The Development Of TPACK (Technological Pedagogical Content Knowledge) – Based Physics Module

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Abstract. The objective of this study is to determine whether or not the physics module developed utilizing TPACK (Technological Pedagogical Content Knowledge) is valid and applicable in practice. Utilizing the ADDIE model analysis, design, development, implementation, and evaluation the module was constructed. The instructor's response sheet and student response sheet are utilized to evaluate the practicability of the physics module under development, whereas the validator's completed validation sheet is employed to ascertain the module's validity. The findings of the TPACK-based physics module development research indicate that the percentages of 76% and 80.5% that comprise the validated results of the evaluation conducted by media experts and subject matter experts, respectively, are reliable. A total of 88% of the responses to the pragmatism test on the teacher's response sheet fell into the very practical category, while 78.18% of the responses on the student response sheet fell into the quite practical category. The validity and usability of the TPACK-based physics module as a physics learning resource were validated, according to the test results.

Keywords: Module, TPACK

1. Introduction

The integration of technology in 21st century learning is an important concern in both developed and developing countries. It is important for physics teachers to have good knowledge in incorporating technology into the teaching process. The model for integrating technology in learning that can help teachers understand the application of technology in accordance with content and teaching techniques is called Technological Pedagogical Content Knowledge (TPACK). Integrating TPACK can increase self-confidence and increase teacher content, pedagogy and technology competence in designing learning (Doering et al, 2009). A good learning process to ensure the implementation of learning in accordance with the demands and technological changes that occur in accordance with the digital era is the development of teaching materials and teacher competence through learning using TPACK.

ICIESC 2023, October 24, Medan, Indonesia

DOI 10.4108/eai.24-10-2023.2343054

The outcomes of classroom interviews with physics instructors Schools and educators in Indonesia continue to face challenges, such as inadequate utilization of media and technology, inadequate material comprehension, and teacher standards that continue to be inadequate (Suyamto et al., 2020). Several factors contribute to the limited technological proficiency of educators, including gender, age, and tenure in the profession. The prevailing mode of learning implementation is overt, in contrast to traditional learning approaches that culminate in task completion and query resolution. As indicated by the fact that student learning outcomes remain below the KKM, the teacher-centered learning process renders physics learning extremely unappealing; therefore, it is imperative to assess the learning process utilizing a variety of instructional materials.

The capacity of educators to develop TPACK (Technological Pedagogical Content Knowledge)-based teacher competency development plans is a significant obstacle for the Indonesian education system in the context of the global complex (Suyamto et al., 2020). TPACK is an instructional approach that integrates technological resources with pedagogical and content knowledge to facilitate the learning process. Since its inception by Shulman (1986), TPACK has been expanded upon by Koehler and Mishra (2006). The TPACK principle, according to Mishra and Koehler (2008), is the application of technology, pedagogy, and content in a single context. The anticipated outcome of integrating technology into TPACK-based instructional materials is the establishment of a more efficient learning environment that aligns with the requirements of the twenty-first century. This integration should pique students' curiosity and motivate them to further their understanding of both subject matter and technology. The most frequently researched topic related to TPACK in the 21st century is the technological knowledge aspect. The era of the industrial revolution 4.0 emphasizes the importance of developing digital literacy which fully connects technological capabilities and pedagogy to improve learning which includes knowledge, skills and attitudes. The research results concluded that the TPACK model is a factor and measure of learning outcomes in the field of education, this is proven by research results which answer the hypothesis that the higher the pedagogical and technological capabilities, the higher the learning outcomes (Susanto, et al. 2020).

TPACK is regarded as a framework that can offer educators a fresh perspective on addressing the challenge of incorporating ICT into the learning environment in the classroom (Hewitt, 2008). In light of the imperative for students to possess technological proficiency and the 4Cs in order to confront the obstacles of the educational landscape during the 4.0 industrial revolution, TPACK development research is crucial. Module Development Based on Technological Pedagogical Content Knowledge (TPACK) was the appellation proposed by the researcher.

Organization of the Text

Interactive Multimedia Teaching Materials

Web-based learning materials, CAI (Computer Assisted Instruction), and interactive multimedia learning compact discs (CD) are examples of interactive multimedia teaching materials. Researchers have created instructional materials in the form of interactive multimedia teaching materials. Online instructional materials are autonomously created and can assist instructors in tailoring learning activities to students' unique requirements. Online teaching materials offer several benefits, including the provision of diverse learning modules, online accessibility, and the flexibility for instructors to utilize them at different times in accordance with the particular requirements of students or study groups.

TPACK (Technological Pedagogical Content Knowledge)

TPACK is a conceptual framework that is constructed upon the Pedagogical Content Knowledge (PCK) framework as its foundation. Shulman (1986) coined the term Pedagogical Content Knowledge (PCK), which he defines as specialized knowledge distinguishing educators from scientists, including physicists and physics instructors, mathematicians and mathematics instructors, and so forth. This framework is elaborated upon through the definitions of subject matter knowledge (content) and pedagogical knowledge (considerations and teaching strategies), as well as an explanation of how these frameworks may interact or combine to generate distinctive knowledge (Pedagogical Content Knowledge) (Shulman, 1986) Therefore, an ability called TPACK was developed which is able to show the relationship or correlation between three knowledge at once and must be mastered by teachers, namely technology knowledge, pedagogy and content. The TPACK component refers to the ability of a teacher to plan a learning design and incorporate the use of technology in tasks that are appropriate to the topic of a subject and is able to support students to demonstrate the results of learning using technology as a means of pedagogical knowledge. Technological Knowledge, Content Knowledge, Pedagogical Knowledge, Pedagogical Content Knowledge, Technological Content Knowledge, and Technological Pedagogical Content Knowledge comprise the TPACK analysis component.

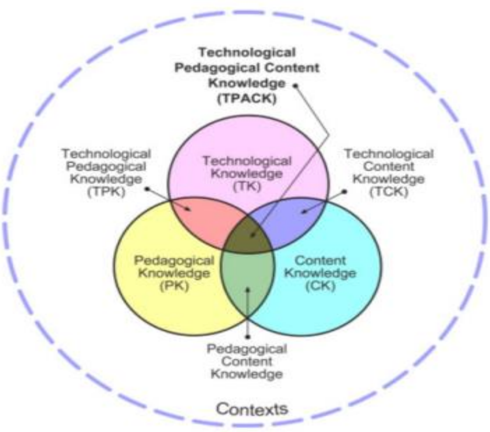

Figure 1. TPACK Framework (Sumber: http://TPACK.org/)

Flip PDF Professional

Flip PDF professional is an interactive learning media that has many characteristics that can be utilized effectively and efficiently to develop modules and make them more creative and interesting. The capabilities of the professional PDF flip application include text, images, video, audio, animation and YouTube videos. Flip PDF professional can create an interesting and interactive learning media that can be viewed on PC, Android, iPhone, iPad so that learning is not monotonous and increases students' interest in learning.

2. Research Methods

The research methodology employed is research and development (R&D). Research and development, abbreviated R&D, is a method of investigation utilized in the production and evaluation of specific products. A Technology Pedagogical Content Knowledge (TPACK) module based on Hooke's law and elasticity has been developed. Branch (2009) provided the inspiration for the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) framework utilized in the research development model. At SMAS Budi Murni 3, Jl. Lotus No. 21 A, Sidorejo, Medan Tembung, Medan, North Sumatra, the research was conducted. The study will be carried out during the odd semester of the academic year 2023/2024.

3. Data Analysis Technique

The analysis of the expert validity questionnaire data involved determining the percentage score of the developed TPACK-based teaching materials. The formula employed to compute the proportion of expert validation questionnaires is as follows Sugiyono (2013) is:

$$P = \frac{f}{N} \times 100\% \qquad (1)$$

Information

P = Score Percentage

f = The total score obtained

N= Maximum total score

The percent results of the validity assessment are subsequently analyzed descriptively in accordance with the classifications presented in Table 1.

Table 1. Module Validity Categories

Persentage	Category
85,01% - 100,00 %	Very Valid (can be used without revision)
70,01% - 85,00%	Valid (usable with minor revisions)
50,01% - 70,00%	Less Valid (can be used with major revisions)
01,00% - 50,00%	Invalid (cannot be used)

Source: (Akbar, 2013)

The efficacy of instructional resources is assessed via student response surveys. Students are the subjects who conduct truth testing (validation) regarding the usability of instructional materials. The questionnaire responses were subjected to analysis utilizing the subsequent formula:

$$A = \frac{TSEV}{S-Max} x\ 100\% \quad (2)$$

Information :

A = *Applying*
TSEV = Total score for empirical validators
S-Max = Expected maximum score

The practicality calculations yield percentage values that are interpreted through the use of qualitative sentences. These sentences are listed in Table 2.

Table 2. Product Practicality Level Conversion

Achievement Level	Category	Information
86% - 100%	Very practical	Acceptable for use without revision
70% - 85%	Quite practical	Applies with only minimal modifications.
60% - 69%	Not practical	Can not be used
0% - 59%	Very impractical	Forbidden to use

Source: (Veri et al, 2019)

4. Research result

Media expert validation of the development of TPACK-based modules was carried out by 1 media expert as a lecturer at Medan State University. The product assessment is intended to obtain information that will be used to improve the validation of TPACK-based modules. The average percentage of learning media experts' assessment results for the modules that have been developed is presented in Table 3.

Table 3. Average Percentage of Media Expert Assessment Results

Num	Assessment Indicators	Average Percentage	Criteria
1	Usage Aspects	75%	Valid
2	Aspects of Suitability to the Material	78%	Valid
3	Animation Display Aspect	75%	Valid
	Average	76%	Valid

The results of media experts' assessments of TPACK-based modules have an average percentage of 76%. The average percentage of assessment indicators has "valid" criteria and can be used for field trials with minor revisions based on media expert responses.

The purpose of material expert validation is to gather data that can be utilized to enhance the compatibility of current materials within the framework of TPACK-based methods based on Hooke's law and elasticity. Table 4 displays the mean percentage of material expert assessment results pertaining to the developed TPACK-based modules.

Table 4. Average Percentage of Material Expert Assessment Results

Num	Assessment Indicators	Average Percentage	Criteria
1	Content Feasibility Aspect	81,42%	Valid
2	Feasibility of Presentation	85,45%	Very Valid
3	Language Assessment	81,80%	Valid
4	TPACK Assessment	73,33%	Valid
	Average	80,5%	Valid

The average percentage of valid criteria obtained by the material expert in their evaluation of the developed TPACK-based module on elasticity and Hooke's law of materials was 80.5%. This indicates that the TPACK-based physics module can be utilized with only minimal modifications.

The results of large group trials generally fall into the "very practical" criteria with a percentage of 86.61%. The lowest percentage was obtained at 82.30% with quite practical criteria on the indicator of being more interested in physics, while the highest percentage was obtained at 93.07% with very practical criteria on the indicator that it can be used for independent learning, meaning that TPACK-based modules can be used independently. wherever and whenever. The substantial percentage obtained indicates that the developed TPACK-based physics module is devoid of any issues or deficiencies and thus does not necessitate any revisions. The developed TPACK-based physics module is practicality-based and therefore effective.

The outcomes of the instructor's hands-on responses were extracted from the instructor's evaluation questionnaire. By distributing response questionnaire sheets to subject instructors, researchers are able to assess whether or not TPACK-based modules are practical. Table 5 displays the outcomes of the practicality assessment conducted by the instructor.

Table 5. Results of Teacher Practical Responses

Num	Assessment Indicators	Average Percentage	Criteria
1	Content Feasibility Aspect	90%	Very practical
2	Feasibility of Presentation	88%	Very practical
3	Language Assessment	82,5%	Practical
4	TPACK Assessment	93,33%	Very practical
	Average	88%	Very practical

The findings derived from practical responses provided by educators demonstrate that, on average, 88% of teachers' response evaluations concerning TPACK-based modules pertaining to elasticity and Hooke's law are deemed extremely practical and applicable to the study of physics.

Eighty-six percent of the outcomes of large group trials meet the "very practical" criterion, according to the research that has been conducted. The minimum percentage achieved was 82.30% when quite practical criteria regarding an increased interest in physics were applied, whereas the maximum percentage reached 93.07% when very practical criteria were applied to the indicator of its suitability for independent learning. This indicates that TPACK-based modules can be utilized autonomously at any time and in any location. The substantial percentage obtained indicates that the developed TPACK-based physics module is devoid of any issues or deficiencies and thus does not necessitate any revisions. The developed TPACK-based physics module is practicality-based and therefore effective.

5. Discussion

The use of TPACK-based modules in learning is able to train and improve students' learning experience in using technology, and can increase student activity in learning. Technology-based learning makes the appearance and style of learning more attractive so as to avoid feelings of boredom and boredom, besides that it can increase media support in learning and have the opportunity to explore material without limitations. The use of technology applied in the experimental class is able to make the learning outcomes obtained higher than in the control class.

The research concludes with the development of a TPACK-based module encompassing content on elasticity and Hooke's law. This module was constructed utilising a professional flip PDF application, the purpose of which was to assess the viability and feasibility of its development. The outcomes of conducting field trials on a TPACK-based module were deemed valid by validators, who comprised media experts and material experts. The developed TPACK-based module satisfies criteria established by standards for the design of media development and learning materials. The objective of the conducted product development research is to create a TPACK-based module on elasticity and Hooke's law that can be utilized to enhance student learning outcomes.

6. Conclusion

The results of the analysis based on research showed that:

1. The efficacy of the TPACK-based module is substantiated by validation outcomes provided by material and media experts, with the former achieving a 76% success rate in the valid category and the latter achieving an 80.5% approval rate.
2. The practicality of the TPACK-based module is classified as extremely practical, as determined by an 86.61% student practicality questionnaire rating and an 88% teacher practicality questionnaire rating.

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