

Development of Multiple Representation Learning Videos on Hydrocarbon Nomenclature

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Abstract. This research focuses on the development of learning media based on multiple representations in organic chemistry courses. Multiple representation-based learning media has the potential to improve students understanding of the concepts of chemical materials that are often considered difficult. However, the lack of learning media used by lecturers to discuss the three aspects of representation is a problem that needs to be addressed. This research aims to produce a nomenclature of hydrocarbon compounds learning video based on multiple representations and to find the eligibility and response for the developed learning video. The research methods are research and development using the 4d development model. The instruments used were the eligibility sheet and response questionnaire using a Likert scale. The eligibility for learning video is included as very feasible, with an average eligibility percentage of 95,03%. The eligibility of learning video was viewed in three aspects, namely, the lesson aspect (94.67%), the language aspect (95.56%), and the media aspect (94.87%). The responses given by students were included as a good category, as shown by the percentage of response results on the small-scale trial of 83,79% and large-scale trial of 83,31%. Based on the outcome of eligibility assessment and field trials, the nomenclature of hydrocarbon compounds learning video based on multiple representations is very feasible for learning media in the organic chemistry of monofunctional compounds course.

Keywords: Hydrocarbon Compounds, Learning Video, Multiple Representations

Introduction

Organic chemistry is a part of the chemistry studied at the college level and even in high school. Organic chemistry is a course taught to Science and Health Study Program students. Many students consider this course difficult because it involves understanding and good reasoning about interrelated concepts (Lestari & Erlina, 2020).

In Chemistry Education of FKIP Untan, hydrocarbons study is included in the kimia organik senyawa monofungsi (KOSMO) or organic chemistry of monofunctional compounds course. One of the sub-capaian pembelajaran mata kuliah (CPMK) or sub-course learning outcomes of the course is that students are expected to be able to name and create structures for hydrocarbon compounds such as alkanes, alkenes, alkynes, and cycloalkanes. To achieve the CPMK, a correct understanding of the concept is required. If the understanding of a concept is incorrect, this can lead to the emergence of errors in the concept, known as misconceptions. Misconception is a misunderstanding of a basic concept,

defining a concept, and linking several concepts with opinions from related references. (Rico & Fitriza, 2021).

Based on research conducted by Lestari & Muharini (2022) on understanding the concept of the study lesson of the nomenclature of organic compounds, the results of the misconception category with an average of 31.36%. One of the question indicators in the study contains IUPAC naming of hydrocarbon compounds. Based on a three-tier diagnostic test conducted on 2021 Chemistry Education students about understanding the concept of naming hydrocarbon compounds, misconceptions occurred with an average of 48.25%. From these results, the misconceptions about naming hydrocarbon compounds still exist.

These results align with previous research by Purwanto (2021) and Romadhona et al. (2020), which state that misconceptions exist regarding hydrocarbon compounds' naming and structural forms. The misconceptions that occur are incorrect in determining the main chain and branches (alkyl groups). The factor in these misconceptions is that students only rely on memorization and memory, but applying them to solve problems related to naming hydrocarbon compounds is difficult.

Misconceptions experienced by someone can affect their achievement and quality of learning (Djarwo, 2019). If the misconception occurs continuously, it will also affect understanding of concepts in the following organic chemistry lesson. Indeed, the purpose of learning chemistry is that students can understand concepts as a whole and relate concepts learned with concepts that are or will be learned because chemistry lessons are defined as continuous and interrelated.

Chemistry requires the ability at three levels of representation so that students can understand the whole concept. The three levels are 1) macroscopic level, which is directly visible; 2) submicroscopic level, which is bound to atoms, molecules, ions, and structures; and 3) symbolic level, which is related such as formulas, equations, symbols, and graphs (Hurrahman et al., 2022). Therefore, according to Johnstone (2000), the application of macroscopic, submicroscopic, and symbolic representations by educators in the classroom is necessary to facilitate the chemistry learning process.

Based on the results of pre-research in class 2021 chemistry education students, students stated that the learning media that are often used in the KOSMO course are handouts from lecturers in the form of PowerPoints, textbooks, and scientific articles are also used as learning resources to broaden their knowledge. Of the various learning resources, students find it easier to understand material through videos by 50%, PowerPoint by 20%, chemdraw by 15%, and books by 15%. Besides that, 75% of students want to learn media through videos about naming hydrocarbon compounds. The students' statement aligns with research conducted by Lestari & Erlina (2020) on analyzing the needs of learning resources and media, explaining that the learning media desired by students in understanding Organic Chemistry material are videos, modules, and worksheets.

Video is a medium that displays motion, sound, and the message conveyed, whether factual, fictional, educational, informative, or instructional (Wati & Adi, 2016). As audio-visual media, videos can show objects, places, and events (Pangestu et al., 2019). Videos based on multiple representations can be used as a learning tool to help visualize abstract lessons so that the lesson can be understood based on existing misconceptions. According to Muharrifa (2018), misconceptions can be remediated using learning videos, with a significant decrease in the percentage of misconceptions.

Based on several previous studies by Aliyyah et al., (2021); Gusmania & Wulandari (2018); Hasanah et al. (2017) on the effectiveness of using multiple representation-based learning videos on learning outcomes, the use of learning videos is strongly supported to increase students' understanding of concepts. Video media is easy to access and share and can be stored on a cell phone or laptop. The learning video can also be w

atched repeatedly. For this reason, it is crucial to develop learning media that students can use to improve their understanding and reduce misconceptions about the nomenclature of hydrocarbon compounds using a learning video based on multiple representations.

Methods

This research is the Research and Development (R&D), which is the process of developing new products or improving existing products, then the final product is tested for effectiveness (Salsabila et al., 2023). This research refers to the 4D development model. The four stages of the 4D development model are Define, Design, Develop, and Disseminate (Thiagarajan et al., 1974). However, the research is limited to the development stage, which will produce a product that has been tested for eligibility by experts and students' response tests.

The research was done in Chemistry Education of FKIP Untan. The subject of the research is the nomenclature of hydrocarbon compounds learning video based on multiple representations, which then will be tested for eligibility by experts and response testing by filling out a response questionnaire by class 2021 Chemistry Education students of FKIP Untan. The students must have completed the organic chemistry of monofunctional compounds course.

The first step is to Define. In the define stage, a series of steps are performed. Front-end analysis is used to determine the initial problems in the learning process. After that, learner analysis is performed to determine the conditions and characteristics of the students' learning style in Chemistry Education at FKIP Untan. The following analysis is a task analysis to determine the main tasks that must be achieved to achieve learning objectives by analyzing the learning outcomes of the organic chemistry course of monofunctional compounds. Next is concept analysis, which aims to develop learning steps by identifying the main concepts to be taught, arranging them in a level sequence, and detailing the concepts. The last step in the define stage is to formulate learning objectives by summarizing the results of task analysis and concept analysis to produce a formulation of learning objectives used as the basis for making learning videos for nomenclature hydrocarbon compounds based on multiple representations.

The second step is to Design. Designing starts with arranging the criteria test by making questions based on the indicator in the nomenclature of hydrocarbon compounds. Later, media selection is carried out through learning videos using software. After that, format selection is done by compiling a learning video storyboard. The last step is the initial design, which involves creating a prototype based on the compiled storyboard.

The third step is to Develop. The development will be performed by an expert assessment to determine the eligibility of the designed learning video. The eligibility of learning videos is assessed based on lesson, language, and media aspects. This assessment process uses an eligibility instrument in the form of indicator items with an assessment score of one to five, according to the likert scale. Furthermore, two stages of response trials were carried out to students, namely small-scale trials and large-scale trials (Utami et al., 2024). The first trial was a small-scale trial involving six students consisting of 2 people with high scores, two with medium scores, and two with low scores on the concept understanding analysis performed at the define stage. The second trial, namely the large-

scale trial, involved 32 Chemistry Education students from the Class of 2021 who did not participate in the small-scale trial. The 32 students came from class A1 as many as 15 people, A2 as many as 13 people, and PPAPK as many as 4. The students' response questionnaire is in the form of statement items consisting of positive and negative statements using a Likert scale of four rating scales, namely SS (Strongly Agree), S (Agree), TS (Disagree), and STS (Strongly Disagree) (Miranti et al., 2024).

The eligibility test assessment data was analyzed using a percentage formula adapted from (Riduwan, 2015):

$$P = \frac{\Sigma X}{\Sigma X_i} \times 100\% \quad (1)$$

Detail:

P : percentage of score

ΣX : total score of each statement

Σx_i : total of the highest score

Then, the average percentage of eligibility is calculated using the formula below:

$$P_{total} = \frac{\Sigma P}{n} \quad (2)$$

Detail:

P_{total} : average percentage of eligibility

ΣP : average percentage scores for each aspect

n : total assessed aspects

The results of the eligibility assessment calculation will be interpreted according to the product eligibility criteria in Table 1

Table 1. Criteria of eligibility percentage

Eligibility Interval (%)	Criteria
0 - 20	Not Feasible
21 - 40	Not Worth It
41 - 60	Enough
61 - 80	Feasible
81 - 100	Very Feasible

(Riduwan, 2015)

Student response data is analyzed using the percentage formula adapted from (Riduwan, 2015):

$$P = \frac{\Sigma X}{\Sigma X_i} \times 100\% \quad (3)$$

Detail:

P : percentage of score

ΣX : total score of each statement

Σx_i : total of the highest score

Then, the total percentage is calculated by the formula below:

$$P_{total} = \frac{\Sigma P}{n} \quad (4)$$

Detail:

P_{total} : average percentage

ΣP : average percentage scores for each statement

n : number of statement

The calculation results will be interpreted in the student response category according to the criteria shown in Table 2.

Table 1. Criteria of students' response percentage

Response Interval (%)	Kriteria
≤55 - 59	Tidak Baik
60 - 75	Cukup
76 - 85	Baik
86 - 100	Sangat Baik

(Amirullah & Susilo, 2018)

Results and Discussion

This research has stages for developing an eligible learning video based on multiple representations. Below is a detailed explanation.

Define Stage

series of analyses were done in the defining stage: front-end analysis, learner analysis, task analysis, concept analysis, and objectives of specifying instructions analysis.

Front-end analysis was done to define the initial problem in the learning activity that underlies the development of video learning. Research by Lestari & Muharini (2022) shows that 31,36% of chemistry education students at FKIP Untan have misconceptions about understanding the concept of the nomenclature of organic compounds. Based on Lestari & Muharini's research, the researcher further analyzed the understanding of the nomenclature of the organic compounds concept using a three-tier diagnostic test for 18 students in chemistry education class 2021. The test has 12 questions with four questions indicator. The result of the test is shown in Table 3.

Table 3. Percentage of misconceptions in diagnostic tests for the nomenclature of hydrocarbon compounds study

No	Indicator	Misconception (%)
1	Nomenclature of straight-chain hydrocarbon (main chain)	31.94
2	Nomenclature of substituent-chain hydrocarbon compounds	47.22
3	Nomenclature of complex substituent hydrocarbon compounds	63.89
4	Nomenclature of hydrocarbon functional groups	49.95

Based on the result in Table 3, students have misconceptions about each indicator. The highest indicator is indicator three at 63,89%, and the lowest is indicator one at 31,94%. The average misconception in the nomenclature of hydrocarbon compounds is 48.25%.

Learner analysis aims to understand students' conditions and criteria. To this end, a literature study about adult learning and a questionnaire about learning styles were used to obtain students' learning characteristics and overcome misconceptions about the nomenclature of hydrocarbon compounds lesson. Chemistry education students have an average age of 19-22 years, included in the adult category. Guidance from educators who are proficient in their fields through various learning models is needed by adults so that they succeed in finding something independent for their further lives (Mau et al., 2022). Based on the learning style questionnaire, chemistry education students in class 2021 have an auditory learning style of 4.7%, a visual learning style of 38.10%, an audiovisual learning style of 38.10%, and a kinesthetic learning style of 19.05%.

Task analysis fulfilled by analyzing the CPMK of the monofunctional organic compound course by Chemistry Education FKIP Untan. The achievement of sub-CPMK is the accuracy of naming and drawing the structure of hydrocarbon compounds.

Concept analysis involves identifying the main concepts to be taught, organizing them in order, and breaking down the concepts. The main concept of the nomenclature of hydrocarbon compounds is grouping the type of hydrocarbon compounds based on bonding, main chain nomenclature, group nomenclature/alkyl group nomenclature, and IUPAC nomenclature.

The objectives of specifying instructions analysis, completed by summarizing the results of task analysis and concept analysis, resulted in specifying instructions of learning objectives used as the basis for developing learning videos for the nomenclature of hydrocarbon compounds based on multiple representations. Students are particularly able to explain concepts, provide names, and create structures of hydrocarbon compounds.

Design Stage

The design stage was used to develop the learning media according to the summary of the previous define stage. Based on the summary, a learning video was chosen to be developed. Several stages were used in designing, namely the drafting of test standards, media selection, format selection, and the initial design of the developed media.

The first step of designing is drafting the standards test based on the learning outcome of the nomenclature of the hydrocarbon compounds study. The test on the developed learning video is an essay question that determines the name and draws the structure of hydrocarbon compounds.

The second step is completed by selecting the developed media. The media developed for this research is a learning video based on multiple representations. The learning video was mainly created using the CapCut software. Additional software used are Prima 3D to form molecules, Canva to create the video's background, Microsoft PowerPoint to create tables, and ChemDraw to create the structure of compounds. Tools used in the development process are laptops and Android smartphones.

The third step is fulfilled by selecting the format of the learning video. The developed learning video uses MP4 format and is approximately 10 minutes long. The effective duration for learning video design is 5-10 minutes long (Susanti et al., 2018).

The last step of the design stage is developing a learning video prototype for the nomenclature of hydrocarbon compounds. The learning video consists of six video parts:

(1) introduction to the naming of hydrocarbon compounds, (2) alkyl groups, (3) alkane naming, (4) cycloalkane naming, (5) alkenes naming, and (6) alkyne naming.

Development Stage

In the development stage, a prototype was produced as a learning video for the nomenclature of hydrocarbon compounds based on multiple representations in MP4 format. This video consists of six parts merged into one link, namely Linktree.



Figure 1. The display of Linktree

Linktree is an application superior to collecting various links on one page (Amaliah et al., 2021; Putu et al., 2022). Merging all parts of the video into Linktree aims to collect and make it easy to access links from the learning video.

The developed nomenclature of hydrocarbon compounds learning video has three levels of chemistry representation: macroscopic, submicroscopic, and symbolic. Students' ability to connect the three levels of chemistry representation can be developed by visualizing learning media based on multiple representations (Asda & Andromeda, 2021; Farida et al., 2020). The example of hydrocarbon in daily life is shown as the macroscopic level in the learning video.



Figure 2. The macroscopic representation level

The form and structure of hydrocarbon molecules are shown as the submicroscopic level.

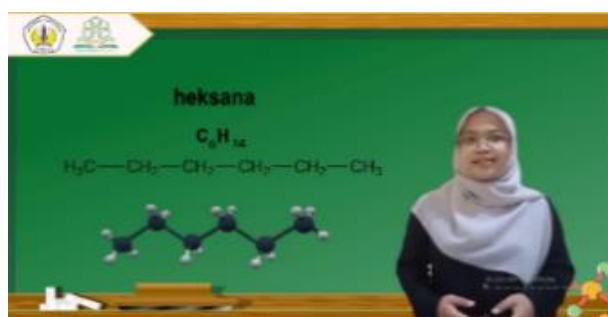


Figure 3. The sub-microscopic representation level

The nomenclature of hydrocarbon compounds is shown as a symbolic level.

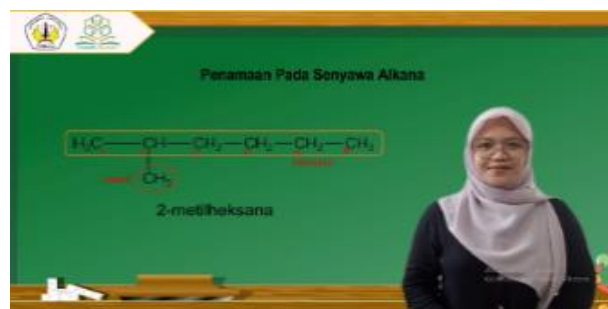


Figure 4. The symbolic representation level

Furthermore, the developed learning video contains refutation text to reduce misconceptions about naming hydrocarbon compounds. The refutation text is shown in the wrong and correct names.

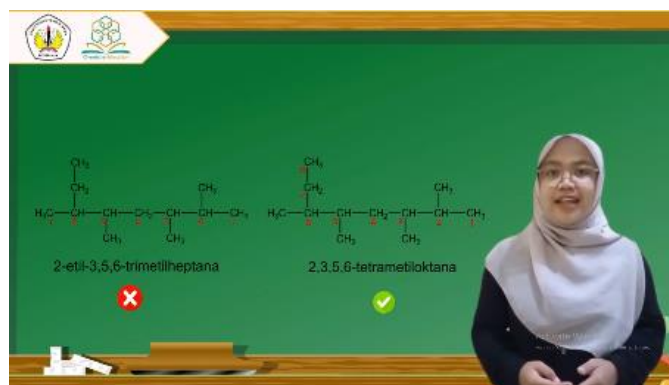


Figure 5. Refutation text

The next step is the eligibility assessment done by experts. Then, field trials were done for the developed learning video.

Eligibility Assessment

The eligibility assessment has three aspects: lesson, language, and media. Three experts assessed each aspect.

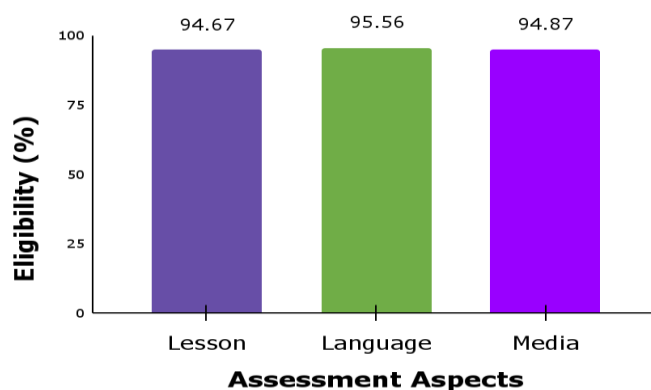


Figure 6. Percentage of eligibility of lesson, language, and media

Based on Figure 6, the percentage of the lesson aspect is 94,67%, the language aspect is 95,56%, and the media aspect is 94,87%. Following Ridwan (2015), an 81%- 100% interval is a very feasible criterion. A very feasible criterion means the developed learning video containing three aspects is very feasible to use as learning media.

Lesson Eligibility

Two sub-aspects viewed in the eligibility assessment of media eligibility contain four indicators: the suitability of the material with CPL and CPMK, the accuracy of the lesson, presentation techniques, and supporting presentation.

Table 4. Percentage of experts' assessment in lesson aspect of video

Sub-aspect	Indicator	Lesson Eligibility (%)
Content Quality	The suitability of the material with CPL and CPMK	100.00
	The accuracy of the lesson	92.23
Presentation	Presentation techniques	100.00
	Supporting presentation	93.33

Based on Table 4, the lesson eligibility from each indicator is 100%, 92,23%, 100%, and 93,33%. The average lesson eligibility is 94,67%, indicating that the lesson in the learning video is very feasible to use. The percentage of indicator one is 100%, which is a very feasible criterion, stating that the lesson content in the from the learning video aligns with learning goals. Learning media will be effective if it maximally supports the understanding of the lesson and aligns with the learning goals (Mustakim, 2020).

Experts present comments in indicator 2 to add the definition of aliphatic and alicyclic. The researcher made improvements by adding a concept map display of grouping hydrocarbon compounds based on the type of carbon chain to convey the definition of aliphatic and alicyclic.



Figure 7. The display concept map on video part 1

Experts also comment on adding the steps to make a structure before entering the example of making compounds' structures. The learning video was improved by adding a display and explaining the steps to make the structures of alkanes, alkenes, alkynes, and cycloalkanes.

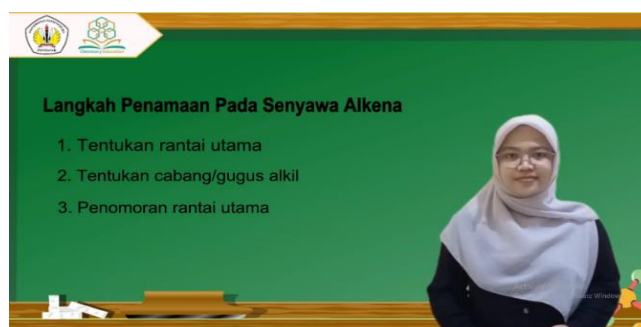


Figure 8. The display of making structure

Experts also notes that the name 4,4-diethyl-2-methylpentane is considered inaccurate because it must comply with IUPAC naming rules. The researcher improved the learning video from these comments by changing the compound 4,4-diethyl-3-methylpentane to 4-ethyl-2,4-dimethylhexane. The change is under IUPAC naming rules, as it describes a more precise structure regarding the length of the main carbon chain. Thus, 4-ethyl-2,4-dimethylhexane is the accurate name based on the IUPAC naming rules.

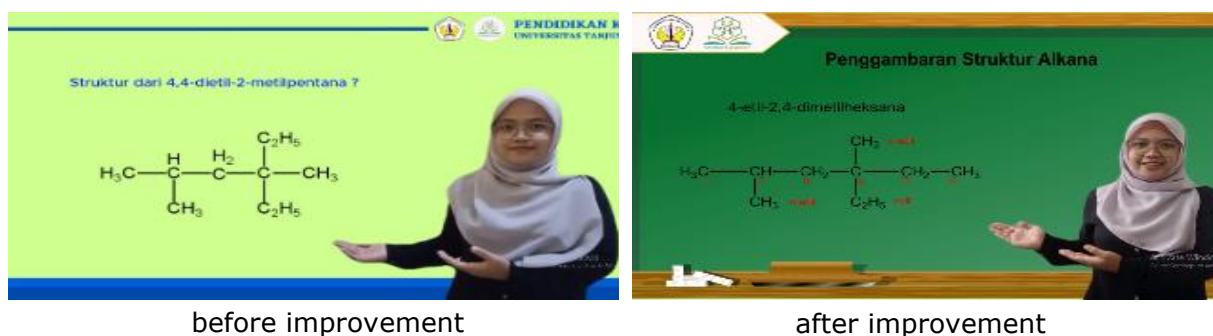


Figure 9. The improvement in making alkanes structure

The percentage of indicator 3 is 100%, which is a very feasible criterion showing that the content of the learning video was delivered systematically and coherently, from simple to complex.

Experts commented on indicator 4 by adding multiple representation aspects in the alkyl function lesson. The researcher improved the learning video based on experts' comments and advice.

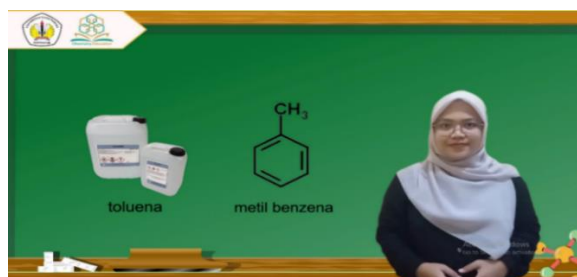


Figure 10. The display of multiple representations in the alkyl function lesson

Media Eligibility

Media eligibility in the media aspect is viewed by four indicators: visual media, audio media, typography, and presentation quality. The result of the media aspect assessment is shown in Table 5.

Table 5. Percentage of media eligibility

Sub-aspect	Indicator	Media Eligibility (%)
Graphic	Visual Media	92.22
	Audio Media	97.00
	Typography	93.33
	Presentation Quality	100.00

According to Table 5, the percentage of each indicator in media eligibility is 92.22%, 97.00%, 93.33%, and 100.00%. The average percentage of media eligibility is 94.87%, a very feasible criterion to use as learning media. Indicator 1 has a percentage of 92.22%, which is very feasible. The experts note that the video display is too dull and lacks harmony between background, text, and table. Using figures, animation, and background in learning media with high quality and correct colors will not just make the understanding of the lesson easier for students but also increase students' interest. Thus, the learning activity will become more interesting and exciting (Cahyani et al., 2022). From the experts' notes, the researcher improved the developed learning video to produce a more interesting video.



Figure 11. The improvement of the beginning video display



Figure 12. The improvement of the table and fonts' color

The audio media as indicator 2 has a percentage of 97,00%, which is very feasible. The experts comment that the background music is too loud. According to the experts' notes, the researcher improved the background music by decreasing the background volume from -16dB to -11 dB so the narrator's voice is not disturbed and can be heard clearly. The non-optimal volume in the outcome voice will make less experience for students to understand the lesson properly. Therefore, the volume setting is important to produce a clear and easy-to-understand voice (Cahyani et al., 2022).

The typography as indicator 3 has a percentage of 93.33%, which is very feasible. The experts note that the type and size of the font should be the same and customized from the beginning until the end of the learning video. From the experts' note, the researcher used Arial as the font type in the learning video display. The characteristics of the Arial font are clear, easy to read, and has an artistic value that supports learning video display (Rakhman et al., 2017).



Figure 13. The improvement of font type

The presentation quality as indicator 4 has a percentage of 100%, which is very feasible. The experts assessed the content in the learning video presented neatly and systematically. The lesson content presented systematically will engage students in learning in order. Thus, objective learning, which is the application of knowledge, can be maximized (Winatha, 2018).

Language Eligibility

The assessment of language eligibility is based on the quality of the language used in the learning video. Four indicators could be assessed to determine language eligibility, as shown in Table 6.

Table 6. Percentage of language eligibility

Sub-aspect	Indicator	Language Eligibility (%)
Language Eligibility	Direct Language	97.77
	Communicative	96.67
	The accuracy to students' development	93.33
	The accuracy to language rules	93.33

Based on Table 6, the percentage of each indicator in language eligibility is 97.77%, 96.67%, 93.33%, and 93.33%. The average percentage is 95.65%, stating that the language used in the learning video is very feasible. The language experts note the use of formal sentences to deliver the lesson. The researcher then improved the use of sentences. Later, in indicator 2, the note from experts is a multi-interpretation of the word 'set locant'. The researcher then improved the learning video by no longer mentioning the word 'set locant'. Direct language, which is easy to understand and clear, will make it easier for the reader or the listener to understand the meaning and goals being delivered (Panjaitan et al., 2021).

Indicator 4 also had notes from experts to use grammar based on basic sentence structure. For example, the prompts of the exercise question must be clear. The researcher improved the prompts by using clearer and easier-to-understand language. The improvement is shown in Figure 14.



Figure 14. The language improvement in prompts of the exercise question

After the eligibility assessment and improvement, the next step is the field trials. The response test was done by Chemistry Education class 2021 students, FKIP Untan. The first response test was small-scale with six students, followed by a large-scale response test with 31 students. The students' response questionnaire has three aspects: lesson, media, and language. The results of the small-scale and large-scale tests are shown in Figure 15.

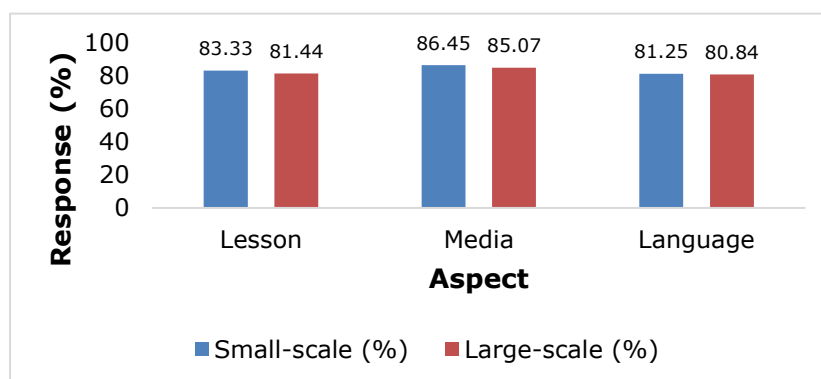


Figure 15. The result of students' responses

Figure 15 shows a decrease in all aspect response percentages on small and large-scales. However, the decrease in the number of respondents is insignificant compared to the number of respondents. The percentage of students' responses to the questionnaire in the lesson aspect for small-scale tests is 83,33%, and the large-scale is 82,23%, both categorized as good. Overall, the lesson's content in the developed learning video could help students understand the nomenclature of hydrocarbon compounds. In this aspect, respondents commented that the structure of the compound was beneficial and cleared the material presented.

The percentage for media aspect on a small scale is 87.50%, and on a large scale, it is 86.71%, both categorized as good. There are comments for the media aspect, such as learning using learning video is easier to understand, learning video could facilitate students with audiovisual learning styles, and learning using videos can be learned repeatedly.

The percentage for language aspect on a small-scale is 80.55%, and on a large-scale is 80.98%, both categorized as good. A student from a small-scale test noted that the lesson delivery between the sub-bab of Introduction to The nomenclature of hydrocarbon compounds is too fast. Students from a large-scale test also indicated that intonation must be more accurate. However, in general, the use of language is clear and easy to understand.

Conclusion

Based on eligibility assessment and field trials, the nomenclature of hydrocarbon compounds learning video based on multiple representations was very feasible for learning media in the organic chemistry of monofunctional compounds course. The average eligibility percentage is 95.03%. The eligibility of learning video was viewed in three aspects, namely, the lesson aspect (94.67%), the language aspect (95.56%), and the media aspect (94.87%). The developed nomenclature of hydrocarbon compounds learning video based on multiple representations received good responses from students, as shown by the percentage of response results on small-scale trials of 83.79% and large-scale trials of 83.31%.

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