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Development of Number Puzzles on KPK And FPB Materials to Improve Mathematics Learning Outcomes

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ABSTRACT

Purpose of the study: The purpose of the study was to test the feasibility and effectiveness of the Number Puzzle media product developed by the researcher, as an innovation in improving math learning outcomes on the material of the Smallest Common Multiple and Greatest Common Factor.

Methodology: This research is a Research and Development (R&D) study with qualitative and quantitative approaches. Researchers used simple random sampling. Data sources consisted of primary and secondary. The research data were obtained from test and then non-test techniques, which include interviews, questionnaires, observations, and a combination of all of them. The aspects measured were learning media, learning outcomes, and learning needs of mathematics subjects.

Main Findings: The learning environment is less supportive in the use of concrete learning media with student characteristics, so learning is not effective. Many students have difficulty in understanding math concepts. The main problem is that a variety of learning media has not been used, only in the form of teacher books, student books and student worksheets.

Novelty/Originality of this study: The novelty of this research is to develop a product in the form of a number puzzle media (puka). The number puzzle media (puka) is designed in the form of a rectangle, with numbers that can be read clearly, the number puzzle media (puka) is designed with the right and harmonious color selection, the number puzzle media (puka) is equipped with QR-Code, so that the learning atmosphere becomes more active, creative, and fun.

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1. INTRODUCTION

Mathematics is one of the fundamental subjects in basic education that has an important role in the development of logical and systematic thinking in students. Mathematics provides opportunities for students to engage in logical reasoning, which is essential for problem solving [1]. However, various studies show that many elementary school students still have difficulties in understanding mathematical concepts, especially related to Least Common Multiple (LCM) and Greatest Common Factor (GFP). This lack of understanding has an impact on students' learning outcomes, which are not optimal and reduces their interest in mathematics. Many students view math as challenging and boring, leading to decreased motivation and avoidance of the subject [2]. One of the effects of learning difficulties is the use of learning media that is less creative, or boring [3]. The role of the teacher is very important in presenting all aspects of learning. The teacher is the driving force who has to design it himself [4]. The concepts of KPK and FPB are often considered abstract by students, causing difficulties in

understanding them. Conventional learning methods that only rely on lectures and practice problems tend to make students less active and unmotivated [5]. Therefore, learning requires an innovative approach, to make it more interactive, interesting, and fun for students. With this approach, it is easier to understand the concept. Usage in the past years of interactive learning media has been increasingly applied as a solution to improve students' understanding and motivation to learn. Interactive media, such as educational games and digital multimedia, have been proven to improve student learning outcomes compared to traditional methods [6].

The development of game-based learning media is expected to help students understand KPK and FPB with more fun. One innovative alternative that can be applied is Puzzle Numbers (PUKA), a number game-based learning media designed to help students understand math concepts through a more interesting learning experience. The use of a game-based approach has been shown to increase student participation in learning as well as improve critical thinking and problem solving skills [7]. Although there have been many studies on interactive learning media, not many have specifically developed number-based games for KPK and FPB materials. Visible gaps that can be done media development innovations, which adjust the character of elementary school students [8]. The development of interactive learning media such as PUKA is also in line with national education policies that encourage the use of technology in learning. Based on previous research, interactive learning media can significantly improve concept understanding and student learning outcomes [9]. By applying PUKA in math learning, it is expected that students can more easily understand KPK and FPB and be more enthusiastic in learning. As an innovative learning media, PUKA can be implemented in various elementary schools easily. In addition, the game-based approach can be used by teachers as a tool in delivering math materials in a more interesting and effective way [10].

Theoretically, this research will add insight into the effectiveness of using educational games in learning mathematics at elementary school stage. Based on the opinions of experts and previous research which states that the number puzzle learning media is feasible and certainly appropriate in learning in elementary schools. As well as considering other things that have been described above, researchers want to conduct development research on learning media that can provide students with ease of learning about KPK and FPB, so researchers intend to conduct development research with the title "Development of Number Puzzle (PUKA) KPK and FPB material to improve Grade V Mathematics Learning outcomes at elementary school 4 Mindahan Jepara". Practically the results of this research can make it a reference for teachers and learning media developers in creating more interesting and effective learning innovations. Lev Vygotsky's theory of the Zone of Proximal Development (ZPD) (1978) suggests that students can develop better understanding with the help of peers or teachers [11]. Therefore, interactive learning models, such as the use of game-based media, are highly recommended in learning mathematics in elementary school.

Mathematics learning in elementary school aims to develop the ability to think logically, analytically, systematically, critically, and creatively in solving problems. Based on Jean Piaget's theory of constructivism in the book [12], children build their understanding through direct experience and social interaction. One of the materials that is often a challenge for students is the concept of Least Common Multiple (LCM) and Greatest Common Factor (GFP). The main difficulties in understanding this material are caused by students' lack of understanding of factors and multiples, difficulty of understanding abstract concepts without visual aids or educational games, and effective communication on the material [13]. To overcome this obstacle, teachers can create a conducive classroom atmosphere, and use of learning media or concrete props to clarify the presentation of concepts with more fun and depth. Then the teacher provides reinforcement at the next meeting by being able to review or repeat the material, and provide remedial programs to train to solve problem problems [14]. the use of media is beneficial in learning, including making the presentation of information clearer and easier for teachers to convey to students, attracting the focus and attention of students to learning material so that students are motivated in learning activities, homogenizing stimuli to minimize information received by students, solving problems of space and time limitations, and can get used to independent learning in students [15]. The benefits of learning media are getting a real picture so that it is not too verbose, students can see firsthand the process which fosters direct interaction between students, teachers, neighborhood or reality, students will be clear observe the important basis for learning in order, reach a large audience and observe objects simultaneously at the same time [16].

Number Puzzle is a game-based learning media that integrates numbers and math operations to help students understand the concepts of KPK and FPB. The development of number puzzles is based on a game-based learning approach [17]. With this concept, number puzzles not only function as learning aids but also as media that can increase student motivation and learning math will be engaged. Puzzle is a game by breaking and installing puzzle pieces that consist of certain patterns to stimulate abilities [18]. Puzzle is a media that involves students to increase critical and creative thinking skills with the motivation to solve a problem that puts the pieces together [19]. As for the advantages of using puzzle media is to train students to be thorough, improve memory, introduce students to the concept of relationships, and train students to think mathematically using the left brain [20], usage of the puzzle media in learning can help improve students' understanding and interest in

learning significantly [21]. Number puzzles are also defined as tools that stimulate cognitive, basic counting skills of students, by arranging the appropriate puzzle pieces [22].

Usage of the puzzle media can be applied to math subjects so that the teaching method from the teacher varies and the motivation of students increases [23]. Based on several definitions that have been described, it can be concluded that puzzle media is a medium in the form of pieces that are put together in one pattern. Therefore, product trials and evaluations will be conducted in stages to ensure its effectiveness in improving student learning outcomes. The main objective of this research is to develop and test the effectiveness of PUKA as a learning medium in improving students' understanding of KPK and FPB in grade V of SD Negeri 4 Mindahan Jepara. In addition, this study also aims to evaluate the extent to which this game can increase students' motivation and engagement in learning mathematics. Through this research, it is expected that PUKA can be an alternative learning media that is innovative and effective in improving mathematics learning outcomes of elementary school students. In addition, the results of this study are also expected to contribute to the world of education in the development of game-based learning methods that are more interesting and in accordance with the needs of 21st century students. It is important to understand mathematical concepts through real-life experiences and contexts [24].

Medium means communication intermediary, and can also mean the delivery of information from the communicator to the recipient of information, namely the communicant. Learning media is a tool used to convey material more effectively and interestingly [25]. Learning media is a tool from the information provider, namely the teacher to the students or recipients of information so that the teacher can streamline the delivery of material and the learning process gets a lot of information that affects the conditions, motivation, and atmosphere of learning [26]. Learning media is a tool used in the classroom to support learning with procedures for use in supporting learning objectives [27]. Media can be called learning media if it contains messages and also goals consisting of two elements, namely the message that the teacher will convey to students, and the viewer [28].

2. RESEARCH METHOD

This research applies (R&D) with a qualitative and quantitative approach which aims to develop and test the effectiveness of learning media in the form of Number Puzzle (PUKA) to improve students' math learning outcomes on KPK and FPB material [29]. The type of Research and Development (RnD) research is a scientific way to research, design, produce, and test the validity of products that have been produced. This research develops a product in the form of learning media with the title “Development of Puzzle Numbers (PUKA) KPK and FPB material to Improve Learning Outcomes Grade V Mathematics at SD Negeri 4 Mindahan Jepara”. This study aims to test the feasibility and effectiveness of the number puzzle product developed by researchers. The media development model used by researchers in this study is the ADDIE model which consists of five stages, namely analysis, design, design, development, implementation, and evaluation.[30]. The research was conducted at SD Negeri 4 Mindahan which is located on Mindahan Kidul road, Batealit Subdistrict, Jepara Regency. It was chosen as a research place because SD Negeri 4 Mindahan, especially class V, needed an alternative in the problem of learning media. This research uses two types of data, namely quantitative data and qualitative data. Quantitative data is data in the form of numbers or qualitative data that is scaled / scoring. Quantitative data in this study are data on learning outcomes. Qualitative data is a type of data in the form of observation, interviews, and documentation studies. Qualitative data in this study are data from interviews that have been conducted with class teachers, questionnaires answered by students, observation data, and documentation. The secondary data of this research is in the form of interviews with class teachers and the results of distributing questionnaires to students. The secondary data of this study is in the form of daily learning outcomes from the teacher. The research subjects in this study were fifth grade students of SD Negeri 4 Mindahan, with the determination of subjects using census sampling (total sampling which where all the population, namely fifth grade students of SD Negeri 4 Mindahan Jepara. This is because the total population is 38 people. The independent variable in this study is the number puzzle learning media (PUKA). The dependent variable in this study is improving fifth grade math learning outcomes at SD Negeri 4 Mindahan Jepara.

Number puzzle media is a learning media game that contains numbers, and puzzle pieces. This game can be used by teachers as a tool in delivering math material in a more interesting way. Retrieval of learning outcomes from the development of mastery of cognitive learning arithmetic logically systematic, analytical, balanced with creative and critical skills as maximization of potential. Data collection is carried out using several techniques, namely interviews (interviews), questionnaires (questionnaires), observation (observation), and a combination of the three. researchers use structured interview data collection techniques where researchers have prepared research instruments in the form of questions. Researchers conducted interviews with fifth grade teachers of SD Negeri 4 Mindahan Jepara whose purpose was to find out all the implementation of Mathematics learning. According to Sugiyono (2020: 283) the framework is a conceptual model of how theory relates to various factors that have been identified as important problems. The framework contains the relationship between the variables to be studied. In this study using the ADDIE model development steps, namely Analysis,

Design, Development, Implementation, and Evaluation. Through the development of this learning media, it is hoped that it can improve the learning outcomes of students so that students can easily understand the KPK and FPB material [31].

The first stage is Analysis in the form of needs analysis. Researchers conducted observations and interviews with fifth grade teachers at elementary school 4 Mindahan to identify problems in the mathematics learning process, especially in the KPK and FPB material. Based on the results of initial observations, it was found that students had difficulty understanding abstract concepts and the lack of interactive learning media. The analysis also included a literature and curriculum review to ensure that the materials and learning objectives were in accordance with applicable educational standards.

The initial design includes the selection of puzzle shapes, colors, difficulty levels, and instructions for use. Research instruments such as validation questionnaires, observation sheets, and evaluation tests (pretest-posttest) are also prepared at this stage. After the design, the Number Puzzle media was developed using thick plywood material and number stickers with attractive designs. The initial product was then validated by two material experts and one learning media expert.

Then Development stage is related to making learning media, by adjusting the design. The implementation stage was carried out by applying PUKA media in small group test learning activities totaling 10 people in class V at elementary school 4 Mindahan. This stage is to ensure that the learning design, teaching techniques, teaching materials achieve the desired success or validity. Furthermore, PUKA media is used in learning. The teacher acts as a facilitator, while students actively arrange puzzles to solve KPK and FPB problems. After the activity was completed, students were given a posttest to measure the improvement of learning outcomes. If it has a positive impact, a large group trial of 28 people is continued.

Figure 1. Small group implementation

Figure 2. Large Group Implementation

Evaluation is carried out in two forms, namely formative and summative. Formative evaluation is in the form of feedback from students and teachers through response questionnaires, while summative evaluation is carried out through comparative analysis of pretest and posttest results. To determine the improvement of learning outcomes, the N-Gain test was conducted. In addition, the normality test and paired sample t-test were used to determine the significance of differences in learning outcomes before and after treatment.

Data in this study were obtained through several instruments, namely questionnaires (for validation and response), observation sheets (for process documentation), and objective test questions (pretest-posttest) to

measure learning outcomes. Quantitative data were analyzed using SPSS for normality test and t-test, while qualitative data were analyzed descriptively. The research phase was conducted from November to March, involving various sources, namely students, teachers, and research documents. First, observation of the math teaching and learning process by making notes on learner involvement and interaction. Second, interviews with class teachers, and distributing questionnaires to students. Then observe the daily test of class V students Sd Negeri 4 Mindahan Jepara which amounted to 38.

Through this approach, researchers try to increase the concept of understanding and experience of students about the concept of KPK and FPB more broadly, from the response during learning.

3. RESULTS AND DISCUSSION

Researchers developed number puzzles of kpk and fpb material. there are also previous studies that developed other media. Various types of game-based learning media have been developed, including traditional games such as Dakonmatika (Dakota), which adapts the dakon game to teach the concepts of GCD and LCM [32]. Then there is the educational media Congklak Bilangan (Cogan) which is designed to increase the understanding of mathematical concepts [33], and komika which also helps students understand the concepts of KPK and FPB [34]. In addition, there are educational board games such as Ludo Math, which is designed to enhance critical math thinking that helps students find patterns and understand operations [35]. Research in the field of education has been carried out by several researchers, including research on learning media in the form of puzzles. Research conducted by Kervin (2024), states that puzzles are suitable for learning Mathematics. This is indicated by the experimental group's average pretest score of 10.39 with a standard deviation of 4.33 and a satisfactory post-test average of 18.73 with a standard deviation of 4.76 [36]. Research conducted by Ramlah (2022), interest in learning increases 82%, ease of understanding 78%, and media presentation 80% with a total overall response increasing 80% [37]. Research conducted by Darmayanti (2023), it is very good and feasible to use in learning. This is shown in the average percentage value obtained from material experts 89.4% and 90.1% from media experts [38]. Research conducted by Wijaksono (2022) use of puzzle games is effective. This is shown by the average pre-test score of 61.92 and the average post-test score of 83.36 [39].

Research conducted by Demetroulis (2024), it is valid and can be used to measure skills. The average value in the first test was 87.40 and the second test (retest) was 87.40 [40]. Research conducted by Pratama (2023) The study was declared valid, because it was effective in reducing pressure, providing a positive experience, and increasing user interest in mathematics, with valid and reliable user evaluation results [41]. The small group approach can be more focused, success is also determined by school conditions, and the growth of logistical, emotional, and professional challenges [42]. Puzzle learning media is very valid and can be used without much revision. This is indicated by the media expert validation test value of 93.7% without design revisions and material expert validation of 90.6% which is in accordance with the content, and supports the critical skills of students. The research is relevant to the research that the researcher will conduct [43]. A significant effect in proving that puzzle-based educational games such as Zoombinis are valid and can be used to detect learning [44]. The demonstration method with puzzle media on learning motivation. The pretest of all students was 100% less and the posttest met the criteria for classical completeness, namely 75% of the total number of students [45]. Research conducted by Nurhadiani (2024) significantly improves students' numeracy skills, with an average pretest score of 22.00 and an average posttest score of 49.16 [46]. Research conducted by Sinaga (2024) which states that it is valid with the research results of material expert validation 92.6% and media expert validation 95%. The research is relevant to the research that the researcher will do. The similarities between this research and the research conducted by researchers are the same as developing puzzle media. Another similarity between these studies lies in the subject of grade V students in elementary school. Then there are similarities in the subjects studied, namely Mathematics. The difference lies in the material studied, the material is about whole numbers. While the material studied by researchers is KPK and FPB [47]. Research conducted by Adelia (2024) which states that the average experimental class is better than the control class. The average experimental class scores were 51.45 (pretest) and 75.24 (posttest). While the average value of the control class is 59.09 (pretest) and 73.33 (posttest) [48]. Puzzle media is easy to understand, and fun. In addition, puzzle media has a considerable influence, with an average post test score of 63.68 (less), cycle I 72.61 (less), cycle II 83.32 (good) [49].

Students' understanding of mathematical concepts in learning mathematics is in the low category. There are some students who have difficulty learning math, and there are some students who are more active in learning, by using concrete media.

3.1. Analysis

The analysis stage is carried out by distributing questionnaires of the needs of teachers and students. the results are analyzed to be used as a reference in the development of media products. The learning environment that has not provided maximum learning facilities makes learning more effective when done with the help of

concrete media that is easy to use and has been adapted to the characteristics of students. The grade V teacher mentioned that the media products to be developed must be in accordance with the curriculum and learning outcomes so that the learning objectives can be achieved optimally. The number puzzle media (puka) will be designed in a rectangular shape, has a user manual that makes it easier for students to use the media, has an overall color presentation, contains multiple choice evaluation questions, and is equipped with QR-Code as a combination of technological elements.

3.2. Design

The front of the puka contains the title, division symbols, and a basin for the puzzle pieces. The puzzle pieces are parts of various number puzzle elements. The puka case contains the number puzzle pieces, and there is a QR-Code that can be accessed by scanning a cell phone, which contains the instruction manual and teaching materials accessed by scanning a cell phone, which contains instruction manuals and teaching materials.

3.3 Product Results

The number puzzle media (puka) was developed based on the results of analysis, observation, interviews, and questionnaires of the needs of teachers and students who then passed the stage of adjusting the content of the material with the existing learning outcomes. The puka media was developed with the help of the canva application with a size adapted to students, namely rectangles. The details are as follows.

Figure 3. Product Results

Figure 4. Product Results

3.4 Media Feasibility

The assessment was carried out by validation of material experts and media experts. Researchers use a questionnaire that has been adjusted to the indicators.

Table 1. Recapitulation of Media Validation

No	Assessment Indicator	Score
1	Media aspect	21
2	Display aspect	52
Sum		73
Max score		84
Percentage		86%
qualification		Very feasible

Based on the table above, it can be seen that the media expert gave a score of 73 with a percentage of 86.9% and very feasible qualifications. This shows that puka media is very feasible to use as learning media.

Table 2. Rekapitulasi Validasi Media

	Assesment Indicator	Score
	Intermediary aspect	12
	Props aspect	
	Learning	18
	materials	12
Sum		42
Nmax score		44
Percentage		95,4%
qualification		Very feasible

Based on the table above, it can be seen that the material expert gave a score of 42 with a percentage of 95.4% and a very decent qualification for puka media. This shows that puka media is very feasible to be used as learning media.

3.5 Media Effectiveness

Table 3. Small Group Normality Test Results

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	Df	Sig.
Pretest	0.157	10	.200*	0.966	10	0.848
Posttest	0.137	10	.200*	0.943	10	0.591

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Table 4. Large Group Normality Test Results

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	Df	Sig.
Pretest	0.160	28	0.064	0.967	28	0.504
Posttest	0.174	28	0.030	0.949	28	0.189

a. Lilliefors Significance Correction

In table 3 the small group results show the pretest value shows a significance of 0.848 and a posttest value of 0.591. The criteria for testing normality is said to be normal if the significance has a value> 0.05. So based on this table it can be concluded that the pretest and posttest values are normally distributed, so the next calculation is to use parametric statistical techniques. In table 4 of the large group using the Shapiro-wilk test, it can be seen that the pretest value shows a significance of 0.504 and a posttest value of 0.189. Normality testing criteria are said to be normal if the significance has a value > 0.05. So based on the table, it can be concluded that the pretest and posttest values are normally distributed, so the next calculation is to use parametric statistical techniques.

Table 5. Small Group Paired T Test Results

		Paired Differences					T	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Pretest – Posttest	-22.0000	5.37484	1.69967	-25.8449	-18.1550	-12.94	9	0.000

The t test results show a sig (2-tailed) value of 0.000. This value is less than 0.05 so that Ha is accepted and Ho is rejected. So it can be seen that the number puzzle media (puka) as a learning media effectively improves the learning outcomes of fifth grade students of elementary school 4 Mindahan Jepara.

Table 6. Large Group Paired T Test Results

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Pretest - Posttest	-20.1785	3.46467	0.65476	-21.5220	-18.8351	-30.81	27	0.000

The t test results show a sig (2-tailed) value of 0.000. This value is less than 0.05 so that Ha is accepted and Ho is rejected. So it can be seen that the number puzzle media (puka) as a learning media effectively improves the learning outcomes of fifth grade students of SD Negeri 4 Mindahan Jepara.

Table 7. Gain Index Interpretation [50]

Gain index	Category
$0.70 \leq g \leq 100$	High
$0.30 \leq g < 0.70$	Medium
$0.00 < g < 0.30$	Low
$g = 0.00$	No increase
$-100 \leq g < 0.00$	decrease

Table 8. N-gain Results

Description	Class	
	Small	Large
Pretest mean	61	52.6
Posttest Mean	83	72.85
Mean Difference	22	20.18
N-gain value	0.68	0.56
Criteria	Medium	Medium

The results of the N-gain test calculation in the small group product trial showed an increase in the average pretest and posttest scores of 0.68 with an average difference of 22 so that it included a moderate category. With this average increase, it shows that the use of puka media as learning media to improve the learning outcomes of fifth grade students of elementary school 4 Mindahan is quite effective. The results of the N-gain test calculation in the large group product trial showed an increase in the average pretest and posttest scores of 0.56 with an average difference of 20.18 so that it included a moderate category. With this average increase, it shows that the use of puka media as a learning media to improve the learning outcomes of fifth grade students of eleementary school 4 Mindahan is quite effective.

The results of the N-gain calculation for small and large groups can be interpreted as an increase in learning outcomes, especially the KPK and FPB material. In interaction activities, tools are needed to improve the maximization of competence. Number puzzle media can be used by teachers as a tool in delivering math material in a more interesting way. Learning outcomes from the development of mastery of cognitive learning arithmetic are logically systematic, analytical, balanced with creative and critical skills as a maximization of

potential. It also includes the integration of various kinds of numerical alliances into the learner's knowledge system. This shows that number puzzles improve learners' learning outcomes. Learning aids can help educators present media that is attractive and useful and economical [39]. The changing behavior of learners is a learning process.

4. CONCLUSION

The objectives formulated in the Introduction Chapter, namely to develop, test the feasibility, and test the effectiveness of the Number Puzzle (PUKA) media in improving the mathematics learning outcomes of grade V students on the KPK and FPB material, have been fully achieved as shown in the Results and Discussion Chapter. The media development design has been successfully carried out with a systematic ADDIE model approach, the media is declared very feasible based on the results of expert validation and user responses, and proven effective in improving learning outcomes based on statistical tests and N-gain analysis. Media development adjusts to the needs of teachers and students supported by media and material validators with a very feasible category to be tested and a few suggestions from validators that have been corrected. The feasibility test of media validators has a percentage of 86.9% and a percentage value of 95.4% and from material experts. The puka results in the subject after the T test by obtaining sig (2-tailed) 0.000 in the small group test and 0.000 in the large group test. Both have a value of less than 0.05 so it can be concluded that Ha is accepted and Ho is rejected. This means that puka media as media is quite effective in improving student learning outcomes. Then, the N-gain test in the small group product trial had an average difference between the pretest and posttest of 22 and an N-gain value of 0.68 in the medium category. While the large group product trial had a difference in pretest and posttest results of 20.18 and an N-gain value of 0.56 in the moderate category. Based on this data, the conclusion is that the number puzzle media (puka) can improve student learning outcomes. The findings of this study indicate that Puzzle Numbers (PUKA) media can be used as an alternative learning media that is innovative and fun in learning mathematics, especially on conceptual materials such as KPK and FPB. Therefore, this media has the prospect to be further developed with a wider range of materials, and can be adapted for other levels of education or even other appropriate subjects.

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