-Gain acquisition category in the form of percent (%) can be referred to in Table 7 (Arini, 2016).

Table 7. Percentage of N-Gain Value

Percentage (%)	Category
<40	Ineffective
41-50	Less effective
56-75	Quite effective
>76	Effective

RESULTS

Research on the development of laboratory virtual learning media on alkene submatter applies the ADDIE model. Media development is measured based on the feasibility of the laboratory's virtual media which is reviewed from the assessment of material and media expert validators; the practicality of the media through student responses to the virtual laboratory that has been developed by the researcher; and the effectiveness of the virtual laboratory after it is implemented to students. In this study, a pretest and posttest were given to students of the class of 2025 which aimed to measure the effectiveness of improving student learning outcomes.

Media Expert Validation

The implementation of media validation is carried out to ensure that the laboratory virtual learning media on the developed alkene submatter has met the media feasibility criteria and can be used in the learning process based on the standards of the National Education Standards Agency (BSNP). Media expert validation based on a validation questionnaire sheet that has been in accordance with BSNP standards is then given to media expert validators with the aim of obtaining assessments and inputs related to graphic aspects and laboratory virtual media techniques. In the validation questionnaire, each aspect has 7 statements for the virtual laboratory assessment so that there are 14 statements with the assessment scale used, namely the likert scale between 1-4.

The implementation of laboratory virtual validation was carried out by 3 expert validators, lecturers in the chemistry department of Medan State University. The scores given by validators will be accumulated in percentages adjusted to the assessment criteria so that the level of virtual feasibility of the laboratory can be known. The percentage of media expert validators against virtual laboratories can be seen in Table 8.

Based on Table 8, the percentage value that has been calculated and accumulated is in accordance with the number of points contained in the learning media feasibility questionnaire which produces an overall percentage value of 83.93% for both aspects. The value of 83.93% when viewed from the media feasibility criteria, the value is included in the category of "Very Feasible" for laboratory virtual learning media.

Table 8. Percentage of Media Expert Validator Scores

Aspects Rating	Percentage Assessment			Percentage Aspects
	V1	V2	V3	
Graphic Aspects	75%	85.71%	89.3%	83.33%
Media Technician Aspect	75%	89.29%	89.3%	84.52%
Total				83.93%

The score given by validator 1 shows that the media is in the decent category while the scores given by validators 2 and 3 for each aspect show that the media is very feasible to be implemented to students. Pay attention to the differences in the scores given by the three validators because each validator assesses from a different point of view and has several reasons for the quality of the media being assessed. Therefore, the validator assessment is also equipped with comments and suggestions so that the media can be revised before being implemented to students so that the final product of the virtual laboratory is more interesting and very suitable for use in the learning process.

In the graphic aspect, validator 1 gave a percentage of 75%, validator 2 of 85.71%, and validator 3 of 89.3%, so that an average percentage of aspects of 83.33% was obtained with a very feasible category. The difference in values shows that validator 1 still finds some parts of the media display that need to be improved, while validator 2 and validator 3 judge that the media display has been interesting, systematic, and in accordance with the characteristics of interactive learning media.

In the aspect of media engineering, validator 1 provided a percentage of 75%, validator 2 of 89.29%, and validator 3 of 89.3%, with an average percentage of 84.52% which is included in the very feasible category. The high score given by validator 2 and validator 3 shows that the laboratory virtual media is considered to have a good function, easy to operate, and able to support the learning process effectively.

Meanwhile, validator 1 gave a lower score because there are still several technical parts of the media that need to be improved so that the use of media becomes more optimal.

Overall, the results of the media expert validation obtained a total percentage of 83.93% with the category "Very Feasible". These results show that laboratory virtual learning media on alkene submatter has met the aspects of graphics and media techniques so that it is suitable for use in the learning process. The differences in assessments from each validator are evaluation material in revising and improving the media to produce a virtual laboratory that is more interactive, interesting, and in accordance with the needs of students.

Subject Matter Expert Validation

The purpose of material validation is to find out the feasibility of the material in the virtual laboratory that is developed and to find out the assessment of the material expert validator on the virtual laboratory. The material validation questionnaire is given to material expert validators with the aim of obtaining assessments and inputs related to the feasibility of content, language, and presentation of material in laboratory virtual learning media. The assessment of the validity of the learning material refers to the BSNP standard. The validation questionnaire has 25 statements for the virtual laboratory assessment and uses the likert scale as the assessment scale with a score range between 1-4.

The implementation of laboratory virtual validation was carried out by 3 expert validators who are lecturers in the chemistry department of Medan State University. The scores given by the three validators will be accumulated in percentages adjusted to the assessment criteria so that the feasibility level of the virtual virtual laboratory can be known. The percentage of media expert validators against virtual laboratories can be seen in Table 9.

Based on Table 9, the percentage value that has been calculated and accumulated according to the number of points contained in the material feasibility questionnaire results in an overall percentage value of 83.67% for these three aspects. The value of 83.93% when viewed from the material feasibility criteria, the value is included in the category of "Very Feasible" for the developed laboratory virtual learning media. The score given by validator 1 shows that the media is in the decent category while the scores given by validators 2 and 3 for each aspect show that the media is very feasible to be implemented to students.

Table 9. Percentage of Material Expert Validator Scores

Aspects Rating	Percentage Assessment			Percentage Aspects
	V1	V2	V3	
Content Eligibility Aspects	75%	86.4%	93.18%	84.85%
Aspects of Material Presentation	75%	85%	95%	85%
Language Aspects	75%	86.1%	83.33%	81.48%
Total				83.67%

In terms of content feasibility, validator 1 gave a percentage of 75%, validator 2 of 86.4%, and validator 3 of 93.18%, so that an average percentage of 84.85% was obtained with a very feasible category. The difference in assessment shows that validator 1 still finds some parts of the material that need to be improved, while validator 2 and validator 3 judge that the material presented is in accordance with the learning objectives and needs of students.

In terms of material presentation, validator 1 provided a percentage of 75%, validator 2 of 85%, and validator 3 of 95%, with an average percentage of 85% which is included in the very feasible category. The high score given by validator 3 shows that the presentation of material in the virtual laboratory is considered systematic, interesting, and able to help students understand the concept of alkenes more easily. However, validator 1 still provides several suggestions for improvements related to simplifying the appearance and arrangement of the material to be more effective in learning. Furthermore, in the linguistic aspect, a percentage of 75% of validator 1, 86.1% of validator 2, and 83.33% of validator 3 was obtained, with an average percentage of 81.48% which is included in the very feasible category. These results show that the language used in learning media is quite communicative and easy to understand, although there are still some sentences that need to be adjusted to be more effective and in accordance with the rules of good and correct Indonesian language.

Overall, the results of the material validation obtained a total percentage of 83.67% with the

category "Very Feasible". These results show that laboratory virtual learning media on alkene submaterials has met the feasibility aspects of content, material presentation, and language so that it is suitable for use in the learning process. The difference in assessment from each validator is the basis for revising and improving the media to produce a better, interactive, and more interactive virtual laboratory in accordance with the needs of students.

Student Response

Student responses are needed to measure how practical the virtual laboratory is developed for students as a learning medium that can make it easier to understand the materials and work procedures of the practicum online before going directly to the chemistry laboratory. Response questionnaires were also given to students to find out the opinions of the laboratory's virtual media users. The questionnaire used is compiled based on the Likert scale, which serves to measure students' attitudes, perceptions, and levels of interest in the learning media used.

Student responses were obtained from students who were treated in the study, namely 33 students of the PSPK 25 C class. Student assessments of virtual laboratories were obtained by distributing student response questionnaires consisting of 18 statements regarding the ease of use of media, media display and design, clarity of material and language, as well as motivation and benefits of virtual laboratories for students, then the scores obtained were accumulated in percentages so that the level of practicality or not of the virtual laboratory was known, which can be observed Table 10.

Table 10. Media Practicality Percentage

Total Assessment Score	Media Practicality Percentage	Category
2.049	86.24 %	Very Practical

Based on Table 10. the number of questionnaire results that have been given to 33 students is 2,049, the total score is then calculated and accumulated based on the number of assessment items in the student response questionnaire so that it produces a percentage of 86.24% which if viewed based on the criteria provided, the media is included in the category of "very practical", so that it is stated that the virtual laboratory is suitable as a tool used in Learning activities for students.

Media Effectiveness

The media effectiveness test stage was obtained from the pretest and posttest scores that were carried out to measure the improvement of student learning outcomes after the implementation of a virtual laboratory on alkene submatter. The effectiveness test was carried out in the experimental class, namely the PSPK 2025 C class and the control class, namely the PSPK 2025 E class. Table 11. shows the value of students' pretest and posttest results in the experimental class and the control class.

Table 11. Students' Pretest and Posttest Results in Experimental and Control Classes

Classes	Mean Pretest	Mean Postest	N-Gain Score	Category
Control	67.59	89.66	0,67	Medium
Experiment	65.76	92.42	0,80	Height

DISCUSSION

This research was conducted to develop laboratory virtual learning media on alkene submatter, using the ADDIE model. The research was carried out in the experimental class and the control class. In the experimental class, a virtual laboratory is implemented, while in the learning control class using powerpoint media, and in both classes group discussions are also carried out.

The needs analysis stage was conducted by conducting interviews with lecturers of the chemistry department of Medan State University (lecturers in the hydrocarbon and derivative courses) and students of the chemistry department batch 22 of the State University of Medan. The conclusion from the interview obtained was that the hydrocarbon course and its derivatives are relatively difficult for students to understand because the scope of the material is quite wide. Learning using laboratory virtual media has never been done by lecturers. In addition, the results of the pretest scores in the experimental class and the control class showed the difficulty of students in understanding abstract and broad chemical concepts, especially hydrocarbon materials.

At the design stage, the media is developed using a powerpoint application as a container for filling in materials, chemical reactions, practicum simulations, and link quizzes. The material consists of the concept of alkene compounds, the determination of double bonds, along with

chemical reactions obtained based on chemistry books, on chemical reactions made using ChemDraw Professional 15.0, and images on the uses of alkene compounds obtained from searches on google. In making quizzes, use a google form that has been equipped with an answer key and description. In making the simulation of the bromine test and potassium permanganate test using the items contained in the powerpoint and then animated and set the time to appear and exit each image icon.

At the development stage, the media that has been developed with powerpoint is then published using the Ispring Suite 11 application which is already installed with powerpoint on the device. The laboratory virtual project file that has been published is then changed in the form of a website link using the netlify platform. So a virtual laboratory link is produced that can be accessed by all users anywhere and anytime at no cost. The following is a virtual link to the laboratory that can be accessed https://dynamic-pavlova-705df4.netlify.app/. Then the virtual laboratory is validated to determine the feasibility of the media before being tested on students.

In the assessment of media experts, there are two aspects of assessment so that the feasibility value for the media graph aspect is obtained a value of 83.33% and the feasibility value of the media engineering aspect is 84.53% so that the final total value for the media expert feasibility test is 83.93% with very feasible criteria. As for the validation of material experts, each also has its own based on aspects, namely on the feasibility aspect of the content of the material, the value obtained is 83.67%; In the aspect of presenting the material, a score of 85% was obtained; and in the linguistic aspect, a score of 81.48% was obtained. So that the total value for the laboratory virtual media feasibility test is 83.67%.

Each validator also provides comments and suggestions to the media, based on the revision of the media expert validator stating that an image of the "Home" icon is added to each slide to make it easier for users to return to the main page, the improvement of the navigation display is carried out based on the input of the media validator because some menus do not show clear functions, for example the navigation button should be given an arrow instead of writing, and each letter should be black or blue instead of red. This revision aims to improve usability so that students can access practicum simulations more effectively.

The advice given by the material expert validator is that for chemical materials and compounds, it is better to use Indonesian that is appropriate and easy to understand by the user and in the alkene use section, it is better to add images instead of just writing. Every suggestion given by the validator has been applied to the laboratory's virtual media and the media has been revised. Based on the percentage of the results of the feasibility test and revision that has been carried out, the interactive learning media developed has displayed interesting animations that make it easier for students to understand the material and be able to increase their attention in the learning process (Aulia et al., 2022).

At the implementation stage, practicing the virtual laboratory that has been developed directly to the experimental class during the learning process in class. The treatment in the experimental and control classes was different so that the benefits of using virtual laboratories to improve student learning outcomes were seen. The implementation of research in the experimental class was carried out in 3 meetings. For two meetings, they were held in the classroom and one meeting was held in the chemistry laboratory. At the end of the meeting, a student response questionnaire was also given. Based on the accumulated student response data, a practicality score of 86.24% was obtained. Based on the criteria that have been determined, the learning media can be declared very practical for students to use in learning in hydrocarbon courses and their derivatives in alkene submaterials.

At the evaluation stage, a posttest is carried out to measure the improvement of student learning outcomes. To see the effectiveness of learning media based on the average score of the pretest and the average score of the posttest. The development of student learning outcomes can be known by comparing the results of the pretest and posttest (Siregar et al., 2023). The results of data analysis for the experimental class, namely PSPK 25 C, show that there is an increase in student learning outcomes after being given learning treatment. This can be seen from the average pretest score of 65.76, then the average posttest score of 92.42 increased after being given treatment. Furthermore, the data from the pretest

and posttest results were processed again with the N-Gain test to see the effectiveness of using the virtual laboratory as a learning medium. From the results of the N-Gain test that has been carried out with excel, a score of 0.80 was obtained which is in the high category. So that the percentage value of N-Gain learning outcomes in the PSPK 25 C class is 80.30%, the media has good effectiveness.

Meanwhile, the results of data analysis for the control class, namely PSPK 25 E, show that there is an increase in student learning outcomes after the implementation of the learning process. This is seen from the average pretest score of 67.59 then the average posttest score of 89.66 also experienced an increase in learning outcomes. Furthermore, the data from the pretest and posttest results were processed again with the N-Gain test to see the effectiveness of using the virtual laboratory as a learning medium. From the results of the N-Gain test that has been carried out with excel, a score of 0.67 was obtained which is in the medium category. So that the percentage value of N-Gain learning outcomes in the PSPK 25 E class is 67.41%. The high value of N-Gain in the experimental class shows that the use of virtual laboratory is able to help students understand abstract alkene concepts through visualization of chemical reactions and practicum simulations. This media also increases students' learning independence because it can be accessed flexibly without space and time limitations. In addition, the simulation of bromine and potassium permanganate practicum helps students understand the changes in reaction in a more concrete way than conventional learning.

Based on the value of improving learning outcomes in the experimental and control classes, it shows that the value of improving learning outcomes implemented by laboratory virtual learning media is higher than that of the control class using powerpoint media. According to the results of the study Andriani et al., (2024) it showed that the mastery of concepts from the experimental group, which was given learning through a virtual laboratory, resulted in higher average scores than the control group, which received learning with PowerPoint. So that practicum learning using virtual laboratories has proven to be effective. Therefore, the virtual laboratory affects the student learning spirit so that it can improve students' understanding and learning outcomes on alkene submaterials.

If you look at the value of learning outcomes in the control class has also increased, this can happen because students continue to get learning through PowerPoint media and group discussions that help them understand alkene concepts. In addition, the learning process that takes place during the research provides opportunities for students to gain new knowledge and improve their understanding of concepts that were previously low and allows students to recognize material that has not been mastered so that they are more focused during the learning process. However, the improvement in learning outcomes in the experimental class remained higher than in the control class. This shows that the use of virtual laboratories provides a more interactive learning experience and is able to visualize abstract chemical concepts, so that learning becomes more effective in improving student learning outcomes.

The achievement of N-gain results shows that practicum activities with virtual laboratories help students in finding solutions in solving problems and drawing the right conclusions. By utilizing laboratory virtual media, students can carry out practicum activities more easily anywhere without having to provide teaching aids or laboratory facilities, so that practicum can still be carried out online. This media is also able to simulate concepts in learning that help improve student understanding and have an impact on improving their cognitive aspects (Arumningtyas et al., 2022).

CONCLUSION

Based on the results of research on the development of laboratory virtual learning media on alkene submatter that has been carried out at the State University of Medan, it can be concluded that the feasibility based on the assessment of media experts, the virtual laboratory that has been developed received the category of "Very Feasible" with a percentage of 83.93%. And feasibility based on the assessment of material experts, the virtual laboratory is categorized as "Very Feasible" with a percentage of 83.67%. The response of 33 PSPK 25 C students to the laboratory virtual learning media on alkene sub-material that has been implemented is categorized as "Very Practical" with a percentage of 86.24%. The difference in score between the pretest and posttest was obtained with the

average student pretest score of 65.76 and the average student posttest score of 92.42. From these results, an N-Gain value of 0.80 was produced with the category "High" so that the percentage value of the N-Gain score of 80.30% can be categorized as "effective".

RECOMMENDATIONS

Based on the results of the research that has been conducted, virtual laboratory learning media on alkene submatter is expected to be a reference for further research in developing technology-based learning media on other chemical materials. Further research is also recommended to implement media in various educational institutions to obtain a broader picture of the effectiveness of its use. In addition, the development of virtual labs can be directed at providing offline and mobile-friendly versions to improve accessibility and flexibility of use. Further research also needs to conduct more robust experimental testing, increase media interactivity, and develop virtual laboratories on other organic chemistry topics so that they can support the learning process more optimally.

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