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Development of an Interactive Digital Module Assisted by Articulate Storyline 3 to Improve Students' Conceptual Understanding of Energy and Its Transformations

Normanisa[1*], Mastur[2], Muhammad Arifuddin[3], Mohd Hanafi Yasin[3]
[1,2,3]Universitas Lambung Mangkurat, Indonesia
[4] INTI International University, Malaysia
E-mail: [1*]nisanorma16@gmail.com, [2]secondauthor@gmail.com , [3]thirdauthor@gmail.com,
[4]mohdhanafi.yasin@newinti.edu.my
*Coresponding Author

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ABSTRACT

The integration of digital technology into vocational education requires learning resources that strengthen students' conceptual understanding through authentic contexts. However, research on conceptual understanding within the *Projek Ilmu Pengetahuan Alam dan Sosial (Projek IPAS)* curriculum remains limited. This study aimed to develop an interactive digital module using Articulate Storyline 3 and evaluate its validity, practicality, and effectiveness in improving students' conceptual understanding of energy and its transformations. This Research and Development study employed the Four-D (4D) model involving 36 tenth-grade Motorcycle Engineering students at SMKPP Negeri Paringin, Indonesia. Data were collected through expert validation, questionnaires, and conceptual understanding tests. The module achieved validity scores of 94% and 96%, practicality of 89.23%, and a moderate N-Gain score of 0.61, indicating improved conceptual understanding. This improvement was supported by interactive multimedia, feedback, and contextual learning that facilitated active knowledge construction. These findings demonstrate that the module is valid, practical, and effective. By integrating interactive multimedia with vocational contexts in Projek IPAS learning, this study provides empirical evidence that such integration strengthens conceptual understanding and bridges scientific concepts with vocational practice.

1. INTRODUCTION

The digital transformation occurring across various industrial sectors has altered the competencies required by the workforce. Vocational education graduates are no longer expected to merely master technical skills; they are also required to possess the ability to understand concepts, analyze problems, and make decisions based on scientific principles relevant to their field of work. This need has driven vocational education institutions to develop learning approaches that can integrate skill mastery with conceptual understanding in a balanced manner. Kovalchuk et al. (2022) explain that modern vocational education faces the challenge of producing graduates who are adaptable to technological advancements and shifting industrial needs. This finding is reinforced by Jia & Huang (2023), who emphasize that digital literacy and conceptual understanding are critical competencies for the future workforce. Widaningsih et al. (2025) also demonstrate that the transformation of vocational education demands the strengthening of digital

competencies and more complex thinking skills compared to conventional learning approaches.

In the context of vocational education in Indonesia, this objective aligns with the implementation of the Merdeka Curriculum, which positions students as active participants in the learning process. The Science and Social Studies Project (IPAS) course is designed to help students understand scientific phenomena through contexts relevant to daily life and the workplace. One of the key topics in IPAS instruction is energy and its transformations. This topic not only covers the forms, sources, and transformations of energy but also its relationship with various technological systems used in daily life and industrial environments (Kemendikbudristek, 2022). For students in the Motorcycle Technology vocational program, understanding energy serves as the foundation for studying engine operating principles, combustion systems, vehicle electrical systems, and energy efficiency in motor vehicles.

Mastering energy concepts remains a challenge in science education. Maison (2020) found that misconceptions regarding work and energy are still prevalent among students. Errors in understanding the relationship between work, energy, and energy transformation cause students to struggle when explaining scientific phenomena or applying concepts to new situations. Jatmika (2021) reported that low ability to understand basic energy concepts is often caused by students' inability to integrate mathematical, verbal, and real-world representations. The results of Liu, G. (2021) study indicate that work, energy, and related mechanics concepts remain among the most challenging topics in physics education, highlighting the need for more innovative instructional strategies to enhance students' conceptual understanding.

These issues indicate that learning is not sufficient if it merely conveys information or problem-solving procedures. Students need learning experiences that allow them to build meaningful connections between concepts. Several studies have shown that interactive multimedia can facilitate the knowledge construction process by presenting various conceptual representations simultaneously. Marisda et al. (2020) demonstrated that combining conceptual learning models with interactive multimedia can reduce the level of misconceptions in science learning. Hermansyah et al. (2022) found that interactive multimedia helps students understand abstract physics concepts through clearer visualizations. The results of Flegr et al. (2023) study indicate an improvement in students' conceptual understanding following the use of digital-based learning environments in science education. The results of Alalwan (2022) study indicate that interactive digital learning environments significantly enhance students' learning outcomes and engagement during science learning. These findings align with the research by Asrizal et al. (2025), Ngandoh et al. (2025) and Saputri et al. (2025), which showed that the integration of interactive multimedia in learning can significantly improve students' conceptual understanding.

One of the most widely used platforms for developing interactive educational multimedia is Articulate Storyline 3. This platform allows for the integration of various multimedia components into a single educational product that is easy to access and use. Hadza et al. (2020) demonstrated that educational media based on Articulate Storyline 3 has a high level of feasibility. Istyadji et al. (2022) reported that media developed using Articulate Storyline 3 meet the aspects of validity and practicality in science education. The results of Irsyad (2023) study indicate that the use of Articulate Storyline 3-based learning media has a positive impact on students' learning outcomes. The results of Daryanes et al (2023) study indicate that the implementation of Articulate Storyline-based interactive learning media significantly enhances students' learning performance and higher-order learning skills, including scientific literacy. The results of Aldalur & Perez (2023) study

indicate that interactive digital learning environments not only facilitate content delivery but also promote active student engagement and meaningful participation in the learning process.

Research on Articulate Storyline 3 continues to expand across various subjects and educational levels. Daryanes et al. (2023) developed Articulate Storyline 3-based media capable of training students' problem-solving skills. The results of Yu (2025) study indicate that integrating Project-Based Learning with digital learning technologies significantly improves the quality of learning by promoting students' creativity, engagement, and active participation. Recent empirical studies consistently demonstrate that interactive learning media developed using Articulate Storyline improve various dimensions of students' learning. These media have been shown to enhance science process skills, learning outcomes, critical thinking, and problem-solving abilities while promoting active student engagement in classroom learning (Daryanes et al., 2023; Aldalur & Perez, 2023; Han, 2023). The integration of interactive digital technologies also supports learner-centered instruction by creating meaningful learning experiences that strengthen conceptual understanding and improve the overall quality of science learning (Timotheou et al., 2023; Alyoussef, 2023). Collectively, these findings suggest that Articulate Storyline-based interactive media provide an effective digital learning environment capable of supporting both cognitive development and active participation across diverse educational settings.

A review of previous research indicates that most studies still focus on learning outcomes, learning motivation, science literacy, critical thinking skills, and problem-solving. Studies that specifically prioritize conceptual understanding as the primary objective of media development remain relatively limited. Febriansyah & Pujianto (2023) have indeed developed Articulate Storyline 3-based media to enhance understanding of physics concepts, but that study was conducted within the context of general education. Hasanati (2021) Developed an interactive multimedia-based digital module on work and energy to improve conceptual mastery, but did not integrate vocational learning characteristics or the IPAS Project context. The study conducted by Daryanes et al. (2023) focused on developing Articulate Storyline-based interactive learning media and validating its feasibility, while further investigation into its effectiveness in improving students' conceptual understanding across broader educational contexts remains necessary.

Studies on energy education also show promising results when combined with interactive digital media. Suwiantini et al. (2021) reported that interactive multimedia helps students understand energy sources more effectively. Hasanati (2021) demonstrated that interactive multimedia-based digital modules on work and energy can improve students' conceptual mastery. Asrizal et al. (2024) reported that STEM-based interactive physics e-modules significantly improve students' conceptual understanding and support the development of essential 21st-century skills. Lailiyah & Marlena (2024) developed an interactive e-module using the ADDIE model and demonstrated high validity and effectiveness, indicating that the product was suitable for implementation in vocational learning. Most of these studies were still conducted in the context of general education and have not linked energy materials to vocational learning needs in the IPAS Project subject.

This analysis indicates a research gap in three main aspects. The first aspect is the contextual gap, namely the limited research on the development of Articulate Storyline 3 media within vocational education settings. The second aspect is the variable gap, namely the scarcity of research specifically targeting the enhancement of conceptual abilities as the primary learning outcome. The third aspect is the content and curriculum gap, namely the scarcity of research developing interactive digital modules on energy and its changes in IPAS Project learning linked to Motorcycle Technology vocational competencies.

The results of a preliminary study at SMKPP Negeri Paringin show that IPAS learning on energy and its changes is still dominated by the use of conventional, text-based teaching materials. Some students have difficulty understanding energy concepts in depth and connecting them to the automotive context they are studying. The availability of interactive digital teaching materials suitable for vocational learning is also still limited. These conditions highlight the need to develop learning resources capable of visualizing concepts, facilitating learning interactions, and connecting energy topics to vocational contexts in a more tangible way.

This study aims to expand and reinforce the findings of previous research on the use of Articulate Storyline 3 in learning. The research focus is directed toward the development of an interactive digital module based on Articulate Storyline 3, specifically designed to enhance the conceptual abilities of vocational high school students regarding energy and its transformations within the IPAS Project learning context. The novelty of this research lies in the integration of interactive learning technology, the strengthening of conceptual abilities, the vocational education context, and the characteristics of energy-related material linked to Motorcycle Technology competencies. This study aims to develop an interactive digital module based on Articulate Storyline 3 and to test its validity, practicality, and effectiveness in improving the conceptual abilities of students at the Paringin State Vocational High School for Motorcycle Technology.

2. METHODS

This study employs a Research and Development (R&D) methodology aimed at developing and testing the feasibility of educational products. According to Sugiyono (2019), the R&D method is used to produce specific products and test their effectiveness. Product development was conducted using the 4D model proposed by Thiagarajan, Semmel, and Semmel, which includes the define, design, develop, and disseminate stages. This model was chosen because it provides systematic development steps ranging from needs identification to product dissemination. The research resulted in an interactive digital module based on Articulate Storyline 3 on the topic of Energy and Its Changes in the IPAS Project learning. The disseminate stage was modified to involve limited dissemination to schools with characteristics similar to the research location.

The research was conducted at SMKPP Negeri Paringin, Balangan Regency. The research subjects consisted of 36 10th-grade Motorcycle Technology (TSM) students as product users. Product validation involved subject matter experts and media experts. The limited dissemination phase involved teachers and students at SMKS Al Hidayah Haruyan to obtain feedback on the product's implementation.

The research procedure followed the four stages of the 4D model. The define stage included needs analysis, student characteristics analysis, task analysis, concept analysis, and learning objective analysis. The design stage included material development, storyboard creation, module interface design, interactive activity development, and research instrument development. The development stage includes module development using Articulate Storyline 3, expert validation, product revision, and field testing. The disseminate stage is carried out through implementation and limited dissemination to obtain user feedback.

Research instruments consist of a content expert validation form, a media expert validation form, a teacher response questionnaire, a student response questionnaire, and conceptual ability tests in the form of pretests s, and posttests. Qualitative data were obtained from validators' comments and suggestions, while quantitative data were obtained from validation results, response questionnaires, and conceptual ability tests.

Data were analyzed using quantitative descriptive and qualitative descriptive techniques. Qualitative data were used as the basis for product revisions. Quantitative data were used to determine the validity, practicality, and effectiveness of the module.

Product validity was calculated based on expert validation scores, while practicality was determined from teacher and student response questionnaires. Product effectiveness was evaluated using students' pretest and posttest scores analyzed through the Normalized Gain (N-Gain) formula proposed by Hake, as this method measures the extent of students' conceptual learning improvement by considering their initial level of understanding. The interpretation of N-Gain followed Hake's classification: high ($g \geq 0.70$), moderate ($0.30 \leq g < 0.70$), and low ($g < 0.30$).

The effectiveness of the developed module was evaluated using the Normalized Gain (N-Gain) because the primary objective of this development study was to measure the magnitude of students' improvement in conceptual understanding after using the product rather than to test hypotheses or compare experimental groups. The N-Gain analysis provides a normalized measure of learning improvement by considering students' initial knowledge levels, making it widely accepted in educational development research. The interpretation of N-Gain scores followed the classification proposed by Hake, which categorizes learning improvement into high, moderate, and low levels. Inferential statistical analyses, such as paired-sample t-tests, were not employed because this study focused on product development and preliminary field testing involving a single group to evaluate product feasibility. Future studies involving larger samples and experimental or quasi-experimental designs are recommended to incorporate inferential statistical analyses to provide stronger evidence regarding the effectiveness of the developed module. The product is deemed feasible if it meets the criteria of validity, practicality, and effectiveness.

3. RESULTS AND DISCUSSION

One indicator of the success of instructional media development is the degree to which the product aligns with learning needs and user characteristics. This alignment can be assessed through a validation process involving subject matter experts and media experts. The validation results provide an overview of the product's quality prior to its use in the pilot testing phase, ensuring that the developed media meets feasibility standards in terms of both content and instructional design.

Table 1. Results Of Subject Matter Expert Validation

Aspect	Average	Percentage (%)	Category
Curriculum Alignment	13,75	92	Highly Valid
Conceptual Accuracy	14,25	95	Highly Valid
Depth of Content	13,25	88	Highly Valid
Systematic Presentation	14,33	96	Highly Valid
Language	14,67	98	Highly Valid
Utility/Feasibility	14,00	93	Highly Valid
Average		**94**	**Highly Valid**

Based on these validation results, the developed interactive digital module achieved a very high level of validity. Content validity reached 94%, while media validity reached 96%, both of which fall into the "highly valid" category.

Table 2. Results of media expert validation

Aspect	Average	Percentage (%)	Category
Visual Appearance	13,75	93	Highly Valid
Visula Media	14,25	95	Highly Valid
Navigation	14,25	95	Highly Valid
Interactivity	14,50	97	Highly Valid
Learning Relevance	14,67	98	Highly Valid
Average		**96**	**Highly Valid**

These findings are consistent with previous studies demonstrating that Articulate Storyline-based interactive learning media achieve high levels of validity through the systematic integration of text, graphics, animation, audio, video, and interactive features within a well-structured instructional design (Arifin et al., 2026; Dahlan, 2024; Marpelin et al., 2023).

After the product was validated by experts, the next step was to identify the product's usability in real-world learning situations. This aspect is crucial because the quality of educational media is determined not only by its content and presentation but also by how easily users can operate it. The usability test results indicated that the interactive digital module achieved a score of 89.23%, falling into the "highly practical" category. These results indicate that the module's development aligns with user characteristics. This finding supports the research by Adawiyah et al. (2024), Nurhasanah et al. (2024), and Syam et al. (2025), which states that Articulate Storyline 3 enhances user engagement by providing an interactive and user-friendly learning experience.

The high practicality score indicates that the module's menu structure, navigation, and presentation of content help users interact with the media more easily. This enables teachers and students to utilize the media without encountering significant technical barriers during the learning process.

Effectiveness is an indicator showing the extent to which the developed product can impact the achievement of learning objectives. In development research, effectiveness is a critical stage because product quality is not only measured by usability and ease of use but also by its ability to support the learning process. The results of the effectiveness analysis show that the interactive digital module yielded an N-Gain value of 0.61, which falls into the moderate category.

Table 3. Table Of N-Gain Calculation Results

Descriptive Statistics					
	N	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
NGain_score	36	.00	1.00	.6079	**.33988**
NGain_percent	36	.00	100.00	60.7870	**33.98759**
Valid N (listwise)	**36**				

These results indicate an improvement in students' conceptual abilities after using the interactive digital module. This improvement suggests that features integrated into the media, such as concept visualizations, instructional videos, interactive exercises, and immediate feedback, are effective in helping students build a better understanding of energy and its transformations.

The improvement in students' conceptual understanding can be explained through the Cognitive Theory of Multimedia Learning, which posits that meaningful learning occurs when learners actively process information presented through complementary verbal and visual channels. The integration of animations, illustrations, instructional videos, narration, and interactive exercises enabled students to construct coherent mental representations of abstract energy concepts by connecting textual explanations with visual demonstrations. This multimedia presentation also aligns with the principles of Dual Coding Theory, suggesting that information encoded simultaneously through verbal and visual representations is more likely to be retained and retrieved effectively than information presented through a single modality. Consequently, the module reduced students' difficulty in understanding abstract scientific concepts and facilitated deeper conceptual comprehension.

The effectiveness of the module can also be interpreted from a constructivist learning perspective. Rather than functioning solely as a medium for delivering information, the interactive digital module encouraged students to actively construct knowledge through exploration, self-paced learning, immediate feedback, and contextual problem-solving activities. The interactive quizzes and instant feedback allowed students to identify misconceptions and refine their understanding during the learning process, while the contextual vocational examples connected scientific concepts with authentic workplace situations. Such learning experiences promote active cognitive processing and meaningful knowledge construction, enabling students to transfer conceptual understanding to vocational contexts more effectively.

These research results are consistent with the findings of Christou et al. (2024), Toli & Kallery (2021), and Rujira et al. (2021), which show that the use of interactive multimedia can improve conceptual understanding through clearer visualizations, more active learning activities, and more contextual presentation of material.

4. CONCLUSION

Although the findings demonstrate that the developed module is valid, practical, and effective in improving students' conceptual understanding, this study has several limitations. The effectiveness of the module was evaluated using N-Gain analysis only, which provides evidence of learning improvement but does not examine statistical significance. Future studies are therefore recommended to employ inferential statistical analyses, such as paired-sample t-tests or quasi-experimental designs with larger samples, to provide stronger evidence regarding the effectiveness of the developed module. In addition, further development may extend the module to other science topics or vocational fields by incorporating more adaptive learning features and integrating it with a Learning Management System (LMS) to support broader implementation.

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