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Development of a Powtoon-Based Learning Video Integrated with Nature of Science (NOS) on Cell Material

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Abstract: Integrating NOS into digital media is important for understanding abstract biological concepts and promoting scientific literacy. This study aimed to develop a Powtoon-based learning video integrated with the Nature of Science (NOS) on cell material for eighth-grade junior high school students and to determine the validity of the developed product. Previous research has developed Powtoon-based learning videos, but the integration of NOS into cell-related learning media remains limited. Therefore, this study offers a novel approach by developing NOS-integrated Powtoon videos to aid understanding of abstract cell concepts. This study employed a Research and Development (R&D) approach adapted from the ADDIE model, focusing on the analysis, design, and development stages. In the analysis stage, data were collected through teacher interviews, preliminary questionnaires, a literature review, and curriculum and content analyses using checklist sheets. Students' needs and characteristics were also identified through questionnaires. During development, the product was evaluated through expert validation by material and media experts using Likert-scale instruments. The data were analyzed quantitatively to determine validity levels and qualitatively based on feedback and suggestions from validators. Quantitative data were analyzed using percentage feasibility analysis based on expert validation scores, while qualitative data were analyzed descriptively through validator input and suggestions. Results showed that the developed learning video achieved material validity of 92.96% and media validity of 95.80%, both of which were categorized as very valid. The novelty of this study lies in integrating the NOS approach into a Powtoon-based animated video to support students' understanding of abstract biological concepts. Developed media can help teachers present cell material more visually and support students' understanding of microscopic concepts and scientific processes. In conclusion, the developed media is considered valid and feasible at the development stage. Further research is recommended to examine its effectiveness in classroom implementation.

Keywords: Cell Material; Learning Video; Nature of Science; Powtoon.

Introduction

The ongoing development of science and technology demands that science learning objectives evolve as well. Science learning today is not sufficient to simply convey scientific concepts; it must also encourage the development of science process skills and enhance various aspects of learning, so that students can understand the material holistically and meaningfully [1]. As a subject, science has unique characteristics encompassing three main elements: products, processes, and scientific attitudes. Science as a product encompasses facts, concepts, principles, and theories that are constantly evolving in response to new discoveries. The primary goal of science learning is to develop students with scientific literacy. Scientifically literate individuals not only understand scientific concepts but also possess a strong understanding of the nature of science (NOS) [2]

The nature of science (NOS) refers to an understanding of how science is developed through observation, experimentation, and reasoning. NOS emphasizes that science is dynamic, subject to change in light of new discoveries, and influenced by values and sociocultural contexts. Understanding NOS helps students think critically and view science as a process rather than a collection of facts [3]. Given the importance of students' understanding of the nature of science, science education resources should not only convey content but also reflect NOS principles.

However, based on a review of the teaching materials used by teachers in schools, the content still focuses on conveying scientific concepts in a factual manner without emphasizing how this knowledge is developed or validated. This indicates that students' understanding of the nature of science has not been explicitly developed through the available teaching materials. One effort to improve students' understanding of cells is to adopt the NOS approach in learning media. This aligns with the research findings of Utama et al., which showed that NOS-integrated videos have a positive impact on science learning outcomes [4]

This approach not only conveys content but also emphasizes scientific thinking, observation, and social interaction in science, helping students develop a deeper understanding of concepts. In this context, learning media play an important role in translating scientific approaches

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into forms that are easier for students to understand and more engaging [5]. Therefore, educational innovation through appropriate learning media is increasingly important for supporting science learning amid current technological developments.

Technological developments have transformed various sectors, including education, requiring learning processes to adapt to technological advancements and integrate technology into classroom practices [6], [7]. These developments have influenced educational tools, methods, and learning media, encouraging teachers to adopt more innovative approaches to support learning processes [8]. Therefore, integrating technology into education has become increasingly important to create learning experiences that align with current educational demands and student needs [9].

Technological advancements have encouraged education to continuously adapt and develop learning approaches that align with current educational needs. In response to these developments, the Independent Curriculum provides teachers with opportunities to design learning experiences that accommodate students' characteristics and technological changes [10], [11]. In this context, teachers play an important role in selecting appropriate learning media to improve learning quality, increase student motivation, and support learning outcomes [12], [13].

Teachers can use audiovisual media, such as animated learning videos, because they combine visual and auditory elements that support students' attention and understanding during learning. Learning media can also be adapted to various subjects, including science. In science learning, visualization plays an important role in helping students understand microscopic and abstract concepts, such as cell organelle structures and functions, which are often difficult to observe directly [14]. Therefore, visual learning media become important tools for supporting students' conceptual understanding of complex biological topics.

Based on interviews with teachers, the media currently used include PowerPoint presentations, YouTube videos, Wordwall, Quizizz, and homemade media such as card-finder maps. Among the various learning media, YouTube videos are frequently used in science learning. However, existing videos still have several limitations, including overly dense presentation of material and English-only narration without subtitles.

Researchers conducted interviews with teachers to obtain information regarding learning difficulties in the cell topic. The interviews indicated that the topic of cells as the building blocks of life was difficult for students to understand. Furthermore, researchers also distributed questionnaires to eighth-grade students to identify material that teachers found difficult. This was evident in the interview results. Based on the student questionnaire results, approximately 75% of students reported that cells as the building blocks of life was the most difficult topic to understand. This finding was supported by student learning outcomes, which showed that 68.18% of students had not yet achieved mastery in the cell topic. Some students stated that cell material was difficult to observe directly and that many scientific terms were hard to understand.

To support more engaging and understandable science learning, learning media that integrate visual and auditory elements are considered beneficial because they optimize multiple sensory channels simultaneously [15], [16]. Audiovisual media are particularly suitable for science learning because they help students understand abstract and difficult-to-visualize concepts [14]. Previous studies also indicate that video media can effectively attract students' attention and support learning processes [17].

In the context of learning, attention and its influence on students' emotions and psychology are crucial, as this will facilitate their understanding of the subject matter. One type of audiovisual media expected to be effective in the learning process is animated video [15]. Animated video media has proven effective in strengthening students' understanding, especially for complex and difficult-to-understand concepts [14], [18], [19].

To create animated video media, various tools can be used, including web-based animation platforms such as Powtoon. Various studies have shown that Powtoon-based animations are effective at increasing student enthusiasm and interest in learning. Furthermore, the use of animated videos as a learning medium is seen as capable of providing a fun and meaningful learning experience, aligning with the goals of the Independent Curriculum to create quality, student-centered learning [20].

This also aligns with research by Suyanti et al., which states that engaging learning activities are reflected in the use of Powtoon media, creating a fun learning atmosphere, enabling students to focus more on the material presented, and encouraging them to actively express new ideas [21].

Several previous studies have developed Powtoon media for science learning and demonstrated improvements in student motivation and learning outcomes [22], [23], [24], [25]. However, most studies still focus on the visualization aspect of the material without explicitly integrating the Nature of Science (NOS) into the learning media, particularly for cell material at the junior high school level. Furthermore, media development that combines Powtoon animation with NOS aspects to aid understanding of abstract cell concepts is still limited.

Although Powtoon-based learning media have been widely developed in science education, studies that explicitly integrate the Nature of Science (NOS) into Powtoon-based media to support students' understanding of microscopic concepts, particularly cell materials at the junior high school level, remain limited. Therefore, this study develops a Powtoon-based learning video integrated with NOS for Grade VIII cell material, with expert validation during development.

Based on these problems, the research questions are: (1) How can we develop a Powtoon-based learning video integrated with NOS for eighth-grade cell material? (2) What is the validity of the developed media based on assessments by subject matter experts and media experts? In response, the researchers developed an NOS-based Powtoon learning video for eighth-grade cell material, limited to expert validation.

Research Methods

This study employed a Research and Development (R&D) approach using the ADDIE model, comprising five stages: analysis, design, development, implementation, and evaluation. However, this research was limited to three stages, namely analysis, design, and development. The

implementation and evaluation stages were not conducted because the study focused on product development and preliminary validity evaluation prior to classroom implementation.

In the analysis stage, data were collected through teacher interviews, pre-research questionnaires, a literature review, and curriculum and material analysis using checklist sheets. This stage aimed to identify learning problems, analyze the suitability of the material with the curriculum, and determine students' needs and characteristics. Students' needs and characteristics were identified through questionnaires administered to Grade VIII students, while curriculum and material analyses were conducted using structured checklist instruments. Student involvement in this study was limited to the needs analysis stage, while product evaluation focused solely on expert validation.

In the design stage, the initial learning video was developed by formulating learning objectives, preparing storyboards, selecting appropriate media elements, and organizing the content structure in line with the Nature of Science (NOS) approach. The video design also included visual planning, narration preparation, animation selection, and integration of NOS aspects into learning activities.

During development, the product was evaluated through expert validation by two material experts and two media experts using Likert-scale instruments. The subject-matter validators were biology education experts with expertise in science content and instructional development, while the media validators were educators experienced in the design of digital learning media. Expert validation involving a limited number of validators is commonly applied during preliminary product development to obtain initial feedback before broader implementation. The collected data included both quantitative and qualitative components. Quantitative data were obtained from validation results and analyzed using percentage techniques with the following formula:

$$K = \frac{F}{N.I.R} x\ 100\%$$

Where *K* represents the feasibility percentage, *F* is the total score across all responses, N is the maximum score on the scale, *I* is the number of items, and *R* is the number of respondents. The results were then interpreted using validity criteria to assess the feasibility of the developed product, as shown in Table 1.

Table 1. Validity Criteria [26]

No.	Percentage (%)	Criteria
1	75-100	Very Valid
2	50-74	Valid
3	25-49	Invalid
4	0-24	Very Invalid

A product is declared eligible if it meets the minimum validity score and a minimum valid category. Meanwhile, qualitative data, in the form of suggestions and feedback from validators, were analyzed descriptively to improve the product's quality. Validator comments and suggestions were used as the basis for revising and improving the developed product.

Results and Discussion

Analysis Stage

Curriculum Analysis

Based on Table 2, the results of the curriculum analysis indicate that all analyzed aspects, namely competency, content, variation, and IKTP, each obtained a percentage of 100%. This indicates that all indicators in each aspect have been met according to the established criteria. Thus, it can be concluded that the developed cell material aligns with the curriculum and meets all analytical indicators, making it suitable as a basis for developing learning media. Curriculum analysis is an important step in media development to ensure that the products developed align with the curriculum [27].

Table 2. Curriculum Analysis Results

No	Aspects	Number of Indicators	Indicators Met	Score (%)
1	Competencies	1	1	100
2	Contents	1	1	100
3	Variations	3	3	100
4	IKTP	3	3	100
	Total	8	8	100

Material Analysis

Based on Table 3, the material assessment results indicate a suitability level of 85.7%. In general, the material covers core content relevant to the learning outcomes (CP), including the definition of cells, cell structure, and the functions of cell organelles. In terms of accuracy, the material draws on relevant reference sources, ensuring that the concepts presented align with biological studies. The cell material in the NOS-based Powtoon learning video is systematically structured according to the Grade VIII science teacher's guide and aligned with the learning outcomes and objectives outlined in the applicable curriculum.

Table 3. Material Analysis Results

No	Aspects	Indicator quality	Indicator Fulfilled	Score (%)
1	Suitability and Depth of Material with CP, TP, and IKTP	4	4	100
2	Material Accuracy	2	2	100
3	Relevance of the NOS Approach to the Material	1	0	0
	Total	7	6	85.7

Design Stage

Initial Design of NOS-Based Powtoon Video

Several NOS-based Powtoon video design presentations are shown in Figure 1**.** Figure 1 shows several initial designs for the media being developed. This design

stage is important for providing an initial overview of the product to be developed [28].

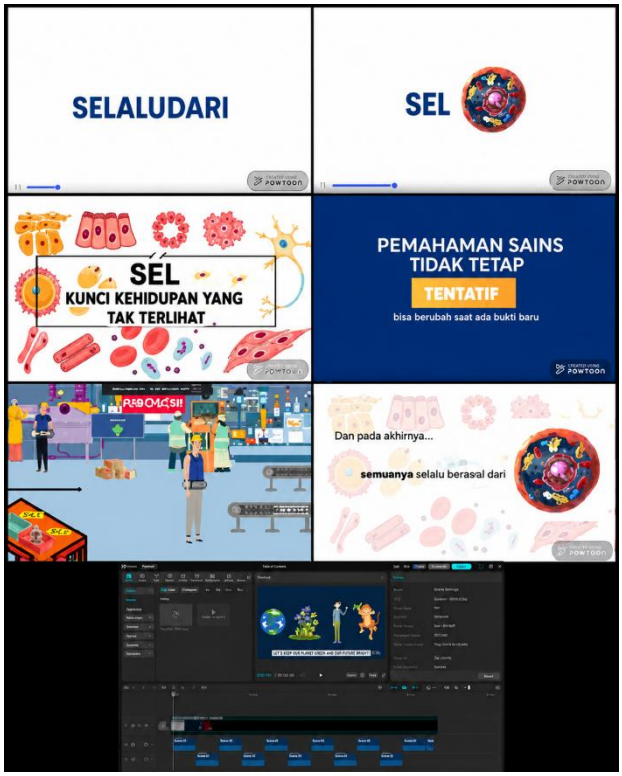

Figure 1. Selected visual representations of the product in the design phase**.**

Development Stage

Based on the results of the first stage of material validation, presented in Table 4, an average percentage of 68.2% was obtained, categorized as valid. These results indicate that the material in the Powtoon-based learning videos met the eligibility criteria, but still requires improvement and refinement before being used in the next stage. Looking at each aspect, the Presentation aspect achieved the highest average percentage of 75%, categorized as very valid, indicating that the flow of material delivery, clarity of information, and systematic presentation were good.

The Language and Visual aspects achieved an average percentage of 72.87%, categorized as valid, indicating that the use of language and visual presentation was clear and engaging. Meanwhile, the Content aspect achieved an average percentage of 65.62%, categorized as valid, indicating that the material's alignment with the Learning Outcomes and Learning Objectives still needs improvement. The content integration aspect achieved the lowest average percentage (59.37%), which is categorized as valid, indicating that integrating Nature of Science (NOS) content into the material still needs further development. Based on the validator's suggestions, revisions were made before proceeding to the second validation stage.

Based on the results of the first stage of material validation, the researcher revised the material in response to the suggestions and input from the two validators to improve the quality of the content, presentation, language, and visuals, and to strengthen the NOS content. Several revisions were made based on suggestions from material experts following the first-stage validation process. These revisions aimed to improve content quality and strengthen the integration of Nature of Science (NOS) components within the developed learning media. The revisions implemented are presented in Table 5. Basically, input from validators is important qualitative data for development, used to improve the quality of the media being developed [28]. After the revisions, the second stage of material validation was conducted. The results of the second-stage material validation by the two validators are presented in Table 6.

Table 4. Results of Phase I Material Validation with the Two Validators

No	Aspects	Score (%)		Average (%)	Interpretation
		Validator I	Validator II		
1	Contents	56,25	75	65.62	Valid
2	Presentation	75	75	75	Very valid
3	Language & Visuals	65,75	80	72.87	Valid
4	Content Integration	50	68,75	59.37	Valid
	Average	61.75	74.68	68.2	Valid

Table 5. Revisions Based on Material Expert Validation

No.	Validator Feedback	Revision Implemented
1	Learning objectives were not explicitly presented in the opening section	Learning objectives were added to improve instructional clarity
2	NOS aspects were not fully integrated into the material	Additional NOS components were incorporated into learning scenes
3	Misconceptions regarding the nucleolus explanation and the protein synthesis process were identified	Scientific explanations were revised, and additional visualization of mRNA processes was provided
4	Developer identity and contributor information were missing	Developer profile and contributor information were added
5	Curriculum references require updating	Learning objectives and curriculum references were revised according to the latest curriculum standards
6	Several scientific explanations required reinforcement	Additional scenes and explanatory animations were included to strengthen conceptual understanding

Table 6. Results of Material Validation Stage II with Both Validators.

No	Aspects	Score (%)		Average (%)	Interpretation
		Validator 1	Validator 2		
1	Contents	100	75	87.5	Very valid
2	Presentation	100	93.75	96.87	Very valid
3	Language & Visuals	100	100	100	Very valid
4	Content Integration	100	75	87.5	Very valid
	Average	100	85.93	92.96	Very valid

Table 7. Results of Media Validation Stage I with Both Validators.

No	Aspects	Score (%)		Average (%)	Interpretation
		Validator I	Validator II		
1	Contents	56.25	75	65.62	Valid
2	Presentation	70	80	75	Very valid
3	Language	100	91.6	95.8	Very Valid
	Average	75.41	82.2	78.80	Very Valid

Based on the results of the second phase of material validation, presented in the table, an average percentage of 92.96% was obtained, categorized as very valid. These results indicate that the Powtoon-based learning video material has undergone significant improvements in quality following revisions informed by the validators' suggestions.

All assessment aspects, Content, Presentation, Language, and Visuals, and Content Integration, achieved an average percentage in the very valid category, with the Language and Visuals aspect achieving the highest percentage of 100%. This indicates that the material was presented in clear language, with attractive visuals, and with optimal integration of NOS content. The researchers conducted two validation sessions with material experts and received several suggestions for improvement, as shown in Table 7.

Based on the results of the media validation stage, I, by the two validators presented in the table, an average percentage of 78.80% was obtained with a very valid category. These results indicate that the Powtoon-based learning video media developed meets the eligibility criteria but still requires improvement and refinement in several aspects before being used in the next stage. When reviewed across all aspects, the Language aspect had the highest average percentage, 95.8%, in the very valid category, indicating that the use of language in the media is clear, communicative, and in accordance with students' characteristics.

The Presentation aspect achieved an average score of 75% in the very valid category, indicating that the appearance and flow of the media presentation are quite interesting and systematic. Meanwhile, the Content aspect had the lowest average percentage in the valid category, at 65.62%, indicating that the media content's suitability for the learning objectives still needs improvement. Based on the results of the first stage of media validation, the researcher revised the learning media in response to suggestions and feedback from the two validators to improve its content, presentation, and language.

Several revisions were implemented following recommendations from media experts during the first-stage validation process. These improvements focused on visual presentation, media design, and instructional aspects of the developed learning media. The revision results are presented in Table 8. Not only the material but also the media quality needs to be considered in product development [29]. Following revisions based on media expert suggestions, the developed media underwent second-stage validation to evaluate improvements in media quality. The results of the second phase of media validation by the two validators are presented in Table 9.

Based on the results of the second phase of media validation by the two validators, presented in the table, an average percentage of 95.8% was obtained, categorized as very valid. These results indicate that the Powtoon-based learning video media has undergone significant quality improvements following revisions informed by input from the previous phase. All assessment aspects, Content, Presentation, and Language, achieved an average percentage in the very valid category, with the Presentation and Language aspects achieving the highest percentage of 100%. This indicates that the media was presented systematically, using clear language, and with an optimized visual display. The use of media displays will help students understand information more effectively [30]. Following the validation and revision process, a summary of the product validation results from the second phase, covering both material and media aspects, is presented in Table 10.

Table 8. Revisions Based on Media Expert Validation

No.	Validator Feedback	Revision Implemented
1	Learning videos lacked subtitles	Subtitles were added to improve readability
2	Visual layout and table presentation were less attractive	Design components were revised to improve visual appearance
3	Some scenes required stronger visual emphasis	Additional visual elements and animation improvements were implemented
4	Learning objective display required adjustment	Learning objective sections were revised according to curriculum requirements

5	Scientific illustration images required refinement	Images and visual representations were updated for better clarity

Table 9. Results of Stage II Media Validation with Both Validators

No	Aspects	Score (%)		Average (%)	Interpretation
		Validator I	Validator II		
1	Contents	100	75	87.5	Very valid
2	Presentation	100	100	100	Very valid
3	Language	100	100	100	Very valid
	Average	100	91.6	95.8	Very valid

Table 10. Summary of Product Validation Results

No	Aspects	Score (%)	Interpretation
1	Material	92.96	Very valid
2	Media	95.80	Very valid

Based on Table 10, the recapitulation results show that the material and media aspects were categorized as very valid. This result indicates that the developed product has met the eligibility criteria, as assessed by the validator. The analysis stage is conducted through curriculum analysis to ensure that media and teaching materials have a clear foundation and align with learning requirements. Researchers examine the alignment among Learning Outcomes (CP), Learning Objectives (TP), and Learning Objective Achievement Indicators (IKTP) to ensure that media development remains aligned with the curriculum. This aligns with [31], who state that learning media must be systematically structured in accordance with the curriculum. Furthermore, the learning formulation also needs to develop 21st-century skills such as critical, creative, collaborative, and communicative thinking. Overall, the CP, TP, and IKTP are systematically structured and aligned with the Independent Curriculum, providing a strong foundation for media development.

The material analysis examines the alignment and depth of the material with the CP, TP, and IKTP. The material is deemed accurate and free from misconceptions. However, the Nature of Science (NOS) approach has not been explicitly integrated into the presentation of materials, despite its importance in helping students understand science as a scientific process. Therefore, the development of teaching materials needs to more clearly integrate NOS. In general, the material is conceptually appropriate, but still needs strengthening in the NOS aspect. NOS integration makes conceptual presentation better [32].

From a needs analysis perspective, students indicated that the learning media used were still limited to images, while they were more interested in animated videos. This indicates a need for more varied and visual media. Based on the characteristics of students aged 11–15 in the formal operational stage, they are beginning to think abstractly but still require visual support. Therefore, animated videos are considered appropriate because they can present material visually, step by step, and in a structured manner [33], [34], [35]. This medium can also be used inclusively, without gendered terms.

The design stage continues the analysis and focuses on developing the initial product. The design is based on the results of the curriculum analysis, the materials, the needs, and the student characteristics. Powtoon-based animated videos were chosen because they present material interactively and engagingly, while being easily accessible. The video was limited to 12 minutes to maintain student concentration. Furthermore, a sans-serif font, such as Arial, was chosen for its readability. The material is structured around CP, TP, and IKTP and is complemented by an NOS approach through aspects of scientific thinking, working, and communication. Analogies are also applied to facilitate understanding of abstract concepts [36].

The development stage is the realization of the product design. Material validation showed that the content aligned with the curriculum and that the presentation was well structured. However, revisions were needed to strengthen NOS integration, correct misconceptions, and add learning objectives and developer identity. Regarding the media aspect, improvements were made to the appearance, such as color contrast, resolution, and visual composition, to enhance aesthetics and consistency. Linguistic aspects were also addressed, particularly narrative clarity and text readability, given that learning videos are multimedia that engage multiple senses [37].

Overall, the development results indicate that the NOS-based Powtoon learning video is suitable for use with several improvements. The resulting product aligns with the curriculum, student characteristics, and learning needs, thus supporting a more effective and meaningful understanding of cell concepts. Theoretically, the results of this study reinforce the view that science learning that integrates aspects of the Nature of Science can support the development of students' scientific literacy. In practice, the developed media can serve as an alternative for teachers to convey abstract material, such as cell structure and function.

Conclusion

Based on the research objectives, this study has successfully developed an NOS-based Powtoon learning video on cell material for grade VIII junior high school students. The validation test results show that the developed learning video achieved material validity of 92.96% and media validity of 95.80%, both meeting very valid criteria. The developed media has the potential to serve as an alternative learning tool for cell material, helping students visualize abstract concepts and strengthening their understanding of the nature of science. Further research is needed to test its effectiveness through direct classroom implementation. Thus, the NOS-based Powtoon learning video was declared theoretically feasible for use at the development stage.

Author's Contribution

F.D.A. Fatimah: contributed to conceptualization, research design, development of learning media, data collection, data

analysis, and manuscript writing. D.Sarkity and A.Fernando: supervised the research process and provided a critical review of the manuscript.

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