

JPPIPA 11(3) (2025)

Jurnal Penelitian Pendidikan IPA Journal of Research in Science Education

Journal of Research in Science Education



http://jppipa.unram.ac.id/index.php/jppipa/index

Development of Teacher Guide Book Based on Technological Pedagogical Content Knowledge (TPACK) on the Material of Forms of Matter and Their Changes for Grade IV Elementary School

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Received: November 22, 2024 Revised: January 11, 2025 Accepted: March 25, 2025 Published: March 31, 2025

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DOI: 10.29303/jppipa.v11i3.9799

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Abstract: This study aims to develop a teacher's guidebook based on Technological Pedagogical Content Knowledge, especially on the material of the state of matter and its changes in grade IV Elementary School. The method used in this study is the Research and Development research method through the Analysis, Design, Development, Implementation, and Evaluation approach. The level of feasibility and practicality and effectiveness through the stages of analysis, design, development, implementation, and evaluation that focus on the material of the state of matter and its changes are based on the trial of the feasibility and practicality of the product with respondents in the implementation, namely expert validation tests, teacher response questionnaires and students. The level of effectiveness measured through a simple evaluation in measuring the achievement of student learning motivation is based on a statistical test stating the r_{table} value in this study where N = 32 and sig. 0.05 of 0.349. From the results of the validity test in the table above, it is known that the feasibility variable has a calculated $r_{value} > r_{table}$, so it can be said that all statement items in the feasibility variable are valid and can be used as a measuring tool in research. The results of the pretest and posttest analysis conducted to measure the improvement in student learning outcomes through the N-Gain test showed that the percentage of students who completed the product implementation group was 86.88%.

Keywords: Learning applications; Technological Pedagogical Content Knowledge (TPACK); Teacher guide book

Introduction

In the era of the alpha generation like today, the views and mindsets of this generation are more open and advanced than the previous generation. The alpha generation is the generation that is most familiar with the internet of all time. The generation that is most familiar with digital technology and the generation that is claimed to be the smartest compared to previous generations (Purnama, 2018) Of course, the current education that must be carried out is education that can facilitate the alpha generation who are familiar with digital technology. Teachers at this time are no longer the only source of learning, but teachers become facilitators who are able to facilitate the learning of this alpha generation of children (Asni et al., 2023).

During the endemic period after the Covid-19 virus outbreak, the transition period for learning that was

How to Cite:

Lestari, N., Irdalisa, & Amaliyah, N. Development of Teacher Guide Book Based on Technological Pedagogical Content Knowledge (TPACK) on the Material of Forms of Matter and Their Changes for Grade IV Elementary School. *Jurnal Penelitian Pendidikan IPA*, 11(3), 355-363. https://doi.org/10.29303/jppipa.v11i3.9799

originally carried out online, where educators and students were forced to follow the flow taken by the school so that learning could take place well and smoothly by utilizing technology as a learning medium, is now starting face-to-face learning activities again (Sholihah & Amaliyah, 2022). The use of technology during the endemic period is still utilized by educators and students in the learning process. Teachers have not utilized and implemented technology-based media in learning so that the learning process is less than optimal (Utami & Amaliyah, 2022).

Based on the researcher's observations conducted on Friday, March 7, 2023 at SDN Cijantung 05 Pagi, the implementation of teacher learning has utilized technology as one of the learning media (Amaliyah, 2021). However, this is not optimal because some teachers are still unable to master and apply technologybased media optimally, so that students are passive in the learning process and do not understand the learning that has been carried out. The lack of technology-based learning media, pedagogy, knowledge with in-depth content is one of the factors causing student learning outcomes not to achieve the expected results (Amaliyah, 2023). Another problem, the researcher found that the value of the Natural and Social Sciences (IPAS) subject on the material on the state of matter and its changes obtained was still below the Learning Objective Achievement Criteria with an average class value of 67.86. This happens because teachers are not optimal in planning learning, developing learning materials and media, and the use of Technological Pedagogical Content Knowledge (TPACK) in developing teaching materials in the learning process is not optimal (Putri et al., 2022).

Based on the background description above, the researcher wants to develop a research on the development of a teacher's guidebook based on Technological Pedagogical Content Knowledge (TPACK) (Bahtiar et al., 2023). The researcher wants to design this research on teaching modules, LKPD, and material development. In several previous studies that have been described above, there are several studies related to the development of teacher guidebooks and learning devices that have been studied, but the research subjects are more on students and high schools (Anggriani et al., 2022). So, the researcher is interested in conducting the latest research, namely by developing a Teacher's Guidebook (BPG) Based on Technological Pedagogical Content Knowledge (TPACK) for Elementary Schools on the material of the form of matter and its changes (Darmawahyuni & Nurmaini, 2019).

Method

Research Methods, Models, Time, and Subjects

This study uses a research and development (R&D) method. with a sample of fourth grade students at SDN Cijantung 05 Pagi East Jakarta 2022/2023. This research was conducted from June to November of the 2022/2023 school year. This research and development are gradual through a research design using the ADDIE approach (Adeoye et al., 2024). Referring to the perspective developed by Robert Maribe Branch. The steps of research and development according to the ADDIE model learning design scheme form a cycle consisting of 5 stages consisting of: Analysis, Design, Development, Implementation and Evaluation (Hidayat & Nizar, 2021) which consists of developing teaching modules, creating LKPD through the Technology pedagogic and content knowledge (TPACK) approach using word wall applications, live worksheets, and puzzle makers. Development of TPACK-based teaching instruments and materials through the canva and digital popup book features (Susanti et al., 2024).

Field Research and Data Collection Techniques

At the analysis stage, the activities carried out include needs analysis which is the initial step and is the basis for developing teacher guidebooks (Darmiyani et al., 2022). In conducting the needs analysis, the source of information in the context of learning in this development was obtained from the Decree of the Head Education Standards, Curriculum, of the and Assessment Agency of the Ministry of Education, Culture, Research, and Technology Number 008/H/KR/2022 concerning Learning Achievements in Early Childhood Education, Elementary Education Level, and Secondary Education Level in the Independent Curriculum of the Head of the Education Standards, Curriculum, and Assessment Agency of the Ministry of Education, Culture, Research, and Technology related to the curriculum and learning outcomes for grade IV in phase B and the Natural and Social Sciences teacher's guidebook (Veryawan et al., 2023).

The second stage of the Design process is that the Author designs the product by selecting and determining the materials used according to the learning outcomes to be designed, including designing the Natural and Social Sciences (IPAS) Teaching Module for grade IV on the material of the Form of Matter and Its Changes, student worksheets, and Development of a Teacher's Guidebook (BPG) Based on Technological Pedagogical Content Knowledge (TPACK) on the material of the form of matter and its changes (Pigai & Yulianto, 2024). Next, in the third stage, namely the Development Stage, this stage is the stage to develop the 356 design and realize the design that has been prepared to create a Teacher's Guide Book (BPG) based on Technological Pedagogical Content Knowledge (TPACK), including the Natural and Social Sciences (IPAS) Teaching Module for grade IV on 62 materials on the Form of Matter and Its Changes, student worksheets, and the Development of a Teacher's Guide Book (BPG) on Technological Pedagogical Content Based Knowledge (TPACK) on the material on the form of matter and its changes which will be validated by language experts, material experts, and media experts related to the feasibility and practicality of developing a teacher's guide book based on Technological Pedagogical Content Knowledge (TPACK) (Meutiawati et al., 2024).

The fourth stage, Implementation The implementation stage is a real step to implement the Teacher's Guide Book (BPG) that has been developed through the Technological Pedagogical Content Knowledge (TPACK) approach (Putri et al., 2023). This means that at this stage, validation tests and reliability tests of the products that have been developed will be carried out so that they can be implemented (Sugiarta et al., 2023).

The fifth stage of this process is the Evaluation Stage. The evaluation stage aims to measure the product's ability to achieve previously set goals and objectives. Seeing the extent to which the product made can achieve previously set goals and objectives (Adamson & Darling-Hammond, 2015). The media used to measure the level of success through a written pre-test and post-test using the word wall, live worksheets, quizziz and google form features (Sabani, 2025). Due to the limited time of the study, at this evaluation stage the author will only test the effectiveness of the product simply. Data Analysis The final data analysis in this descriptive study used quantitative analysis (Mackiewicz, 2018). The data analyzed included the values obtained from the validator team, the values from observations and questionnaires of teachers and students, and the values obtained from the results of the pretest and posttest by calculating with the t-test. Analysis of the results of student tests from the pretest and posttest used to determine the effectiveness of the teacher's guidebook in the science learning process, so in this study using the N-Gain test for statistical testing (Hermawati & Yulianto, 2025).

Result and Discussion

Results Analysis

Based on the analysis of student needs, the learning outcomes of students in the Natural and Social Sciences (IPAS) subject of the material on the state of matter and its changes have not reached the Learning Objective Achievement Criteria (KKTP) with an average class value of 67.86. Based on the analysis of student needs, it is necessary to improve student outcomes. Therefore, the researcher seeks to develop a product in the form of a Teacher's Guidebook (BPG) based on Technological Pedagogical Content Knowledge (TPACK) on the material on the state of matter and its changes for Grade IV Elementary School by utilizing technology-based features and applications to deepen knowledge and content on the material (Gunanto & Suprivadi, 2021). In analyzing needs, the researcher will test the validity, feasibility, and practicality of the product development the Teacher's Guidebook (BPG) of based on Technological Pedagogical Content Knowledge (TPACK) on the material on the state of matter and its changes for Grade IV Elementary School (Fakhriyah et al., 2022). After the product being developed has been determined, the next stage is to collect further data and information regarding the product being developed so that it is in accordance with the analysis of needs and learning characteristics at SDN Cijantung 05 Pagi.

Design

The first stage in the Development of Teacher Guide Books (BPG) based on Technological Pedagogical Content Knowledge (TPACK) on the material of the state of matter and its changes for Grade IV Elementary School begins with making a learning plan. The learning plan design is made in the form of a teaching module as follows.

ILMU PENGETAHUAN ALAM

BAB 2. WUJUD ZAT DAN PERUBAHANNYA

MODUL AJAR

DIFORMASE UNUM			
Nama Penyusun	: Noni Lestari, S. Pd.	Fase / Kelas	1 8 / IV (Empat)
Unit Kerja	: SDN Cijantung 05 Pagi	Nata Pelajaran	: Simu Pengetahuan Alam
Alokasi waktu	: 27.39	Juniah Peseta Didik	: 32 PD / heterogen
Profil pelajar Pancasila yang berkaitan	 Eletaçua terhadap Tuhan YME. berakhlak mula Mandri Bernalar kritis Bernalar kritis Bergotong reyong Kreatif 	Noda Pembelajaran Nodel Pembelajaran Metode Pembelajaran	1 Tatap Nuka 1 Project Sase Learning 1 Ceramah, tanya jawab, diskusi demonstrasi dan Penugasan

Figure 1. Teaching module on the material of the form of matter and its changes

In designing the teaching module, the learning steps are designed in accordance with the provisions of the Technological Pedagogical Content Knowledge (TPACK) approach in creating content through YouTube content, https://youtu.be/1CPSQ0zNBuI and digital popup books. Student Worksheets (LKPD) through the IT-based TPACK approach 89 use the liveworksheet, wordwall, quizziz, and googleform applications as a form of evaluation (Mulyanah et al., 2024). At the content design stage based on



Technological Pedagogical Content Knowledge (TPACK), the author designs content through YouTube content and digital popup book applications (Haryati et al., 2022).



Figure 2. Content design based on Technological Pedagogical Content Knowledge (TPACK)

Researchers develop learning materials through several references such as teacher's guide books from the Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia 2021 (Salsabila et al., 2024). Deepening of Materials Based on Digital Technology Apart from the teacher's guide books, the materials are further deepened through YouTube content, Google and collaboration with colleagues, as well as several other books related to the material on the Form of Matter and Its Changes.



Figure 3. Deepening the content of the material through the digital popup book application

The design of the teacher's guidebook developed by the researcher is a development of the teacher's guidebook published by the Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia in 2021 which has been used by teachers in grade 4 (Johan, 2018). At the design stage of the Student Worksheet (LKPD) based on Technological Pedagogical Content Knowledge (TPACK), the author designed it in the form of using the liveworksheet application, wordwall, quizziz, and googleform application as a form of evaluation (Wangsa & Indah, 2024).

Development

The researcher started the stage of Developing a Teacher's Guidebook (BPG) Based on Technological Pedagogical Content Knowledge (TPACK) on the Material of the Form of Matter and Its Changes in Grade IV Elementary School. The purpose of this stage is to validate the language expert and the development of a TPACK-based teacher's guidebook. The results of the language expert assessment questionnaire on the Development of Teacher Guide Books (BPG) Based on Technological Pedagogical Content Knowledge (TPACK) on the Material of the Form of Matter and Its

Changes for Grade IV Elementary Schools based on the linguistic aspects containing 6 indicators and 15 statements, obtained the following results.

Table 1. Results of validation of language expert assessment instruments

Aspect	Amount	Criteria
Language Aspect	22.00	Very Worthy
Mean	3.67	Very Worthy

Based on the following statement, the Development of Teacher Guide Books (BPG) Based on Technological Pedagogical Content Knowledge (TPACK) on the Material of the Form of Matter and Its Changes for Grade IV Elementary Schools based on the linguistic aspect is declared valid, showing an average of 3.67 in a percentage of 91.75% with very feasible criteria.

The results of the media expert assessment questionnaire on the Development of Teacher Guide Books (BPG) Based on Technological Pedagogical Content Knowledge (TPACK) on the Material of the Form of Matter and Its Changes for Grade IV Elementary Schools based on the appearance aspect, there are 6 indicators and 15 statements and the programming aspect, which contains 1 indicator and 5 statements, obtained media results showing an average of 3.76 in a percentage of 94% declared valid with very feasible criteria (Rahman, 2019).

The results of the material expert assessment questionnaire on the Development of Teacher Guide Books (BPG) Based on Technological Pedagogical Content Knowledge (TPACK) on the Material of the Form of Matter and Its Changes for Grade IV Elementary Schools, there are 10 indicators and 20 statements consisting of learning achievements, learning materials, learning methods, learning resources, and learning activities showing that an average of 3.69 in a percentage of 92.25% is declared valid with very feasible criteria (Iswanto et al., 2021).

Implementation

The implementation stage is a real step to implement the research development that has been made. Based on the results of the initial data analysis in this study using qualitative descriptive analysis. The results of the teacher response feasibility questionnaire on the Development of Teacher Guide Books (BPG) Based on Technological Pedagogical Content Knowledge (TPACK) on the Material of the Form of Matter and Its Changes for Grade IV Elementary Schools conducted by two teachers as respondents, there are four aspects consisting of the feasibility of content, language, material, and media and 15 indicators that obtained the following results (Mulyanah et al., 2024).

Table 2. Results of the teacher res	ponse feasibility	assessment instrument
	, j	

	1			
Aspects	Mean Responden 1	Mean Responden 2	Mean	Criteria
Content Suitability	3.5	3.75	3.63	Worthy
Language	4	3.5	3.75	Worthy
Material	3.25	4	3.63	Worthy
Media	3.4	3.6	3.5	Worthy
Total Number	14.15	14.85	14.51	
Mean	3.54	3.71	3.63	Worthy

Based on the teacher response questionnaire on the Development of Teacher Guide Books (BPG) Based on Technological Pedagogical Content Knowledge (TPACK) on the Material of the Form of Matter and Its Changes for Grade IV Elementary Schools, it shows that 104 are at an average of 3.63 in a percentage of 92.25% with feasible criteria (Sahin, 2018).

Table 3. Results of the assessment instrument for the eligibility of student responses

Aspect	Mean	Criteria
Learning Media	3.35	Good
Material	3.42	Good
Benefits	3.48	Good

Aspect	Mean	Criteria
Total Amount	10.25	
Mean	3.42	Good

Based on the questionnaire of the feasibility of student responses to the Development of Teacher Guide Books (BPG) Based on Technological Pedagogical Content Knowledge (TPACK) on the Material of the Form of Matter and Its Changes for Grade IV Elementary Schools, it shows that it is at an average of 3.42 in a percentage of 85.5% with good criteria (Surayya et al., 2023).

At this stage, the Development of Teacher Guide Books (BPG) based on Technological Pedagogical Content Knowledge (TPACK) which focuses on the Material of the Form of Matter and Its Changes which has been tested and revised began to be implemented so that a final product was created from the development of teacher guide books that were feasible and tested for use by others. The stages in product distribution include the following. The product implementation stage is the stage of testing the teacher guide book on a wider scale. The respondents in this implementation were 2 teachers and 32 Grade IV students.

Evaluation

The evaluation stage is carried out to determine the use of the product in the learning process. However, because this study has time constraints and research limitations, in the evaluation stage, the researcher only tested the validation results, feasibility and practicality of the product only at the evaluation stage of the Student Worksheet in the form of pretest and posttest questions (Usman et al., 2024). This study is in line which only researched through the stages of analysis, design, implementation and development. This study is also in line with Rahmat Arofah Hari Cahyadi who conducted the evaluation stage in the formative evaluation. Based on the results of the initial data analysis in this study using qualitative descriptive analysis. The data analyzed include the results carried out with grade IV students at SDN Cijantung 05 Pagi, the following is an explanation of the results in the following table (Septiyani et al., 2022).

Table 4. Test calculation results

Data Tura	Class		
Data Type	Pretest	Postest	
Amount	2.172	2.780	
Maximum Value	94	100	
Minimum Value	46	70	
Average	67.86	86.88	

Based on the table above, it can be explained that the average score in class IV at SDN Cijantung 05 Pagi before receiving treatment was 67.86 and after treatment the average score increased to 86.88. This shows an increase in student learning outcomes after the teacher carried out learning activities using the Teacher's Guide Book 115 (BPG) Based on Technological Pedagogical Content Knowledge (TPACK) (Yarni & Kusuma, 2022). Data analysis of the pretest and posttest results of students was carried out to measure the ability to understand concepts and student learning outcomes before and after learning on the material on the state of matter and its changes as a benchmark for the effectiveness of product development (Salsabila et al., 2024; Bangun et al., 2024).

Effectiveness is measured simply using the average score in class IV at SDN Cijantung 05 Pagi before the teacher carried out learning using the product 67.86 and after the teacher carried out learning using the product the average score increased to 86.88. This shows an increase in student learning motivation and effectiveness in learning using the Teacher's Guide Book (BPG) Based on Technological Pedagogical Content Knowledge (TPACK) (Hayati, 2022; Eviota & Liangco, 2020). Final data analysis was conducted to determine the feasibility, validity and effectiveness of the developed product in a simple way. Final data analysis in this study used quantitative descriptive analysis in the form of values obtained from the results of the pretest and posttest (Net et al., 2024).

Analysis of student test results from the pretest and posttest used to determine the feasibility of the Teacher's Guide Book (BPG) Based on Technological Pedagogical Content Knowledge (TPACK) in the science learning process on the material of the state of matter and its changes. Therefore, in this study, a gain score will be used. Calculating the normalized Gain score based on the formula according to The N-Gain test was conducted using pretest and posttest data on the product trial group and the product implementation group presented in the following table (Putri et al., 2023).

Table 5. Results of the calculation of the N-Gain score test for the product trial group

Parameter	N	Min	Max	Mean	Std.Deviation
NGain	32	-8.00	1.00	0.3282	1.56255
Valid N	32				

From the data, it can be seen that the value of student learning outcomes after using the Development of Teacher Guide Books (BPG) based on Technological Pedagogical Content Knowledge (TPACK) with the N-Gain test, the result is 0.3282. Based on the criteria expressed it is included in the moderate category.

Conclusion

Based on the results of the research and discussion of the development of the Teacher's Guidebook based on Technological Pedagogical Content Knowledge on the material of the state of matter and its changes for Grade IV Elementary School, it can be concluded that, the Process of Developing a Teacher's Guidebook based on Technological Pedagogical Content Knowledge on the material of the state of matter and its changes for Grade IV Elementary School is valid and feasible and practical to use at SDN Cijantung 05 Pagi. In developing teaching materials, and student worksheets through the

Technological Pedagogical Content Knowledge approach in the learning process of the material of the state of matter and its changes for Grade IV Elementary School by utilizing technology-based features and applications to develop a valid and feasible teacher's guidebook can help teachers improve student learning outcomes so that they can be achieved optimally. The results of the expert instrument on the Development of a Teacher's Guidebook Based on Technological Pedagogical Content Knowledge on the Material of the State of Matter and Its Changes for Grade IV Elementary School based on the linguistic aspect showed an average of 3.67 in a percentage of 91.75% with very feasible criteria. The development of a Teacher's Guidebook Technological Pedagogical based on Content Knowledge on the material of the state of matter and its 140 changes for grade IV Elementary School through the ADDIE approach is declared practical to use . Based on the questionnaire on the practicality of teacher responses to the Development of a Teacher's Guidebook Based(Jurnal et al., 2024) on Technological Pedagogical Content Knowledge on the Material of the State of Matter and Its Changes for Grade IV Elementary School on the practicality variable, it is known that there is one invalid item, namely item 10 where the r-count value <r> 0.6.

Acknowledgments

The researcher would like to thank all parties who have contributed to this research, To the Supervisor, Mr. and Mrs. Expert Lecturers who have provided input, support and suggestions. To the Principal and Teachers of Cijantung 05 Pagi Elementary School who have given permission. To the Parents who have provided moral and material support and to all parties who have helped in every process.

Author Contributions

All authors contributed to the preparation of this article. The author members jointly carried out each stage of the preparation of this article.

Funding

This research is independent research, does not receive external funding from any party and in any form.

Conflicts of Interest

The author declares no conflict of interest in the publication of this scientific article.

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