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Development of a TPACK-Based E-Module Integrating the Anime Dr. Stone on Static Electricity Material for Junior High School Students

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ABSTRACT

The rapid development of information and communication technology in the era of the Industrial Revolution 4.0 has driven major transformations in the world of education, including in the delivery of challenging subject matter such as physics. One of the main challenges in learning physics is to convey abstract concepts such as static electricity in an interesting and easy-to-understand manner, so innovative technology-based learning media is needed that can increase student engagement and motivation to learn. This research aims to develop E-Modules based on Technological Pedagogical Content Knowledge (TPACK) assisted by Dr. Stone anime media on static electricity material for junior high school level. The method used is Research & Development with the Alessi & Trollip model with three main stages: planning, design, and development. The research instrument used was a validation questionnaire consisting of (1) a material expert validation sheet and (2) a media expert validation sheet. Data collection techniques were carried out through validation by experts, involving three material experts and three media experts as validators. The validation results showed that the e-module developed was in the "very feasible" category, with an average score that met the criteria of 89.4% of material experts and 90% of media experts. Thus, this anime-assisted TPACK-based e-module can be an innovative alternative to developing learning media that is contextual, interesting, and relevant to the characteristics of today's students.

1. INTRODUCTION

The development of information and communication technology (ICT) in the era of the Industrial Revolution 4.0 was very rapid, so it has significantly changed the face of the world of education (Flipbook, 2019). On the one hand, technological advances facilitate access to information and allow teachers and students to utilize various digital platforms to support the teaching and learning process (Nevrita et al., 2020). Physics is one of the branches of science that studies natural phenomena and the laws that govern the behavior of matter and energy. Physics materials cover a variety of concepts, ranging from motion

and force to electricity and magnetism. However, many students have difficulty understanding abstract concepts in physics, including static electricity, which often cannot be seen directly. This is because physics is a subject that is considered challenging. Despite the importance of the subject, some students lack interest for various reasons. This can cause children to develop misconceptions (Nawanda De Gupita et al., 2022). Therefore, in the learning process, students are expected to develop their own knowledge through active involvement in teaching and learning activities.

The results of interviews with Physics teachers at MTsN 1 Sabang conducted on September 19, 2024, as well as analysis of students' needs, revealed that although physics learning has been going well, there are still various obstacles that affect its effectiveness. Physics, which is abstract, makes many students less interested, especially with learning media that is only based on PowerPoint (PPT) and textbooks, so students tend to be passive. Although learning videos are occasionally used, the material presented is still limited and less developed, causing students to be less motivated. One of the materials taught is static electricity, but the lack of effective teaching materials and teachers' ability to utilize technology are also major factors that affect the learning process. This is important because physics is often considered a difficult subject, so more interactive and tangible teaching materials are needed to help students improve their understanding.

To achieve optimal student learning outcomes, educators need to have effective strategies in implementing the learning process, which will also adopt the TPACK (Technological Pedagogical Content Knowledge) approach to ensure effective integration between technology, pedagogy, and content in the learning process. TPACK is a framework used to design modern learning models with the incorporation of three main components, namely technological, pedagogical, and knowledge components (Hanik et al., 2022). Recent Research proves that the application of TPACK can significantly improve the quality of learning. Hamid found that the TPACK-based guided inquiry learning strategy was able to significantly improve student learning outcomes, with the average pretest and posttest scores increasing from 33.6 to 88.1 and an N-Gain value of 81.9% (Hamid et al., 2023). Research by Masrifah also shows that the use of TPACK-based physics e-books is effective in improving students' multi-representation abilities and conceptual understanding (Amiroh et al., 2025). Meanwhile, Purnawati, Fajrin, and Mawarni also developed TPACK-based E-LKPDs that were validated by experts with high scores and received very positive responses from teachers and students (Purnawati et al., 2020).

TPACK is the knowledge that is essential for integrating technology into the learning process. In this context, a teacher's professionalism demands mastery of theoretical and practical aspects to organize the relationship between technology, pedagogy, and learning content (Pratami & Ajisuksmo, 2022). In other words, TPACK includes an understanding of how technology can be utilized to support and improve the effectiveness of the teaching and learning process. TPACK competence is an important foundation for teachers in creating a more interactive and engaging learning experience for students. Teachers' mastery of TPACK has a positive impact on their skills in implementing more effective digital learning. One potential form of media to support the implementation of TPACK is educational animated films(Hari Santhi Dewi et al., 2024) Dr. Stone is an anime that raises various science concepts, such as physics, chemistry, and biology, in an informative and entertaining manner. With a story setting that emphasizes the importance of science in rebuilding civilization, this anime can be used as a visual aid in e-modules to help students understand abstract physics concepts in a more concrete and fun way (Septaria & Fatharani, 2022).

Despite the promising aspects of TPACK-based learning materials, challenges and gaps still need to be addressed for its widespread and effective implementation. A systematic literature review in mathematics education found that although TPACK is widely used, barriers such as teachers' lack of confidence, resistance to change, lack of institutional support, and limited technological resources still often affect its effective implementation (Kholid et al., 2023). In addition, differences in the level of digital expertise between teachers, inadequate infrastructure, and high workloads are the main obstacles to developing TPACK competencies at various levels of education. Therefore, addressing these issues requires improvements in teachers' professional training, increased access to technology, and school-

based policy support are important steps for TPACK strategies to truly impact learning quality (Hasanah et al., 2024)

Thus, the development of e-modules assisted by Dr. Stone anime based on TPACK is expected to be an innovative solution in improving the quality of physics learning, especially on static electricity material. This e-module not only helps students understand abstract concepts more easily and interestingly but also supports teachers in utilizing technology as a learning medium that is relevant to the times. Through the integration of technology, pedagogy, and content, it is hoped that this e-module will be able to increase student learning motivation while enriching a more interactive and meaningful learning experience. Based on these reasons, researchers are interested in developing TPACK-based E-Modules assisted by Dr. Stone anime on static electricity material for junior high school level.

2. METHODS

The research method used in this study is the research and development method, or by another name, Research & Development (R&D). The development of this TPACK-based E-Module uses the development model developed by Stephen M. Alessi and Trolip (2001). In general, the development of TPACK-based E-Modules has three phases, namely the planning, design, and development phases (Admadja & Marpanaji, 2016). Allessi and Trollip's development design can be seen in the figure.

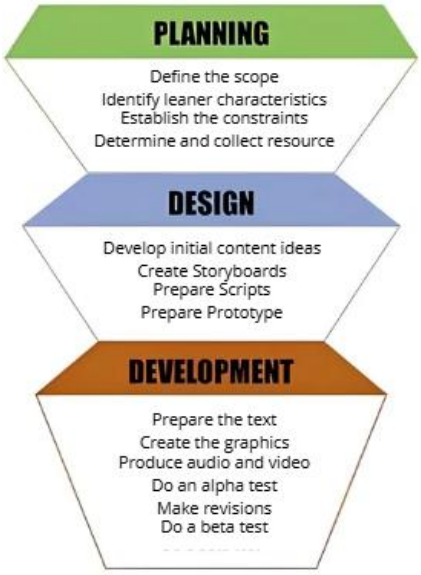

Figure 1. Allessi & Trollip Development Design (2001)

In the planning stage, researchers conducted a needs analysis through observation, interviews with Physics teachers at MTsN 1 Sabang, as well as a review of the curriculum and static electricity teaching materials that have been used. Learning objectives were formulated specifically, and resources ranging from Dr. Stone anime references to e-module creation software were prepared to ensure integration between content, technology, and pedagogy. The next stage is design, where the module content is organized and illustrated with scenes from Dr. Stone that match the concepts of electric charge and force. Narration was developed to connect the storyline with physics concepts, and the e-module interface was designed to be interactive and easy to navigate, complete with simulation buttons and video links. After the initial design was completed, the prototype was developed into an interactive digital format that was validated by three material experts and three learning media experts. Validation was conducted using a Likert scale evaluation sheet to assess content, presentation, appearance, and

interactivity. Feedback from the validators was used to improve the module, including sentence improvement, illustration adjustment, and feature optimization.

Data analysis was conducted by calculating the average validator score and converting it into a percentage of feasibility for each aspect tested. This percentage is the main indicator of product feasibility before it is applied more widely. Overall, this research method ensures that Dr. Stone's anime-assisted E-Module is developed with a strong theoretical foundation, systematic expert validation, and field testing that reflects the real needs and responses of learners.

The validation data obtained from the validator's assessment of all aspects evaluated are displayed in tabular format. Furthermore, to find out the average value of the assessment score, a calculation was made using the formula determined by the following equation:

$$\bar{x} = \frac{\sum x}{N} \quad (1)$$

Description:
$\bar{x}$ = average score of the validator
$\sum$x = number of scores from validators
N = number of question items

Meanwhile, change the average score of the experts' assessment in order to determine the feasibility/validity of the E-Module. The results of the development of physics teaching materials in the form of E-Module that were originally valued in the form of scores were converted into qualitative data using the percentage formula:

$$\text{Feasibility percentage} = \frac{average\ score\ of\ all\ aspects}{maximum\ possible\ score\ per\ aspect} = \times 100\% \quad (2)$$

The next step is to interpret the value obtained in the form of a percentage (%) the category is determined based on the table.

Tabel 1. Percentage Value

Percentage Value %	Feasibility Level
81-100	Very Feasible
61-80	Feasible
41-60	Moderately Feasible
21-40	Not Feasible

3. RESULT AND DISCUSSION

This study uses a research and development approach that aims to produce and test the effectiveness of a product in the form of teaching materials in the form of E-Modules. This E-Module is designed based on the Technological Pedagogical and Content Knowledge (TPACK) approach for use at the SMP'/MTs level. In the process, this Research applies the development model proposed by Alessi and Trollip, which includes three main stages, namely planning, development, and evaluation.

In the planning stage, researchers collect information related to student characteristics, learning constraints, teacher teaching strategies, and the media used. Researchers also reviewed the Merdeka Curriculum to ensure the suitability of the material, with the research subject being class IX students of

MTsN 1 Sabang. After completing the analysis stage, the researcher proceeded to the e-module design stage by utilizing the Canva application. The first step taken is to collect reference material on the topic of static electricity from various sources, both printed books and learning websites. Next, researchers collected a number of images that would be included in the e-module, especially those that had a direct relationship with the content of the material. The images were obtained through personal documentation during field observations as well as from several online sources.

In addition, researchers also added excerpts of scenes from the Dr. Stone anime that are relevant to the material content as an interesting visual support. Figure 2 below represents the footage of the Dr. Stone anime.

Figure 2. A snippet of Dr. Stone anime

Below is presented Figure 3, which is a graphic design application that provides diverse and interesting features in it. The appearance of the Canva application can be seen in Figure 3.

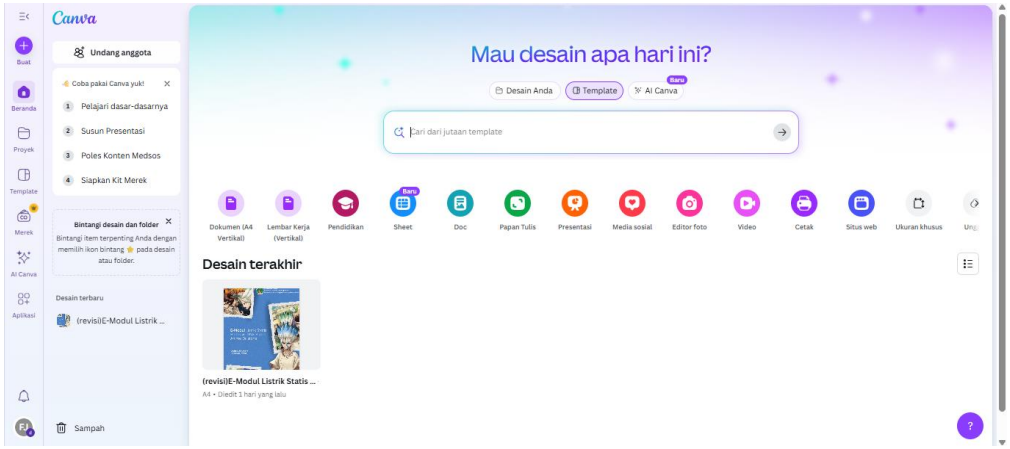

Figure 3. Canva application view

After the design stage was completed, the researchers proceeded to the development stage of the TPACK-based E-Module on Dr. Stone anime. This stage aims to test its validity by six experts, consisting of three material experts and three media experts. In general, the experts assessed that the TPACK-based E-modules and Dr. Stone anime media developed had met the criteria of validity and feasibility to use, although some improvements still need to be made based on the suggestions and input obtained. The feasibility of the TPACK-based E-Module that discusses the material of rotational dynamics and

equilibrium of a fixed object has been assessed by two experts, consisting of media experts and material experts. The assessment results from the two validators can be seen in Table 2.

Table 2. Validator percentage data

No	Validator	Percentage	Feasibility
1	Material expert	89.4%	Very Feasible
2	Media expert	90%	Very Feasible

Based on the results of validation conducted by three material experts and three media experts, the TPACK-based e-module assisted by Dr. Stone anime is declared very feasible to use as learning media. This is indicated by the average score obtained, which is 89.4% from material experts and 90% from media experts. The assessment of the material experts includes aspects of the suitability of the material with the curriculum and learning outcomes, the correctness of the concept and quality of physics material, the application of the TPACK (technological pedagogical content knowledge) approach, the suitability and effectiveness of Dr. Stone animation integration, contextualization, readability, and attractiveness of the module. The percentage assessment of each aspect is shown in Figure 4 below.

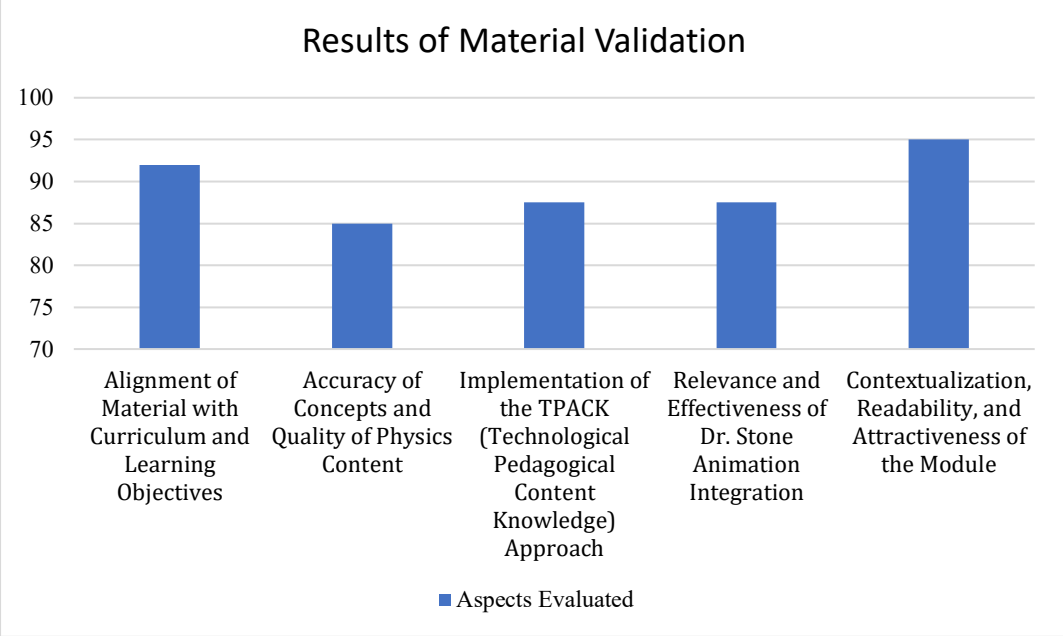

Figure 4. Percentage of material validation results

Based on the graph above, it can be seen that the percentage obtained from each aspect of the assessment by material experts is as follows: 1) the suitability of the material with the curriculum and learning outcomes of 92%, 2) the correctness of the concept and the quality of the material of 85%, 3) the application of the TPACK (Technological Pedagogical Content Knowledge) approach of 87.5%, 4) the suitability and effectiveness of Dr. Stone's animation integration of 87.5%, and 5) contextualization, readability, and attractiveness of the module of 95%.

The assessment from media experts, which includes visual design and layout, technological quality and functionality, integration of Dr. Stone animation media, and consistency with TPACK principles, is presented in Figure 5 below.

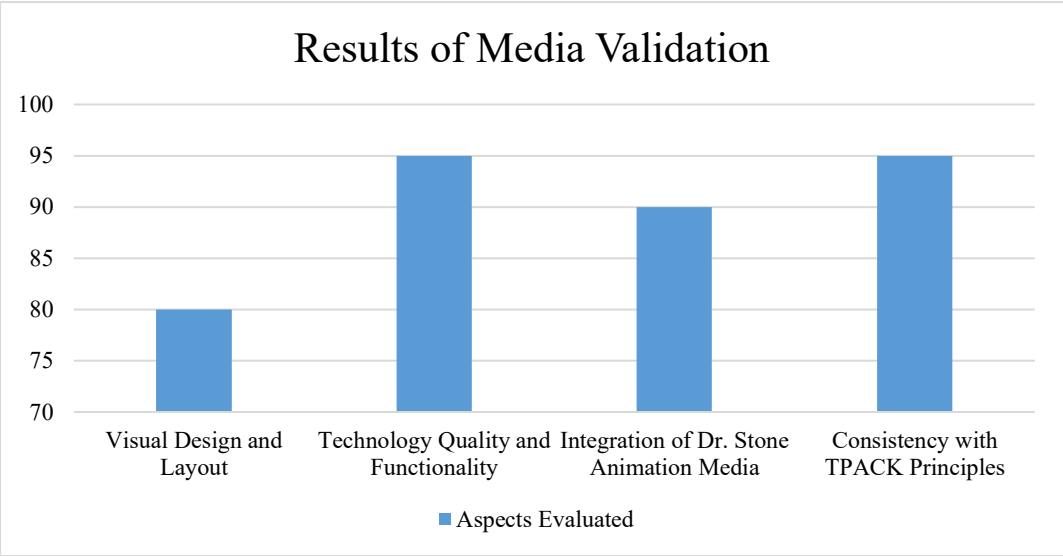

Figure 5. Percentage of media validation results

Based on Figure 5, it can be seen that the percentage obtained from each aspect of the assessment by media experts is as follows: 1) visual design and layout by 80%, 2) technology quality and functionality by 95%, 3) integration of Dr. Stone animation media by 90%, and 4) consistency with TPACK principles by 95%. Although overall, the e-module was classified as very feasible, some suggestions, such as adding infographics, improving text layout, and separating answer keys for teachers and students, were important notes in the final revision process. These findings indicate that the developed e-modules have met the eligibility standards as TPACK-based interactive teaching materials. For more details, the following are presented comments and suggestions from material expert validators and media experts.

Table 3. Comments and suggestions from material experts and media experts

No	Validator	Validator Code	Comments and Suggestions
1	Material expert	V1	Uniform the steps of the LKPD, and the solution of the example problem is equipped with units.
		V2	Add the answer key to the evaluation questions at the end of the E-Module.
		V3	Add pictures and infographics that support the material
2	Media expert	V1	Answer key separated for teachers and students
		V2	The writing is too dense on one page; provide distance so that it does not look like full text.
		V3	Add some pictures also related to electricity in the anime.

The input submitted by the validators is the basis for making improvements, especially in terms of visualization, completeness of content, and the convenience of using e-modules by teachers and students.

When compared with previous Research, these results are in line with the findings of Junaida, who developed a TPACK-based physics magazine and obtained high validation scores from material experts (94%) and media experts (87.9%) (Junaida et al., 2024). Likewise, Irfan Faozun reported that the e-module he developed obtained an average valid score of 3.09 (Budiarti et al., 2021). Meanwhile, Rosidah (2022) noted the feasibility of TPACK-based math e-modules with an average score of 85.35% (Rosida et al., 2022). However, in contrast to these studies, this e-module is unique in the integration of

popular media, namely the Dr. Stone anime, as visual support. This makes the developed e-module not only valid in content and media but also more contextual and interesting for digital-era learners.

The results of this study contribute to educators in developing learning media that are more adaptive and contextual to the needs of 21st-century students. TPACK-based e-modules, with the help of Dr. Stone's anime, provide a concrete example of how combining content, pedagogy, and technology can create an interactive and meaningful learning experience. Effective utilization of TPACK encourages teachers to design learning based on dynamic visualization and interactive simulations (Priyanda et al., 2025). Similar findings also state that the integration of TPACK in the development of learning resources encourages teachers to create learning media that is contextual and easy for students to understand (Nurdilla et al., 2020). By utilizing popular media that is close to the students' world, teachers not only develop their TPACK skills but also build learning experiences that are more relevant and interesting for today's learners.

The development of TPACK-based learning media has several limitations that need to be considered. One of them is the dependence on adequate technological infrastructure, such as digital devices and stable internet connections, which are not yet evenly available in all schools, especially in remote areas. Limited access to devices and networks in peripheral schools is a major obstacle in implementing TPACK-based learning. In addition, teachers' digital competence is also a challenge (Ningsih, 2024). Not all educators have sufficient technical skills to design, adapt, or implement TPACK-based e-modules effectively. In addition, the low technology literacy among teachers is one of the factors for the failure of technology integration in learning. As a result, although the media used has been optimally designed, the success of its implementation is still influenced by the readiness and skills of teachers in utilizing it.

Future Research is suggested to explore the analysis of scientific content in the Dr. Stone anime in more depth to identify other physics concepts that can be utilized as learning materials. Thus, the use of anime is not only limited to visualization but also acts as a contextual resource based on science literacy (Halimah et al., 2022). In addition, further studies can also examine students' perceptions and interest in physics learning using anime media, such as Dr. Stone, in order to assess the affective impact of applying popular media in learning. It would also be interesting to conduct Research with a digital ethnography approach to explore how students independently seek and understand science concepts from entertainment shows such as anime. Furthermore, it would be beneficial if Research examines the influence of TPACK integration and students' digital literacy in using anime-based e-modules to see if the popular media also has an impact on critical thinking and problem-solving skills.

4. CONCLUSION

This study successfully developed TPACK-based E-Modules and Dr.Stone anime media on static electricity material for junior high school / MTs using the Research and Development approach with the Alessi & Trolip model. The validated e-module showed feasibility based on the assessment of material experts and media experts, namely 89.4% and 90%. These findings indicate that the E-Module is well received and supports the improvement of technology-based interactive learning in the context of science education. This is in line with the development of digital competence, which is currently the focus of education. Nevertheless, the limitation of this study lies in the narrow scope and limited number of samples, which may affect the extension of the research results. Therefore, future Research is recommended to cover a wider population, use a larger sample, and explore more technological tools to strengthen the effectiveness of interactive learning. This study makes a positive contribution in emphasizing the importance of using innovative learning media and continuous professional development in the field of science education.

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