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Development of Audiovisual Learning Media: Dyeing Spun Silk Yarn Using Ketapang Leaf Extract

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ABSTRACT

This study aimed to develop and validate an instructional video on dyeing spun silk using ketapang leaf extract as an ethnochemistry-based contextual learning medium. The study employed a Design and Development (D&D) approach using the Planning–Production–Evaluation (PPE) model. Validation was conducted by two subject content experts and two media experts. The results showed that the developed video achieved a very high validity level, with an average validity score of 100% for both subject content and media aspects. The reliability analysis also indicated a perfect agreement score (100%). These findings suggest that the instructional video met the criteria for suitability in terms of content accuracy, media design, and technical quality. In addition, the visualization of the dyeing process helped explain abstract chemical concepts, such as the interaction between natural dyes and fibers as well as color transformation processes, thereby supporting students' conceptual understanding. Nevertheless, this study was limited to the expert validation stage and did not examine the effectiveness of the media on students' learning outcomes in broader educational settings. Practically, the video can serve as a digital demonstration tool and contextual learning resource for sustainability-oriented textile chemistry instruction.

1. Introduction

Natural dyes, colorants derived from natural sources such as plants, animals, and minerals, are increasingly gaining attention as textile dyes due to their environmentally friendly characteristics and greater safety for human health compared to synthetic dyes. In recent years, the development of the sustainable textile industry has encouraged the utilization of natural dyes as an alternative that supports the concept of green textile and sustainable production (Dey et al., 2025; Repon et al., 2024). Indonesia possesses vast biodiversity that serves as a rich source of natural dyes, which can be utilized in both traditional and modern textile industries. Various tropical plants in Indonesia are known as sources of eco-friendly

natural pigments for textile and support the sustainability of the textile sector (Miranda et al., 2025; Rahayuningsih & Permana, 2025). It has long been utilized by local communities in the production of various traditional textiles across different regions of Indonesia. Example of the application can be found in traditional textile products from East Kalimantan, such as ulap doyo and Samarinda sarong, which utilize local natural resources for both fibers and dyes in their production processes as part of local wisdom and regional cultural identity (Ditahardiyan et al., 2025).

The dyeing process of yarn or fabric in the textile industry involves chemical interactions between dyes and textile fibers through adsorption mechanisms and molecular diffusion, where dye molecules move from the dye solution into the fiber structure, resulting in a stable color on the textile. The efficiency of dye sorption is influenced by several factors, including fiber type, dye concentration, dyeing temperature, dyeing time, and dye solution pH. These factors affect the strength of interaction between dye molecules and fibers (Zhai et al., 2022). In addition, pretreatments of fibers play a crucial role in enhancing the dyeing process. As the example is mordanting, a process involving the addition of binding agents that form chemical complexes between dye molecules and fibers, thereby improving color fastness against washing and light exposure (Islam et al., 2025). Various studies also indicate that the use of additional treatments such as organic acids or bio-mordants can enhance the dye sorption by strengthening chemical interactions and accelerating the diffusion of dye molecules into the fibers, resulting in more stable colors and improved efficiency in the textile dyeing process (Darmawan et al., 2024; Q. Zheng et al., 2023).

The phenomenon of yarn or fabric dyeing can be utilized as an example of contextual chemistry learning that connects chemical concepts to the real-life. Contextual learning in chemistry aims to relate scientific concepts to students' real-world experiences, thereby improving conceptual understanding and chemical literacy (Munawwarah & Alqadri, 2025). This approach is known as ethnochemistry, which integrates chemistry with local wisdom (Aldiansyah et al., 2023). Through an ethnochemical approach, processes of traditional textile production can be used as learning resources to explain various chemical concepts to students (Yusaerah et al., 2023). For instance, the dyeing process in traditional textile production can be linked to several chemistry topics at both secondary and higher education levels, such as the scientific method in designing dyeing experiments, the concept of adsorption explaining the sorption of dyes by fibers, chemical bonding and intermolecular forces that describe interactions between dye molecules and textile fibers, as well as reaction rate concepts that influence the speed of the dyeing process (Kartikasari et al., 2025; Yusaerah et al., 2023). The integration of these concepts can help students understand chemistry in a more contextual and meaningful way because it is directly connected to the local culture present in their environment (Hendrawani et al., 2024).

Although several studies have explored the natural dyes usage in both the textile industry and science education, research on the development of video-based learning media that links the traditional yarn dyeing process in Samarinda sarongs

with chemical concepts remains limited. Studies that integrate this traditional dyeing practice as a contextual learning resource within audiovisual media are still scarce, indicating that opportunities to develop instructional media connecting local wisdom with chemistry concepts are widely open (Hartati & Siregar, 2024). Video-based learning has also been reported to enhance students' motivation, engagement, and conceptual understanding in chemistry compared to conventional teaching methods (Ayudia & Kamaludin, 2024; Nadia et al., 2025). Furthermore, the development of ethnochemistry-based learning media that incorporates local cultural practices has been shown to bridge cultural experiences with scientific concepts, thereby improving students' creativity and scientific competence (Erna et al., 2026). However, based on preliminary reviews and previous studies, the development of instructional videos specifically highlighting the yarn dyeing process in Samarinda sarong production as a chemistry learning resource is still rarely conducted. Therefore, this study aims to develop and examine the validity of a learning video on spun silk yarn dyeing using Ketapang leaf extract as a contextual ethnochemistry-based chemistry learning medium.

2. Methodology

This study employs a Design and Development (D&D) approach using the Planning, Production, and Evaluation (PPE) model (Richey & Klein, 2008), which aligns with research on the development of instructional media that emphasizes systematic stages in producing a usable product (Gusmida & Islami, 2017).

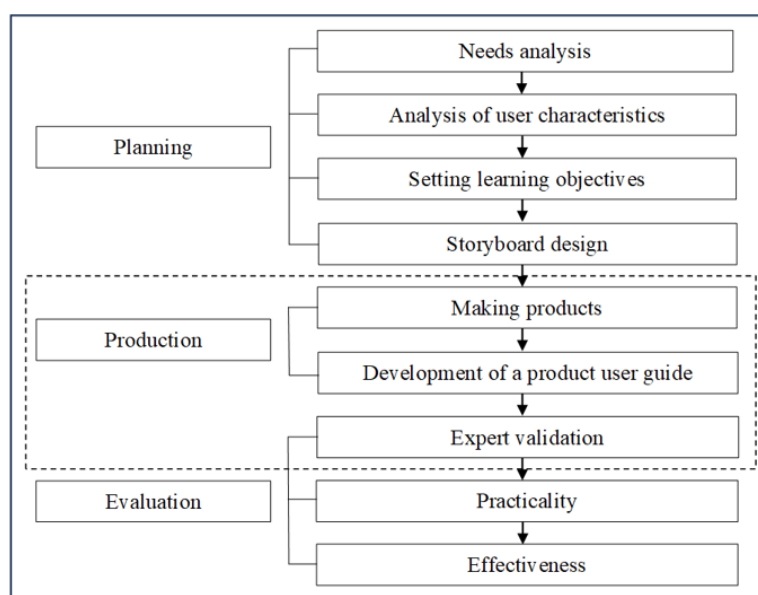


Figure 1. Steps of the PPE Model

In this study, the researchers focused on the product development stage, the creation of product usage guidelines, and expert validation. This is because several of the preceding stages had already been conducted by previous researchers. This approach is also consistent with research on the development of instructional media,

which emphasizes the importance of the expert validation stage in ensuring the product's suitability before it is used in instruction (Khusnunnisa & Andriani, 2025). However, during the stage of developing the product user guide, the researchers did not create a specific guide, considering that the video media developed is intended to be flexible and adaptable to the strategies, approaches, and instructional models implemented by teachers.

Production: Making Products

The video editing process was carried out using FilmoraGo and CapCut software. The production began with the preparation of tools and materials, including both equipment for video production and materials required for the experiments. Once everything was ready, the process continued with the recording of moving images (videos) and static images (photos). The recordings were taken using smartphones, specifically a Xiaomi 15T and an iPhone 11. At this stage, additional moving images and photos were also obtained by downloading relevant visual resources from the internet. Voice-over narration was then recorded using the Xiaomi 15T smartphone. After all voice-over audio was collected, anime-style visual elements of the narrator were generated using Gemini AI, followed by the integration of the voice-over audio with the anime visuals using Pipit AI. The next stage involved selecting and downloading background music from YouTube, as well as creating background visuals using personal photos that were processed through Canva. Once all elements were prepared, compositing was performed by combining visual components (images and videos), backgrounds, special effects, and audio into a single cohesive learning video.

Validity

Validity in this study was assessed using a questionnaire designed to evaluate the validity of an instructional video on the process of dyeing spun silk yarn using natural dyes derived from Ketapang leaf extract, a common approach in instructional media development research (Septiani et al., 2025). The instructional video was validated by two subject matter experts and two media experts, respectively, which is a standard procedure in development research to ensure the appropriateness of content and media quality (Karlina & Iryani, 2025). Aspects evaluated during content validation included message clarity, self-contained nature, user-friendliness, content representativeness, visualization, as well as classical and individual elements. Meanwhile, media validation covers aspects such as user-friendliness, visual quality, audio quality, and video display resolution. The measurement of perceived validity by experts in this study utilized a combination of closed-ended questionnaires (using a Likert scale, Table 1) and open-ended questionnaires, which allowed for a systematic assessment of the media's quality and suitability based on user perceptions (Abdurrahman et al., 2025). The researchers used the experts' notes and suggestions to revise the product. The average validity score was determined by the scores given by the validators based on the criteria presented in Table 1.

Table 1. Likert Scale Assessment

Scale of Assessment	Criteria
4	Very good
3	Good
2	Poor
1	Very poor

The obtained scores were then analyzed by calculating the percentage of validity values to determine the feasibility level of the developed product. The validity percentage was computed using Equation (1). Furthermore, the resulting percentages were interpreted based on the criteria for product validity levels as presented in Table 2.

$$\text{Percentage of Validity (PV, \%)} = \frac{\text{Obtained score}}{\text{Maximum ideal score}} \times 100\% \quad (1)$$

Table 2. Product Validity Criteria

Percentage of Validity (PV, %)	Criteria
$85 < PV \leq 100$	Very valid
$70 < PV \leq 85$	Valid
$55 < PV \leq 70$	Fairly valid
$40 < PV \leq 55$	Less valid
$25 < PV \leq 40$	Not valid

3. Results and Discussion

Production

The learning videos on the dyeing of spun silk yarn using natural dyes from Ketapang leaf extract have been successfully developed. The product consists of two videos, where video 1 covers the introduction of spun silk yarn, the preparation of natural dye from Ketapang leaf extract, and the treatment of spun silk yarn and Ketapang leaf extract using hydrochloric acid (Table 3). Meanwhile, video 2 focuses on the dyeing process of spun silk yarn using the natural dye derived from Ketapang leaf extract (Table 4). The video editing process was carried out through a systematic sequence of stages, including the preparation of tools and materials, the recording and downloading of moving images (videos) and static images (photos), the recording of voice-over narration, the creation of anime-style visual elements and their integration with voice-over audio, the selection and downloading of background music, the development of background visuals, and compositing, which involves combining visual elements, backgrounds, special effects, and audio into a cohesive and complete learning video.

Based on Table 3 and Table 4, the structure of the instructional videos demonstrates a consistent and complementary pattern in supporting effective learning processes, where the narrator introduction is placed at the beginning to establish initial connection and encourage audience engagement through social cues such as direct

communication, which has been shown to enhance attention and learning effectiveness (Adler et al., 2025; Pi et al., 2026), followed by an introductory section presenting a glimpse of the dyeing process that functions as a visual stimulus to capture attention and foster learning motivation since visual elements such as motion and process representation can guide learners' cognitive focus (Adler et al., 2025; Navarrete et al., 2025). Then is introduction stage, which includes learning objectives and topics, provides clarity of instructional direction while supporting the formation of an initial cognitive framework in which objectives function as a reference for systematically organizing information (Brame, 2016; Ikram et al., 2024; Muñoz & Letouze, 2022; Pierce, 2021). While in the main content section, Table 3 presents a step-by-step delivery ranging from concept introduction, tools and materials, to preparation and treatment processes reflecting a demonstrative-procedural approach that supports conceptual understanding and practical skills through direct observation (Hamzah et al., 2025; Ott et al., 2024).

Table 4 extends this approach by incorporating digital analysis using ImageJ to integrate procedural learning with analytical skills and enhance critical thinking abilities (Juldial & Haryadi, 2024; Kusuma et al., 2025). Part of results and discussion is strengthening learners' ability to interpret observed phenomena through deeper information processing (Schindler et al., 2021). At the end of both videos include closing remarks and credits. The closing remarks and credits play as reinforcement of learning content and appreciation for contributors while supporting knowledge consolidation (Brame, 2021; Koumi, 2020). Overall, this structure aligns with multimedia learning principles emphasizing structured information organization and integration of visuals, narration, and demonstration to improve engagement and learning outcomes as stated by Mayer (2021) and Fiorella & Mayer (2018), and supported by findings on interactive technology's role in enhancing understanding, engagement, and digital literacy (Lai & Bower, 2020; Zhang et al., 2022).

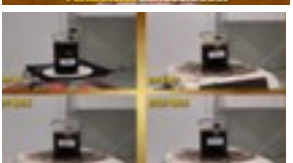
The production stage represents the implementation of the design developed during the planning phase. The presentation of material is delivered in a step-by-step manner to support cognitive load management and facilitate more effective information processing (van Merriënboer & Kirschner, 2018). Special attention is given to visual and audio quality, as image clarity and narration synchronization influence learners' perceptions of instructional quality and their understanding of the subject content (Fiorella & Mayer, 2018). Visual representations of the extraction process, yarn treatment, and variations in dyeing techniques enable students to conduct comparative observations of the color of dyed yarn. The presentation of practical procedures through digital media has also been reported to strengthen procedural understanding and enhance learning engagement (Utomo et al., 2018). The consistency of visual design with natural tones is chosen to reinforce the thematic identity of the media while minimizing distractions, which in digital learning environments contributes to improved focus and a better learning experience (Bawa, 2016).

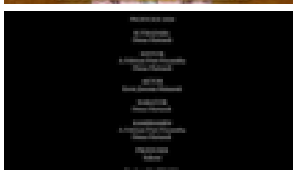
Table 3. Display and Description of Video 1

Part	Picture	Description
Introduction		Narrator introduction
Opening		Preview of the spun silk yarn dyeing process using Ketapang leaf extract
Preface		Presentation of learning objectives and learning topics
Introduction to spun silk yarn		Introduction to spun silk yarn Applications of spun silk yarn Dyeing process of spun silk yarn Dangers of synthetic dyes and their alternatives (natural dyes)
Tools, chemicals and sample		Tools and materials used in the dyeing process
Production of natural dye solution		Extraction process of Ketapang leaves to produce natural dye "Terapang"
Treatment of yarn and dye solutions		Treatment of yarn and dye solution
Closing		Conclusion

Part	Picture	Description
Credits		Credits listing cast, crew, and producer

Table 4. Display and Description of video 2

Part	Picture	Description
Introduction		Narrator introduction
Opening		Preview of the spun silk yarn dyeing process using Ketapang leaf extract
Preface		Presentation of learning objectives and learning topics
Dyeing process		Dyeing process with various treatments
ImageJ application	 	Information on how to use the ImageJ application
Results and discussion	 	Results and discussion

Part	Picture	Description
Closing		Conclusion
Credits		
		Credits listing cast, crew, and producer

Evaluation

The validity of the initial learning videos from the content aspect is presented in Table 5. Based on Table 5, it can be seen that the level of validity and reliability of the subject content in both Video 1 and Video 2 is generally categorized as very high. All assessed aspects, namely message clarity, self-contained content, user-friendliness, content representativeness, as well as classroom and individual suitability, obtained a validity score of 100% with the “very valid” category and a reliability score of 100% with the “reliable” category for both videos. This indicates that the content presented has met the standards of content feasibility, consistency, and ease of use in an optimal manner. Meanwhile, the visualization aspect obtained a validity score of 88% with the “very valid” category and a reliability score of 86% with the “reliable” category, indicating that although it is already in a very good category, improvement was needed, particularly in visual presentation. Overall, these findings confirm that both learning videos have very good quality and are suitable for use as learning media, as they meet high standards of validity and reliability in accordance with development research criteria.

Table 5. Content's Validity and Reliability of Videos 1 & 2 Before Revision (Initial)

Aspect	Video 1				Video 2			
	Validity		Reliability		Validity		Reliability	
	%	Criteria	%	Criteria	%	Criteria	%	Criteria
Message Clarity	100	Very valid	100	Reliable	100	Very valid	100	Reliable
Self-contained	100	Very valid	100	Reliable	100	Very valid	100	Reliable
User Friendly	100	Very valid	100	Reliable	100	Very valid	100	Reliable
Content Representativeness	100	Very valid	100	Reliable	100	Very valid	100	Reliable
Visualization	88	Very valid	86	Reliable	88	Very valid	86	Reliable
Classical and Individual	100	Very valid	100	Reliable	100	Very valid	100	Reliable

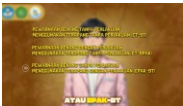
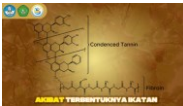
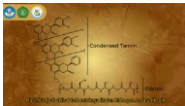
Based on Tables 6 and 7, the revised videos show a significant improvement in presentation quality. Before revision, the videos still had several shortcomings, such as poorly organized subtitles. It could hinder information processing and increase

cognitive load (Van Hoecke, 2023). In addition, delivering learning objectives that not clear enough resulted a lack of direction in the learning process. A clear objective plays an important role in helping learners organize information (Ikram et al., 2024). The use of less appropriate wording also reduced the clarity of the messages delivered to students (Torgersen & Boe, 2021). It was found in the initial videos and have been revised. Furthermore, the video duration that was not yet optimal potentially reduced students' attention and engagement in learning (Y. Zheng et al., 2022). After revision, improvements were observed, particularly in the more structured subtitles that helped enhance understanding (Persson & Wattengård, 2019). The addition of learning objectives at the beginning of the video provided clearer direction for students in following the subject content (Liu, 2024). Refinement of sentence structures into more communicative forms also improved the effectiveness of information delivery (Torgersen & Boe, 2021). Overall, these improvements indicate that more structured and systematic video presentation can enhance learning effectiveness (Malakul & Park, 2023). The video duration was also adjusted, resulting in Video 1 with a duration of 8 minutes 6 seconds and Video 2 with a duration of 8 minutes. Both videos fall within the optimal range for educational video duration (approximately 8-10 minutes), which has been shown to improve students' attention and learning engagement (Brame, 2017; Manasrah & Masoud, 2021).

Table 6. Revision of Learning Video 1

Video before revision		Video after revision	
Picture	Description	Picture	Description
	Subtitles were not well organized		Subtitles have been properly arranged
	Learning objectives were not included at the beginning of the video		Learning objectives are included and clearly stated
	There was an opening sentence that did not function optimally as a learning stimulus		The sentence "Yuk kita mulai proses pembuatan terapangnya" has been added
	The original sentence "Ingat ya, jangan lupa untuk menyaring larutan, agar terapang yang dihasilkan bebas dari sisa bahan."		The sentence has been revised to "Ingat ya, jangan lupa untuk menyaring larutan agar terapang yang dihasilkan bebas dari residu."
-	Video duration was less than 8 minutes	-	Video duration has been adjusted according to the revision standards

Table 7. Revision of learning video 2

Video before revision		Video after revision	
Picture	Description	Picture	Description
	Subtitles were not well organized		Subtitles have been properly arranged
	Subtitle appears in this scene		Subtitle has been removed for this scene
	The original text is "condensed tannin"		The text has been corrected to "condensed tannin"
-	Video duration was less than 8 minutes	-	Video duration has been adjusted according to the revision standards

The results of the content validation for Video 1 and Video 2 after revision are presented in Table 8. Based on Table 8, it can be observed that the level of validity and reliability of the subject content in both videos shows a highly optimal improvement compared to the previous stage. All assessed aspects, including message clarity, self-contained content, user-friendliness, content representativeness, visualization, as well as classroom and individual suitability, each obtained a validity score of 100% with the "very valid" category and a reliability score of 100% with the "reliable" category for both videos. These findings indicate that the developed learning subject contents have fully met the standards of content feasibility, presentation quality, and consistency without any significant weaknesses across all evaluation aspects. In particular, the improvement in the visualization aspect, which was previously not optimal, reflects an enhancement in visual quality that contributes to more effective subject content delivery. It can be concluded that the revised learning videos possess excellent quality and are highly suitable for use as instructional media in terms of both validity and reliability, in accordance with development research criteria.

Table 8. Content's validity and reliability of video 1 & 2 after revision

Aspect	Video 1		Video 2	
	Validity		Reliability	
	%	Criteria	%	Criteria
Message Clarity	100	Very valid	100	Reliable
Self-contained	100	Very valid	100	Reliable
User Friendly	100	Very valid	100	Reliable
Content Representativeness	100	Very valid	100	Reliable
Visualization	100	Very valid	100	Reliable
Classical and Individual	100	Very valid	100	Reliable

The validity of the initial learning videos from the media aspect is presented in Table 9. Based on Table 9, it can be seen that the level of validity and reliability of Video 1 and Video 2 at the initial stage is generally categorized as very good. The

user-friendly aspect, as well as the display and video resolution for both videos, obtained a validity score of 100% with the “very valid” category and a reliability score of 100% with the “reliable” category, indicating that, in terms of ease of use and display quality, the product has met optimal feasibility standards. Meanwhile, the visual quality and audio quality aspects also showed high results, with validity scores of 98% and 97% for Video 1 and 97% for Video 2, all of which fall under the “very valid” category, with reliability levels ranging from 97% to 100% (reliable). Overall, these findings confirm that both learning videos have very good quality and are suitable for use as instructional media, as they meet high standards of validity and reliability in accordance with development research criteria. However, there is still room for improvement, particularly in enhancing image clarity and audio quality.

Table 9. Media's validity and reliability of video 1 & 2 before revision (initial)

Aspect	Video 1				Video 2			
	Validity		Reliability		Validity		Reliability	
	%	Criteria	%	Criteria	%	Criteria	%	Criteria
User friendly	100	Very valid	100	Reliable	100	Very valid	100	Reliable
Visual quality	98	Very valid	100	Reliable	97	Very valid	97	Reliable
Audio quality	97	Very valid	100	Reliable	97	Very valid	97	Reliable
Display and video resolution	100	Very valid	100	Reliable	100	Very valid	100	Reliable

The results of the media validation for revised video 1 and video 2 are presented in Table 10. Based on Table 10, the results of validity and reliability testing of both videos show very optimal outcomes across all assessed aspects. Each aspect, including user-friendliness, visual quality, audio quality, as well as display and audio resolution, obtained a validity score of 100% with the “very valid” category and a reliability score of 100% with the “reliable” category. These findings indicate that the developed media have met substantial feasibility standards in terms of both content and technical quality, and demonstrate a very high level of consistency in measurement. Therefore, both learning videos can be considered highly suitable for use in the learning process, as they are able to provide a clear, engaging, and easily understandable learning experience for users.

Table 10. Media's validity and reliability of video 1 & 2 after revision

Aspect	Video 1				Video 2			
	Validity		Reliability		Validity		Reliability	
	%	Criteria	%	Criteria	%	Criteria	%	Criteria
User friendly	100	Very valid	100	Reliable	100	Very valid	100	Reliable
Visual quality	100	Very valid	100	Reliable	100	Very valid	100	Reliable
Audio quality	100	Very valid	100	Reliable	100	Very valid	100	Reliable
Display and video resolution	100	Very valid	100	Reliable	100	Very valid	100	Reliable

Evaluation was conducted through validity and reliability testing by subject matter experts and media experts. The validation results showed a “very valid” category across all aspects after two rounds of assessment. The improvement in scores in the second stage indicates that the revision process was carried out systematically based

on the validators' feedback. Expert judgment-based evaluation is a commonly used approach in development research to ensure the alignment between the construct being measured and the representation of its indicators (Zamanzadeh et al., 2015). The consistency of reliability values reflects the stability of assessments among validators and strengthens the credibility of the evaluation results (Taber, 2018). This iterative revision process reflects the cyclical nature of instructional media development, where evaluation does not merely function as a final stage but also serves as a continuous refinement mechanism (Richey & Klein, 2014).

The findings of this study indicate that learning videos systematically designed using the PPE model are able to produce media that is valid, reliable, and relevant to the needs of chemistry learning. The integration of multimedia learning principles with a sustainability-based approach expands the practice of media development within the context of environmental education. The use of natural dyes as part of the learning material is also in line with the trend of sustainable textile development, which emphasizes the reduction of environmental impacts (Yusuf et al., 2017). Thus, the development of this learning video not only contributes to pedagogical innovation but also supports the strengthening of environmental literacy in chemistry and textile education.

In addition, this learning video helps visualize abstract chemical concepts. Visualization of the production of spun silk yarn (Figure 2.a), the production of natural dye from Ketapang leaves extract (Figure 2.b), the treatment of natural dye and spun silk yarn (Figure 2.c), the dyeing process of spun silk yarn by using natural dye (Figure 2.d), the sorption of natural dye by spun silk yarn (Figure 2.e), and the effect of treatment on the resulted color changes (Figure 2.f) allows students to directly observe processes and chemical phenomena such as the interaction between natural dye molecules and fibroin in spun silk yarn fibers, as well as the effect of chemical treatment on the intensity and stability of the resulting color. This representation is important because the concepts of dye fiber interactions and color change mechanisms are generally difficult to grasp when conveyed solely through verbal explanation. In line with this, the integration of dynamic visuals and verbal narration enables simultaneous information processing through visual and auditory channels, thereby aiding the development of better conceptual understanding (Fiorella & Mayer, 2018; Mayer, 2021). Realistic visualizations of color changes also serve as a bridge between observable macroscopic phenomena and microscopic concepts such as molecular interactions, thereby strengthening students' mental models in understanding chemical processes. This, along with the high validity scores in the content representation and visualization aspects, not only indicates the technical quality of the media but also reflects the alignment of audiovisual media characteristics with the needs of chemistry learning, which emphasizes the visualization of processes and the transformation of substances. To provide a clearer illustration of these abstract and process-oriented concepts, the following figures present key stages of the extraction process, visual representations of chemical interactions, and the resulting color variations observed in spun silk yarn.

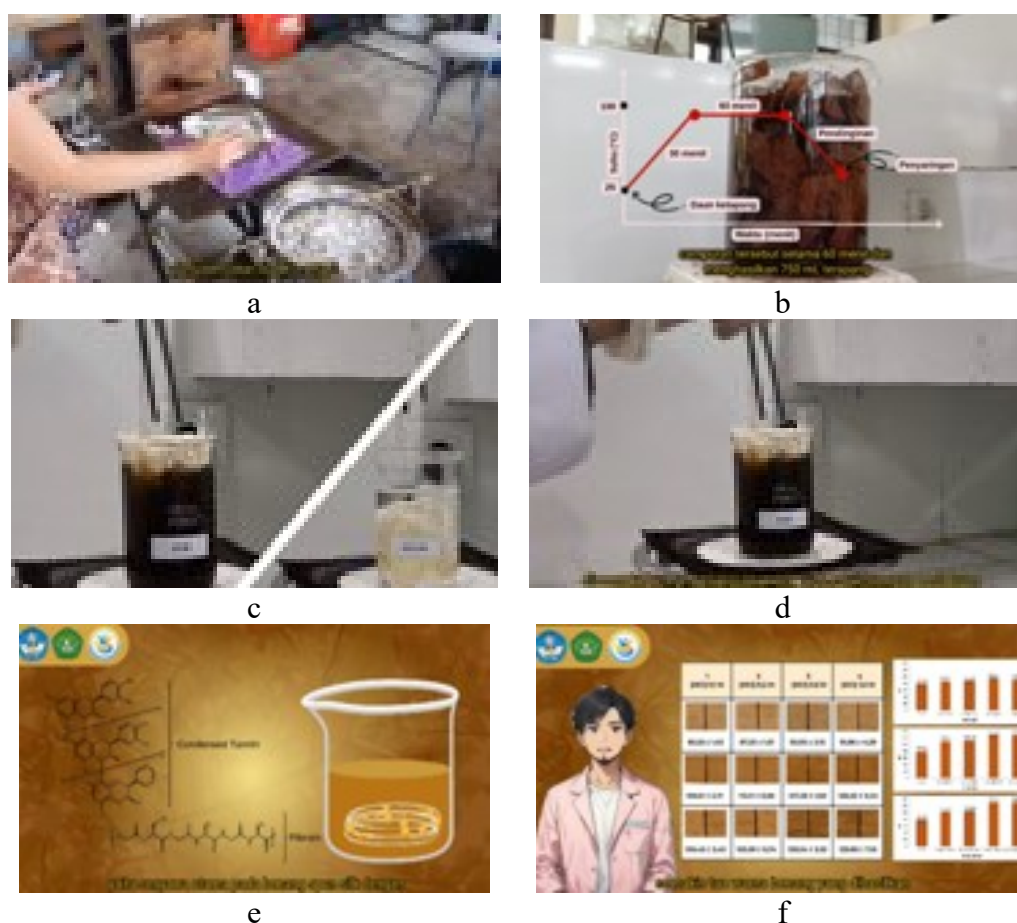


Figure 2. Visualizations of process and chemical concepts of dyeing spun silk yarn

Although the validation results indicate that the categories are highly valid and reliable, this study still has limitations. Testing of the instructional media was limited to the expert judgment phase and has not yet included large-scale empirical testing with students to quantitatively measure its impact on learning outcomes, conceptual understanding, or practical skills. Furthermore, the development of the media remains focused on a single specific topic, so generalizing it to other textile chemistry subjects requires further study. The practical implications of this study suggest that instructional videos can be utilized as an alternative demonstration medium, particularly for topics involving laboratory procedures that are difficult to conduct directly in the classroom. Chemistry teachers can integrate this medium into blended learning or flipped classroom settings, allowing face-to-face time to be focused on discussion, analysis, and concept reinforcement. Furthermore, the context of using natural dyes can also support sustainability-based learning and enhance students' environmental literacy.

4. Conclusion

This study produced video-based learning media with very high levels of validity and reliability in terms of both content and media aspects. These findings indicate that videos are capable of presenting subject content clearly, systematically, and in accordance with the characteristics of chemistry learning. The primary advantage of this medium lies in its ability to concretely visualize the dyeing process, thereby helping students understand the connection between chemical concepts and practical applications in a more meaningful way. In practice, this medium can be utilized as a digital demonstration tool, project-based teaching material, or a self-learning resource in blended learning for sustainability-based textile chemistry.

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