

Learning tools development based on Technological, Pedagogical, and Content Knowledge (TPACK)

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Abstract

Research on the development of TPACK-based learning tools in this linear program aims to develop Lesson Plan (RPP), Learner Modules and Worksheets (LKPD). The lesson plans in this study were developed by following the steps of learning based on Discovery Learning and by adding the TPACK component. The module and LKPD in this study were developed by incorporating the TPACK element. The module in this study can be accessed in 2 ways, hardcopy and also an online module within play store. This study was designed using a 4D development design. The instrument used in this study was in form of validation sheet. The tools that have been developed in this study were validated by experts consisting of 2 lecturers of mathematics education study program, 1 mathematics teacher and 1 widiyaswara (Civil Servant Supervisor). The results showed that the Lesson Plan that had been developed had a legitimate level of validity, the Learner Module developed had a fairly valid level of validity and the Worksheet developed also had very good criteria.

Keywords: TPACK, Research and development, Discovery learning

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Introduction

Learning tools serve as references for teachers in conducting and implementing lessons to achieve curriculum goals. Structured devices make the learning process more focused and facilitate the attainment of learning objectives (Nur Utami & Mustadi, 2017; Salim et al., 2021). The 2013 curriculum demands a learning approach that aligns with the 21st century by integrating technology into education (Redhana, 2019; Purnasari & Sadewo, 2020; Sari et al., 2017). One such approach that emphasizes technology use is TPACK-based learning.

TPACK learning combines content knowledge with technology-based pedagogical knowledge (Schmidt et al., 2009; Mishra & Koehler, 2006; Suyamto et al., 2020). Technological Pedagogical Content Knowledge (TPACK) represents the fusion of Technological Content Knowledge (TCK) and Technological Pedagogical Knowledge (TPK), enabling the effective integration of technology in the learning process. Given that teachers play a crucial role in education, they must master TPACK knowledge to effectively manage technology-enhanced learning (Arsyad, 2017; Chai et al., 2010; Dewi & Rahmawati, 2022)



The demand for technology in education is rapidly growing. Educators require technology to facilitate the learning process, particularly in today's educational landscape which places significant emphasis on its use. Therefore, implementing TPACK-based learning is essential to achieve learning objectives optimally.

For another reason, technology is currently utilized by only a subset of teachers as a means of delivering instructional content. For instance, the WhatsApp application is primarily employed as a tool for distributing study materials to students. However, instructional media often consist solely of reading materials and assignments that students must complete. Instead, teachers should diversify their use of technology to enhance student understanding of subjects. By implementing TPACK-based learning as a foundation, teachers can integrate technology effectively and adapt it to meet the specific needs of their classrooms.

The limited use of devices in education leads to lower achievement of learning goals. Meanwhile, the demand for student achievement has already reached the Higher Order Thinking Skills (HOTS) stage (Dinni, 2018). However, the current learning tools employed by teachers remain monotonous and fail to adequately support online learning for students. Therefore, efforts should be made to develop learning tools that enhance the online learning environment. These tools must be grounded in the teacher's expertise across content, pedagogy, and technology, which is known as TPACK-based learning.

TPACK is a multifaceted blend of content, pedagogy, and technology that educators must grasp. It comprises seven components: Technological Knowledge (TK), Pedagogical Knowledge (PK), Content Knowledge (CK), Technological Content Knowledge (TCK), Pedagogical Content Knowledge (PCK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical Content Knowledge (TPACK) (Mishra & Koehler, 2006). The interplay among these seven components can be described as Figure 1.

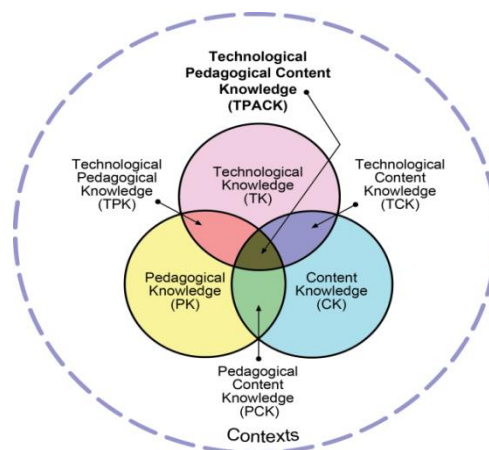


Figure 1. Interrelationship of 7 TPACK components

Methods

This research follows a developmental approach using the 4-D model developed by Thiagarajan (Kurniawan & Dewi, 2017), which includes the definition stage, design stage, development stage, and dissemination stage. Research instruments are tools employed to conduct research, specifically for data collection. In this study, researchers utilized a validation sheet to assess and provide comments and suggestions on various aspects related to the

developed product. The data collection technique in this research began with analyzing learning tools made by teachers and analyzing product validation sheets by experts including Mathematics Education Lecturers who teach Mathematics Learning Planning and Micro Teaching courses, *Widyaswara* (Civil Servant Supervisor), and mathematics teachers.

The researchers carried out an analysis of validity test data by calculating the combined percentage of the scores given by each validator. The presentation of validity data is explained descriptively. According to Akbar (Tarmizi & Sthephani, 2020), descriptive analysis can be carried out by calculating the combined value of each validator. Then, the analysis continued by calculating the combined analysis results into the validity results. The interpretation of the validity criteria categories in percentages is as Table 1.

Table 1. Instrument Validity Level Criteria

Validity Criteria	Validity Level
85,01% – 100%	Very valid or can be used without revision
70,01% – 85%	Quite valid or usable but needs minor revisions
50,01% – 70%	Not valid enough, it is recommended not to use it because it needs major revisions
0% – 50%	Invalid or unusable

Result

Define Stage

The define stage involves examining and analyzing the initial requirements for product development. This includes evaluating the instructional tools used by teachers. In our study, we focus on the instructional tools employed by several high school teachers in the Aceh Besar and Banda Aceh regions. Additionally, we collect data through interviews with high school students regarding their use of technology-based learning.

During the initial and final analysis stages, we observed that teachers' lesson plans (RPP) tend to underutilize technology (Pusdiklat, 2016) Furthermore, there is a significant lack of content elements in lesson planning. Our initial findings also indicate infrequent utilization of electronic-based modules. When learning with printed modules lacking explanations from various sources, students perceive their effectiveness to be lower. Based on these identified needs, there is a necessity for developing tools that can address a variety of existing requirements.

Design Stage

At this stage, researchers undertake several activity steps, including the selection of learning tools such as lesson plans, modules, and Student Worksheets (LKPD). The chosen lesson plan format aligns with the TPACK components and incorporates the 4C elements: Critical Thinking, Communication, Creative Thinking, and Collaboration (Mardhiyah et al., 2021). These components encompass creative thinking skills, critical thinking, problem-solving abilities, as well as effective communication and collaboration.

The module designed by the researcher incorporates all the essential components necessary for a high-quality module. These components, developed by researchers, include Front Cover Page, Module Start Page, Foreword, Table of Contents, Introduction (This section provides

details about the module, including its description, basic competencies, indicators of competency achievement, and learning objectives), Instructions for Using the Module, Concept Map, Linear Program Material (This material contains student activities, example questions, conclusions, and learning evaluations), Assessment Guidelines, Overall Conclusion, Final Learning Evaluation, Glossary, Bibliography, and Author Biography.

The research modules exist in two formats: hardcopy and application-based. Students can access the application-form modules for free via Play Store apps.

The Student Worksheets (LKPD) designed in this research include characteristic elements: 1) the worksheets are structured attractively and systematically so that students are motivated to complete them and can apply the concepts effectively, 2) the content of the worksheets is systematically organized concerning Core Competencies (KI), Basic Competencies (KD), and Competency Achievement Indicators (IPK), 3) the selected words are easy for students to understand, 4) the language used is simple and communicative, and 5) the worksheets include usage instructions to guide students in their use. The LKPD developed relates to linear programming materials adapted to the model steps taken and incorporates elements from TPACK.

Development Stage

After the planning stage is completed, the development stage will follow. The designed tools will then be validated by experts and practitioners to obtain comments and suggestions as inputs for the development process. The assessment results from the validators are as Table 2, Table 3, and Table 4.

Table 2. Lesson Plan Validation Results Data

No	Assessment Criteria	Average of Each Aspect	Validity Category
1	Subject Lesson Identity	88.75%	Very Valid
2	Formulation of Indicators and Learning Objectives	77.5%	Quite Valid
3	Material Selection	85%	Quite Valid
4	Selection of Models, Approaches, and Learning Methods	90%	Very Valid
5	Selection of Learning Media and Materials/Tools	87.5%	Very Valid
6	Selection of Learning Resources	85%	Quite Valid
7	Learning Activities with the Discovery Learning Model	73.75%	Quite Valid
8	Assessment of Learning Outcomes	86.67%	Very Valid

Table 3. Data from Module Validation Results

No	Assessment Criteria	Average of Each Aspect	Validity Category
Content Aspect			
1	Subject Identity	88.75%	Very Valid
2	Formulation of Indicators and Learning Objectives	77.5%	Quite Valid
3	Material Selection	85%	Quite Valid
4	Selection of Models, Approaches, and Learning Methods	90%	Very Valid
5	Selection of Learning Media and Materials/Tools	87.5%	Very Valid
6	Selection of Learning Resources	85%	Quite Valid
7	Learning Activities with the Discovery Learning Model	73.75%	Quite Valid
8	Assessment of Learning Outcomes	86.67%	Very Valid
Media Aspect			
9	Format	91.67%	Very Valid
10	Organization	82.5%	Quite Valid
11	Attractiveness	88%	Very Valid
12	Letter Shape and Size	82%	Quite Valid
13	Space Aspect	90%	Very Valid
14	Consistency	93.75%	Very Valid

Table 4. LKPD Validation Results Data

No	Assessment Criteria	Average of Each Aspect	Validity Category
Content Aspect			
1	Feasibility Components of LKPD design	87.5%	Very Valid
2	Language Eligibility Components	78.75%	Quite Valid
3	Presentation Eligibility Components	85%	Quite Valid
4	Content Eligibility Component with GPA and Learning Objectives	80%	Very Valid
5	Feasibility Components of the Discovery Learning Model on LKPD with GPA and Learning Objectives	53.3%	Very Valid

Discussion

The development of learning tools in this research has gone through a series of activities starting from the definition stage, design stage, and development stage. Meanwhile, the dissemination stage has not been carried out in this research due to time constraints. Hence, it is expected that the dissemination stage will be carried out in further research. This series of activities were carried out to produce new products in the form of lesson plans (RPP), modules, and LKPD based on TPACK in linear program subjects that can be used by teachers in the learning process.

Definition Stage

The define stage contains a series of activities that have been carried out by researchers in the development process starting from the analysis of the availability of teaching materials, student analysis, concept analysis, task analysis to goal analysis. Analysis of learning tools is carried out to find out what learning tools have been used by teachers in the learning process. The initial analysis in this research was to analyze learning tools in the form of lesson plans, modules, and LKPD. Researchers looked at whether the learning tools created and used by teachers so far contained elements of content, technology, and pedagogy.

Based on the researchers' analysis, the learning tools used by teachers so far still do not contain the complete elements of content, technology, and pedagogy, there is only one element, even though these three elements are important points in a learning process (Rohmaini et al., 2020). Researchers analyzed the lesson plans used by teachers, it was seen that the lesson plans made by teachers still did not follow the 21st-century lesson plan format and did not include TPACK elements in the learning steps.

Furthermore, the researcher analyzed the modules and teaching materials used by teachers. The findings revealed that these materials predominantly took the form of textbooks provided by schools. These textbooks typically included content, example questions, and practice exercises at the end of each lesson. However, the content lacked student activities that could foster independent concept discovery. Consequently, the teaching materials currently employed do not align with students' expectations.

This observation is consistent with research by Rohmaini, who identified one of the reasons for students' limited ability to solve mathematics problems: the textbooks and worksheets they use remain monotonous and fail to meet expectations (Rohmaini et al., 2020). In response to these challenges, researchers aim to address the issue by updating teaching materials for both teachers and students. Specifically, they propose developing TPACK-based mathematics learning modules.

Design Stage

After the definition stage has been completed, it continues with the design stage. At this stage, a design is obtained in the form of RPP, Module, and LKPD which are designed following the TPACK components and follow the discovery learning model (Sari & Saminan, 2017) The lesson plan developed in this research is a lesson plan that follows the 21st century (4C) format, uses a discovery learning model, and applies the use of technology (Satriawati et al., 2022). Furthermore, the researchers also developed a module for linear program material. The modules developed were in the form of hard copies and can also be accessed online. The LKPD developed in this research follows the steps of the discovery learning model.

Apart from paying attention to what elements must be present in a good module, it is very important to pay attention to the quality elements of the module that are attractive in terms of appearance. Rohmaini in her research revealed that students need interesting teaching materials so that students are motivated to learn and can make it easier for them to remember the material (Rohmaini et al., 2020). To make the resulting module applicable and work effectively in learning, the researcher designed an instrument that has an expert validation sheet containing an assessment in terms of the content and appearance of the module. Assessment in terms of module content includes the opening section, core section, and closing section. The assessment in terms of module appearance includes aspects of format, organization, attractiveness, letter shape and size, space aspects (blank spaces), and consistency. This validation sheet instrument was created based on adaptations from previous research, but several assessment criteria were modified according to the designed module (Yusuf et al., 2009). Likewise, with students' readability test sheets, the assessment includes aspects of interest, material aspects, and language aspects. This validation sheet was obtained from previous research and then modified by the researcher according to the module developed.

Develop stage (development)

After going through the definition and design stages, the development stage is then carried out. The learning tools that are ready to be designed are then validated by validators based on the assessment sheet that has been designed at the design stage. In stage I, the learning tools were validated with 4 validators, namely 2 lecturers, 1 mathematics teacher, and 1 Widiyaswara (supervisor).

After going through the validation stage, suggestions and input were obtained from the validator, then the researcher revised the product according to the suggestions and comments given. The result of the revision in the form of a new product is called a product in the form of a TPACK-based learning tool for linear programming material for MA students. This is following the results of the lesson plan validation data which has a validation value of 84.27%. Meanwhile, for the module, the validation value was 87.98% and for the LKPD the validation value was 76.91%.

Conclusion

The development of TPACK-based mathematics learning tools yielded a valid categorization based on the evaluation by validators. Expert analysis of the lesson plan indicated that the overall average assessment fell within the 'very valid' criteria. Additionally, module validation results showed that the content achieved 85%, qualifying as 'quite valid.' The module's appearance received an average assessment of 87.98%, also meeting the 'very valid' criteria. As for the LKPD (Students Worksheet), the opening part achieved 82.21%, which falls within the 'quite valid' range. Furthermore, the validation results for the LKPD in terms of shape, size, letters, and consistency reached 87.98%.

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Author Contribution : S: Conceptualization, Writing-Original Draft and Visualization.
KS: Review & Editing, Formal Analysis, Validation and Supervision.
DRF: Visualization.
RH : Software.

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- Conflict of Interest : The authors declare no conflict of interest.

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