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Development of Multirepresentation-Based Learning Videos on the Material of Physical Properties of Alcohols and Ethers

Hanna Rohmatul Maulidiyah[1*], Rini Muharini[1], Maria Ulfah[1], Eny Enawaty[1], Risya Sasri[1]

[1]Pendidikan Kimia, Universitas Tanjungpura, Pontianak, Indonesia

ABSTRACT W
The topic of the physical properties of alcohol and ether compounds is often perceived as challenging by students due to its abstract nature. Consequently, the development of effective learning media is essential to address these difficulties. This study aims to develop a multirepresentation-based instructional video that illustrates the impact of intermolecular forces on the boiling points of alcohols and ethers. The research utilized the 4D model by Thiagarajan, comprising four stages: Define, Design, Develop, and Disseminate. However, this study was limited to the Develop stage. The research instruments included validation sheets and response questionnaires, employing indirect communication measurement techniques. The validity assessment involved three experts evaluating various aspects of the product, while the response test was conducted with 29 students. Data from the validation results were analyzed using the Content Validity Index (CVI), where the instructional video achieved a CVI score of 1.00, indicating very high validity. Student responses demonstrated a satisfaction rate of 85.98% (very good) in the limited trial and 83.57% (very good) in the main trial. In conclusion, the multirepresentation-based instructional video is a highly valid and effective tool that can be utilized in teaching the physical properties of alcohols and ethers.

Keyword: *multirepresentation, physical properties of alcohol and ether, learning video.*

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INTRODUCTION

Alcohols and ethers are compounds that share the same general formula but differ in their functional groups. Consequently, the physical properties of alcohols and ethers also vary due to the influence of intermolecular forces. Intermolecular forces are weaker attractive forces compared to intramolecular forces in organic compounds. However, these forces play a crucial role in determining the physical properties of organic compounds, such as boiling point, melting point, freezing point, solubility, and density. The type of intermolecular forces present in an organic compound is determined by its molecular structure and the molecular environment. Therefore, differences in the molecular structures of organic compounds lead to variations in intermolecular forces, which in turn contribute to the distinct physical properties of these compounds.

In their learning process, chemistry education students at FKIP Untan encounter difficulties in predicting the physical properties of organic compounds. This aligns with the analysis of final semester exam results for chemistry education students in the 2021/2022 academic year for the Organic Chemistry of Monofunctional Compounds (KOSMO) course, specifically on questions related to the boiling points of alcohols and ethers. The results showed that 95% of students did not achieve the maximum score. Exam answers revealed that students struggled to identify hydrogen bonding between alcohol molecules and failed to explain the presence of Van der Waals interactions between alcohol and ether molecules based on their molecular structures.

Alcohols and ethers are functional group isomers that serve as excellent examples for explaining intermolecular forces such as hydrogen bonding, Van der Waals forces, and London dispersion forces. According to a questionnaire administered to 51 students, 66.4% reported difficulties in analyzing the physical properties of alcohols and ethers. Interviews further highlighted challenges in predicting which compound has a higher boiling point between alcohols and ethers, identifying hydrogen bonds in alcohols, and recognizing the presence of Van der Waals or London dispersion forces in both alcohols and ethers.

The challenges described above indicate that students struggle to connect the concepts of hydrogen bonding and Van der Waals forces (or intermolecular attractive forces) with the physical properties of alcohols and ethers. Similar difficulties in analyzing the physical properties of alcohols and ethers were also observed in previous research by Lathifa & Ajiati (2020), which reported that 42% of students found alcohol-related topics difficult to understand, particularly in illustrating hydrogen bonding between alcohols and water at both submicroscopic and symbolic levels. Likewise, a prior study by Cooper (2013) highlighted that students failed to comprehend the concept of hydrogen bonding during the transition from the liquid phase to the gas phase.

The topic of the physical properties of alcohols and ethers is a part of chemistry that is inherently abstract. Abstract chemistry concepts can be represented across three levels of representation: macroscopic, submicroscopic, and symbolic (Sinaga et al., 2023). The intermolecular forces discussed in the context of alcohols and ethers fall within the submicroscopic and symbolic levels, as molecular interactions cannot be observed directly. Consequently, describing these interactions requires the use of diagrams or models for visualization (Pratamadita & Dwiningsih, 2022).

In addition to the submicroscopic and symbolic levels, this topic also incorporates the macroscopic level. The macroscopic level serves to bridge the concept of intermolecular forces with observable phenomena in the students' surroundings. Unlike the abstract nature of submicroscopic and symbolic levels, the macroscopic level is tangible and directly observable (Sukmawati, 2019).

Thus, in organic chemistry learning, students are required to develop spatial abilities—the capacity to generate, store, and manipulate abstract visual representations (Setyarini et al., 2017). This requirement explains why students often struggle to connect the physical properties of alcohols and ethers with intermolecular forces, as well as to relate the structures of alcohols and ethers to these forces.

To assist students in understanding the abstract concepts related to the physical properties of alcohols and ethers, learning media in the form of audiovisual materials that encompass the three levels of chemical representation are needed. However, a review of the literature indicates that, as of the writing of this research, no publications have documented the development of audiovisual learning media incorporating these three levels of multirepresentation for this particular topic (Edi Elisa & I Nyoman Pasek Nugraha, 2023).

Several previous studies have shown that audiovisual teaching materials accessible via mobile devices can enhance students' understanding of the subject matter. This is supported by the results of a questionnaire administered to 51 students, all of whom reported owning a laptop or mobile device and utilizing the internet to support their learning. The students expressed a preference for learning materials in the form of text, images, videos, audio (audiovisual), and animations.

This aligns with prior research by Lestari & Erlina (2020), which found that 48.54% of students favored video-based learning media. Students expressed a strong desire for learning materials such as videos, images, and animations to better understand Organic Chemistry. Interviews with 17 students from the 2021 cohort revealed that most found it easier to understand the material through YouTube videos during their studies. Similarly, students preferred video-based learning media, as learning through watching and listening facilitated their understanding of organic chemistry topics.

Based on the aforementioned challenges and students' preferences for learning media, there is a need for innovative audiovisual learning materials that integrate the three levels of representation (multirepresentation) with microscopic visualizations in the form of dynamic, fully visible 3D animations. These materials aim to explain the concept of intermolecular forces in the physical properties of alcohols and ethers, particularly in the subtopic of boiling points.

The multirepresentation-based instructional video developed incorporates images and animations to enhance the explanation. At the macroscopic level, real images and demonstrations of boiling point determination for alcohol and ether functional group isomers are included. At the submicroscopic level, the dynamics of intermolecular forces in alcohols and ethers are described using 3D animated visualizations. For the symbolic level, chemical symbols and formulas are integrated with 2D animated images to provide a comprehensive and engaging learning experience.

This multirepresentation-based instructional video is expected to assist students in understanding intermolecular forces in relation to the boiling point properties of alcohols and ethers. A review of the literature indicates that multirepresentation-based instructional videos can improve learning outcomes and receive positive feedback from students (Khairani et al., 2019; Apriani et al., 2021; Akay et al., 2022; Nukila et al., 2022).

The objective of this study in developing the multirepresentation-based instructional video on the physical properties of alcohols and ethers is to determine its validity and to describe students' responses to the multirepresentation-based instructional video for learning about the physical properties of alcohols and ethers.

METHODS

This study employed a Research and Development (R&D) methodology, utilizing the 4D development model proposed by Thiagarajan et al. (1974). The subject of this research was a multirepresentation-based instructional video on the physical properties of alcohols and ethers, which was tested on students from the Chemistry Education Program at FKIP Untan who were enrolled in the Organic Chemistry of Monofunctional Compounds course during the 2021 academic year. The 4D model implemented in this research comprised three stages: defining (Define), designing (Design), and developing (Develop).

The data collection techniques employed in this study included direct communication through interviews and indirect communication using instruments such as product validation sheets and student response questionnaires. The aspects evaluated in the validation process were content, language, and media. Product validation was conducted by three experts, each assessing these aspects. Prior to this, the validation sheets were reviewed by two experts to ensure the validity of the instruments. Following the completion of the product validation process, development trials were conducted to assess students' responses to the developed instructional video.

The response testing was conducted in two stages: a limited trial and a main trial. The limited trial was carried out on a small scale, involving nine respondents selected through purposive sampling. These respondents were categorized into three groups based on their academic performance: three high-performing students, three moderate-performing students, and three low-performing students. The main trial, on the other hand, was conducted on a larger scale with 20 respondents who were selected randomly.

The data analysis technique used in this study was the Content Validity Index (CVI), as suggested by Lynn (1986), which recommends using a minimum of three validators. A Likert scale was employed for measurement, with the following scoring system: 4 = Strongly Agree, 3 = Agree, 2 =

Disagree, and 1 = Strongly Disagree (Riduwan, 2015).

Indicator items for the I-CVI (Item-Level Content Validity Index) were calculated based on the number of experts who rated the item as favorable (scores of 3 or 4, categorized as ordinal scale 1 = valid). In contrast, unfavorable ratings (scores of 1 or 2) were categorized as ordinal scale 0 = invalid (Hendryadi, 2017).

The CVI was calculated using the formula:

$$\mathrm{I-CVI} = \frac{\substack{Number\ of\ validators \\ rating\ the\ item\ as\ valid}}{Total\ number\ of\ validator} \ldots\ldots (1)$$

Here are the validity assessment criteria for indicators, as shown in Table 1:

Tabel 1. Kriteria penilaian CVI

I-CVI Value Range	Interpretation
0,81-1,00	Very Valid
0,61-0,80	Valid
0,41-0,40	Less Valid
0,40-0,00	Not Valid

(Parlaungan et al., 2022)

The aspects measured in the student response test included media design, media usability, content relevance, and usefulness. Data processing involved calculating the number of respondents selecting each criterion on a Likert scale, where 5 = Strongly Agree, 4 = Agree, 3 = Neutral, 2 = Disagree, and 1 = Strongly Disagree. This evaluation was applied to both positive and negative statements. The total score was then calculated using a percentage formula adapted from Riduwan (2015), which is expressed as:

$$\mathrm{P} = \frac{Total\ Score\ Obtained}{\text{Maximum Possible Score}} \times 100\% \ldots (2)$$

Next, the total response percentage was calculated using the formula adapted from Siregar (2004). The formula is expressed as:

$$\mathrm{V} = \frac{\substack{\text{Total Score Obtained} \\ \text{by Respondents}}}{\text{Total maximum score}}\ x\ 100 \ldots .(3)$$

The calculated percentage is then interpreted using specific criteria, as outlined in Table 2.

Tabel 2. Response Test Percentage and Criteria

Percentage Range (%)	Interpretation
0 – 19,99%	Very poor
20% – 39,99%	Poor
40% – 59,99%	Fair
60% – 79,99%	Good
80% – 100%	Very Good

(Riduwan, 2008)

RESULTS AND DISCUSSION

The result of this study is an instructional video that presents the physical properties of alcohols and ethers, specifically boiling points, using a multirepresentation approach.

Defining Stage

Front-End Analysis

In the final exam for the KOSMO course during the 2021/2022 academic year, topics covered included alcohols and ethers, aldehydes and ketones, alkyl halides, and carboxylic acids. An analysis of student responses focused on the section discussing alcohols and ethers, particularly questions about their physical properties, with a maximum possible score of 20. The results showed that 85.5% of the 60 students did not achieve satisfactory scores, and 38.3% of them did not attempt to answer the questions. These findings indicate that the learning outcomes for this topic were suboptimal.

A survey distributed to 51 students from the 2021 cohort who had completed the KOSMO course revealed that 66.4% of the students' experienced difficulties in analyzing the physical properties of alcohols and ethers. This was evident in their exam answer sheets, where many students failed to identify hydrogen bonding between alcohol molecules and were unable to explain the Van der Waals interactions present between alcohol and ether molecules based on their molecular structures.

Interviews conducted with 17 students from the 2021 cohort revealed specific challenges, including difficulty in predicting which compound has a higher boiling point between alcohols and ethers, identifying hydrogen bonding in alcohols, and understanding the presence of Van der Waals or London dispersion forces acting between alcohol and ether molecules. To address these issues, the researchers developed an instructional video designed to assist students in understanding the physical properties of alcohols and ethers using a multirepresentation approach.

Student Analysis

In this stage, a questionnaire was distributed to 51 students from the 2021 cohort, revealing that all students reported the use of printed teaching materials or PowerPoint presentations by their instructors. The students stated that the existing teaching materials were motivating, visually appealing, colorful, and written in language that was easy to understand. All students expressed a preference for teaching materials that included text, images, videos, audio (audiovisual), and animations.

However, the students noted that the instructors had not utilized audiovisual teaching materials, particularly for the topic of the physical properties of alcohols and ethers. The students believed that audiovisual teaching materials would enhance their understanding of the subject matter. Additionally, regarding the use of technology, it was found that all students owned laptops or gadgets used for learning and actively utilized the internet to support their studies.

Interviews were conducted to gather information about students' independent learning experiences and their preferred learning media. These interviews involved 17 students from the 2021 cohort, revealing that most students used resources such as Google, PowerPoint slides, and YouTube videos. However, students tended to better understand the material when learning through YouTube videos, as watching and listening made it easier to grasp organic chemistry concepts.

Regarding media preferences, most students favored audiovisual materials (videos) for learning. Instructional videos allow students to visualize images and hear explanations about phenomena that are otherwise imperceptible, which can deepen their understanding and make learning more engaging and enjoyable (Akay et al., 2022). Moreover, instructional videos align with the learning styles of the current generation (Jordan et al., 2016).

Task Analysis

In this stage, the sub-learning outcomes (sub-CPMK) of the Organic Chemistry of Monofunctional Compounds course in the Chemistry Education Program at FKIP Untan were analyzed. The targeted sub-CPMK requires students to explain the physical properties of alcohols and ethers, with a particular focus on the subtopic of boiling points. Task analysis was conducted to assist in conceptualizing the learning objectives for the instructional video. However, the development process did not include the creation of standard test instruments. As a result, the instructional video developed by the researchers is limited to providing explanations of the material and does not include evaluation questions for assessment purposes..

Concept Analysis

The concept analysis stage involves identifying and establishing connections between relevant concepts based on the learning objectives for the topic of alcohols and ethers, with a specific focus on their physical properties. The physical properties discussed in this study center on boiling points and include several key aspects. First, the influence of intermolecular forces, such as hydrogen bonding and Van der Waals forces, on the boiling points of alcohols and ethers is examined. Second, the effect of molecular shape and branching on the boiling points is explored, highlighting how structural variations influence this property. Finally, the impact of chain length on the boiling points is analyzed, focusing on how increasing the carbon chain length affects the boiling point. These interconnected concepts serve as the foundation for understanding the boiling points of alcohols and ethers and form the core content of the instructional video developed in this study.

Formulation of Learning Objectives

At this stage, the learning objectives were formulated to define the scope of the research. The objective of this instructional material, delivered through a multirepresentation-based video on the physical properties of alcohols and ethers, is to enable students to explain the influence of intermolecular forces in alcohols and ethers on their boiling points.

Design Stage

Test Standard Development

At this stage, the development of test standards was not conducted. This study is limited to the development stage, and the video product does not include evaluation tests on the physical properties of alcohols and ethers.

Media Selection

The media used is the 'Multirepresentation-Based Learning Video on the Physical Properties of Alcohols and Ethers.' This learning media facilitates students in accessing it through electronic devices such as smartphones and laptops. The software used to develop this video media includes Adobe Illustrator for creating 2D animations, CapCut for overall video editing, Dolby on for audio recording, KingDraw for creating 2D chemical structures, Prisma 3D for developing 3D chemical structures, Canva for creating backgrounds and supporting animations, YouTube as the platform for students to access the learning videos, and Linktree as a tool to compile various video links uploaded to YouTube into a single page.

Format Selection

The format selection was carried out by reviewing existing device formats and adapting them to the design created by the researcher. The developed video has a duration of approximately 10 minutes and is in MP4 format. This learning video consists of three parts. The first video discusses the physical properties of alcohol and ether compounds, focusing on the general boiling points and explaining the differences and effects of intermolecular forces in functional group isomers of alcohols and ethers. The second part of the video covers an experiment on determining the boiling points of functional group isomers of alcohols and ethers. Finally, the third part discusses the influence of chain length and branching on the boiling points of alcohol and ether compounds.

Initial Design

The initial design stage includes several activities: (1) Designing the content, creating a prototype as the framework for the flow of the multirepresentation-based learning video, designing visuals and layouts, scripting, creating animated graphics, and finally producing the dubbing. (2) Designing evaluation sheets for validation instruments and response assessments.

Develop Stage

This stage produced a valid multirepresentation-based learning video on the physical properties of alcohols and ethers, which received positive responses. The material is explained alongside examples from everyday life and is presented in the form of chemical representations: macroscopic, symbolic, and submicroscopic. Multirepresentation-based learning media is an effective tool to enhance student learning outcomes and mastery of conceptual material, as it supports conceptual understanding (Astuti & Mulyatun, 2019).

The macroscopic level explained in the video media includes examples of alcohol and ether compounds in daily life, along with the physical forms of these compounds. It also features an experiment on determining the boiling points of functional group isomers of alcohols and ethers (Figure 1).

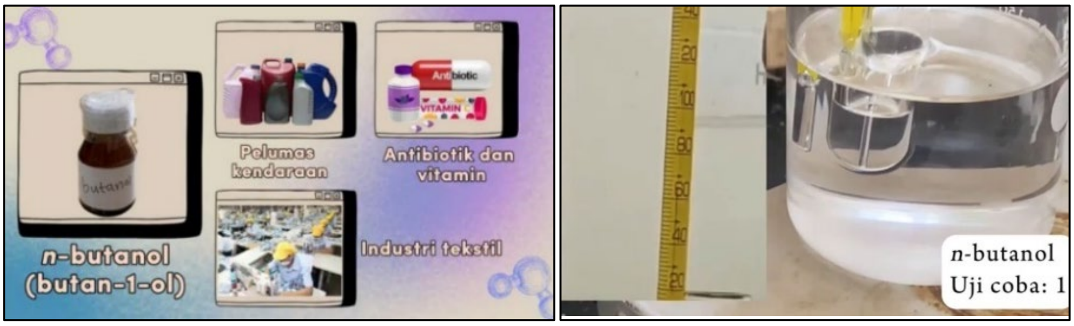

Figure 1. Macroscopic Level Chemical Representation Display

The symbolic level in the video media presents the 2D chemical structures of alcohol and ether compounds, along with their chemical formulas (Figure 2).

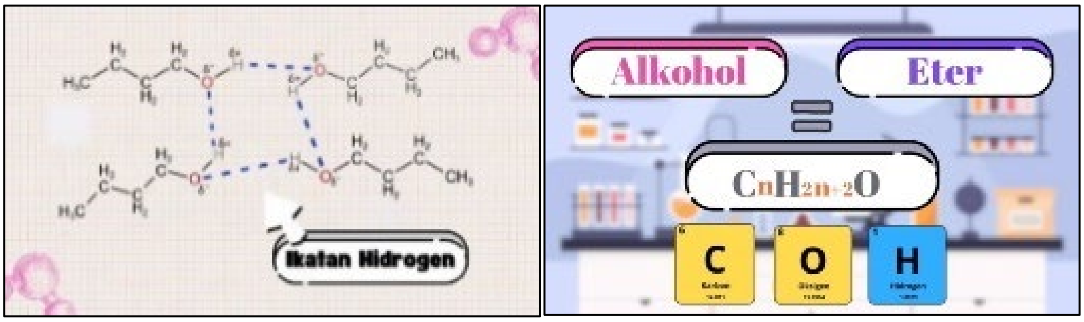

Figure 2. Display of Symbolic Level Chemical Representation

The submicroscopic level explains the intermolecular forces in alcohol and ether compounds using 3D modeling for the structures of alcohols and ethers. It is also complemented with transparent spheres representing electron clouds, where the red-colored electron clouds indicate the negatively charged parts of the molecule (δ-), and the blue-colored electron clouds indicate the positively charged parts (δ+). For alcohol compounds, hydrogen bonds are illustrated with dashed lines (Figure 3).

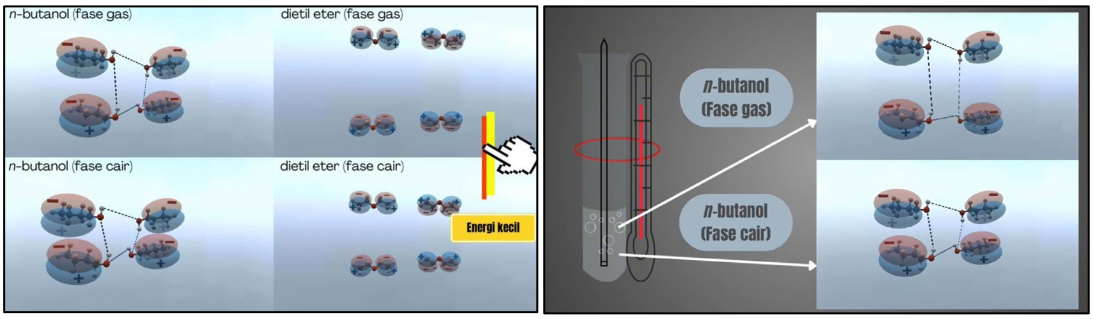

Figure 3. Display of Submicroscopic Level Chemical Representation

The use of dynamic visualization in the form of learning videos facilitates students' understanding of chemical concepts, particularly in the submicroscopic aspect (Rasmawan, 2020). The application of multirepresentation in material presentation is expected to help students grasp abstract concepts, especially regarding intermolecular forces, to prevent misconceptions or misunderstandings of the physical properties of alcohols and ethers, particularly in the subtopic of boiling points. Students can effectively study chemistry when they understand its fundamental concepts, as chemical concepts are interconnected and hierarchical (Habiddin et al., 2023).

Expert Assessment

At this stage, the validation sheets for the instruments were first evaluated by two instrument experts. The video product was assessed by three experts focusing on content, language, and media aspects. The validation results were analyzed using the CVI method. The processed validation data for each aspect yielded an I-CVI value of 1.00, indicating that the video product is classified as highly valid for use as a learning medium. A score range of 0.81–1.00 is categorized as highly valid (Parlaungan et al., 2022).

Content Aspect

The average validation results for the content aspect, evaluated by three validators across three assessment indicators, are shown in Table 3.

Table 3. Validation Results by Content Experts

Indicator	Item	Expert 1	Expert 2	Expert 3	Number of Agreements	I-CVI
1	1	1	1	1	3	3/3 = 1.00
	2	1	1	1	3	3/3 = 1.00
2	3	1	1	1	3	3/3 = 1.00
	4	1	1	1	3	3/3 = 1.00
	5	1	1	1	3	3/3 = 1.00
3	6	1	1	1	3	3/3 = 1.00
	∑	6	6	6	Mean I-CVI	1.00
Proportion of Relevance		1.00	1.00	1.00		

Note:

Indicator 1: Content relevance
Indicator 2: Content accuracy
Indicator 3: Content coherence

The results of the content expert validation included suggestions and feedback to improve and enhance the content of the video. For Indicator 2, the content expert commented that the naming concept in the representation of the general formula for alcohol and ether compounds was inaccurate in the first part of the video. The general formula was corrected to CnH2n+2O.

For this indicator, the content expert commented that the macroscopic representation had not been included in the second part of the video. In the second part of the video, macroscopic representations for each example of alcohol and ether compounds were added, as shown in Figure 5.

Figure 5. Macroscopic Display in the Second Part of the Video After Revision

For Indicator 2, the content expert commented that the differences between the ether molecules were not apparent, specifically the variation in carbon chain length that affects the size of the electron cloud. The animation of the intermolecular structures was revised to be larger, making the carbon chain length differences more visually clear.

For Indicator 3, the content expert commented that there was no scene to explain the subtopics in the second part of the video. Scenes were added to include explanations of the subtopics 'Effect of Carbon Chain Length' and 'Effect of Branching' in the second part of the video. This was done to make it easier to distinguish the presentation of each subtopic.

The validation results from content experts indicate that the material in the learning video product is highly valid, with an average score of 1.00. Learning media is considered effective if it presents content aligned with learning outcomes, accurate material, systematic presentation techniques, and keeps up with scientific developments, thereby providing comprehensive understanding and avoiding misconceptions (Apriliani et al., 2022). Ensuring the accuracy of teaching materials is crucial to prevent the creation of new knowledge that contradicts scientific theories and to deliver correct concepts to students (Salyani et al., 2020).

Language Aspect

The average validation results for the language aspect, evaluated by three validators using four assessment indicators, are presented in Table 4.

Table 4. Validation Results by Language Experts

Indicator	Item	Expert 1	Expert 2	Expert 3	Number of Agreements	I-CVI
1	1	1	1	1	3	3/3 = 1.00
2	2	1	1	1	3	3/3 = 1.00

Indicator	Item	Expert 1	Expert 2	Expert 3	Number of Agreements	I-CVI
3	3	1	1	1	3	3/3 = 1.00
4	4	1	1	1	3	3/3 = 1.00
∑		4	4	4	Mean I-CVI	1.00
Proportion of Relevance		1.00	1.00	1.00		

Note:
Indicator 1: Standardization of language/words used
Indicator 2: Effectiveness of sentences used
Indicator 3: Clarity and completeness of information conveyed through language or sentences
Indicator 4: Ease for students in understanding the language used

The validation results from language experts provided suggestions and feedback to improve the language in the video media that did not fully meet the assessment criteria. For Indicator 2, the language expert commented that the formulation of the learning objectives was less effective in the first part of the video. The learning objectives were revised to be more effective in the first part of the video.

For Indicator 1, the language expert noted that there were still foreign terms used in the practical section of the video, which did not comply with PUEBI (General Guidelines for Indonesian Spelling), specifically the word 'Trial.' The word 'Trial' was replaced with 'Uji coba'.

The validation results from language experts indicate that the language used in the learning video product is highly valid, with an average score of 1.00. The language used in the video product adheres to the rules of the General Guidelines for Indonesian Spelling (PUEBI). The language and sentences used are clear and unambiguous, making it easier for students to understand the material (Paramita et al., 2019).

Media Aspect

The average validation results for the media aspect, evaluated by three validators using three assessment indicators, are presented in Table 5.

Table 3. Validation Results by Media Experts

Indicator	Item	Expert 1	Expert 2	Expert 3	Number of Agreements	I-CVI
1	1	1	1	1	3	3/3 = 1.00
	2	1	1	1	3	3/3 = 1.00
	3	1	1	1	3	3/3 = 1.00
	4	1	1	1	3	3/3 = 1.00
2	5	1	1	1	3	3/3 = 1.00
	6	1	1	1	3	3/3 = 1.00
3	7	1	1	1	3	3/3 = 1.00
	8	1	1	1	3	3/3 = 1.00
∑		8	8	8	Mean I-CVI	1.00
Proportion of Relevance		1.00	1.00	1.00		

Note:
Indicator 1: Appropriateness of layout design, image settings, transitions, and animations in the media display

Indicator 2: Appropriateness of background music and narration in the media display
Indicator 3: Appropriateness of font selection and text color

The validation results from media experts provided suggestions and feedback to improve the format and design elements of the video media that did not fully meet the assessment criteria.

For Indicator 3, the media expert commented that some background colors in the video were not harmonious with the text colors. The background design was adjusted to use more appealing colors that harmonize with the text colors to enhance readability.

For Indicator 1, the media expert noted that the font size and the size of the compound structure images were not proportional in the first part of the video. The font size and structure size were revised to achieve better balance and visual appeal in the first part of the video. Learning media that feature dynamic visuals can provide a rich visual experience, motivate learning, clarify material content, and simplify concepts to make them easier to understand (Afrianti & Zainul, 2021).

For Indicator 2, the media expert pointed out that the dubbing voice volume decreased in some scenes. The voice was re-recorded to achieve better quality dubbing. Speaker voices must be clear, with minimal interference from other noises, and pronunciation should be precise (Yuwono & Antonio, 2015).

The validation results from experts indicate that the media aspect of the learning video product is highly valid, with an average score of 1.00.

Development Testing

The development testing in this study was conducted twice to produce a product with a very high response score for the developed media. The two tests were the limited trial and the main trial. The limited trial was conducted with 9 students from the 2021 cohort of the Chemistry Education Program at FKIP Untan, selected based on their academic performance in the final exam of the Organic Chemistry Monofunctional Compounds course (Table 6). The main trial was conducted with 20 randomly selected students from the 2021 cohort of the Chemistry Education Program at FKIP Untan (Table 7).

Table 6. Results of Student Response Questionnaire in Limited Trial

Aspect	Percentage	Interpretation
Media Design	84,42%	Very Good
Media Usage	86,67%	Very Good
Content Material	84,42%	Very Good
Media Benefits	88,44%	Very Good

Tabel 4. Results of Student Response Questionnaire in Main Trial

Aspect	percentage	Interpretation
Media Design	82,5%	Very Good
Media Usage	87%	Very Good
Content Material	82%	Very Good
Media Benefits	82,8%	Very Good

The results of the student responses in the limited trial showed very positive feedback for each aspect (Table 6). Similarly, the responses in the main trial (Table 7) were also very positive. However, the response percentages decreased slightly from the limited trial to the main trial. This decline was not significant given the number of respondents and did not affect the overall criteria for the responses, which remained favorable.

In the main trial, several comments were provided by students. For the media design aspect, a suggestion was made to animate the teacher figure in the video to make it more engaging. Regarding the media usage aspect, students commented that the video media was very easy to access.

In the content material aspect, students commented that the animation presented in the video media helped them understand the material better. In the benefits aspect, several comments were noted, such as the video media making it easier for students to comprehend the material, increasing their motivation to learn, creating enthusiasm for learning through animations, providing flexibility for use at any time, and supporting independent learning. Thus, this study successfully developed a learning video product that was very well-received by the students.

The advantages of the multirepresentation-based learning video on the physical properties of alcohols and ethers are its clear audio quality and readable text. This learning video is easily accessible to both lecturers and students as it is uploaded on YouTube (Wulandari et al., 2020). The video can be accessed by anyone, anywhere, and can be rewatched multiple times. The links to the videos are as follows:

Part 1: Link

Practical Section: Link

Part 2: Link

CONCLUSION

This study produced a multirepresentation-based learning video on the physical properties of alcohols and ethers that is highly valid and received very positive responses. However, the research was conducted only up to the development testing stage. The dissemination stage in the 4D model needs to be implemented by distributing the product to students to evaluate its effectiveness in addressing conceptual misunderstandings.

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