



Design of Electronic-Based Handout Teaching Materials with Problem-Based Learning Nuances in Learning Mathematics

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ABSTRACT

This study is based on Permendikbud No. 65 of 2013, which mandates that students learn in accordance with 12 learning principles. As a result, educators must be adept at utilizing a variety of strategies to meet students' learning goals. Consequently, the purpose of this study is to assist teachers in utilizing a method that is in line with the curriculum, one of which is a problem-based learning method, in order to help students develop their critical thinking skills. So, in this study, problem-based learning, or a strategy that presents challenges connected to daily life in real terms, is used in the teaching materials created, namely E-Handout. To improve student motivation and learning results, interactive digital teaching resources have been developed. The study methodology employed is called ADDIE, which stands for Analysis, Design, Development, Implementation, and Evaluation. Analysis includes curriculum analysis, material analysis, and student analysis. Design includes handout design and material design, The systematics of Electronic Handout teaching materials are cover or title of the handout, KI/KD, learning objectives, concept maps, material and videos, exercises and quizzes, and bibliography.

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1. INTRODUCTION

Mathematics is the science of counting which aims to instill and develop the counting process in students as well as curiosity in solving problems encountered. With the provision of mathematics, a person can think logically, critically and systematically so that they are able to argue with others (Indariani, Pramuditya, and Firmasari 2018). Mathematics is one of the lessons that will require creativity in solving a problem, because in mathematics there are many exercises that are presented in the form of problems (Marshanawiah et al., 2023). This is in accordance with Permendikbud number 65 of 2013 that based on the Graduate Competency Standards and Content Standards, there are several learning principles in the 2013 curriculum, some of which are students being told to students finding out, from the teacher as the only source of learning to learning based on various learning sources, from verbalism learning to applicative skills (Menteri Pendidikan dan Kebudayaan Republik Indonesia, 2013). Therefore, to make it easier for students to understand and solve problems, the approach used is an appropriate approach, namely an approach that can train students to think critically and encourage students to be able to solve problems or called the PBL (problem-based learning) approach.

In its understanding, the problem-based learning approach is learning that uses real problems as the main factor and as a means for students to think critically in solving problems related to concrete daily life (Octavianis, Subroto, and Susanti, 2022). especially on the material of fractions worth in class IV. Fractions are material that is found in many other materials such as linear equations, functions, algebra, geometry, and so on. Fractions are also material that is very close to everyday life (Zaini, Darmawan, and Hernawan, 2019). For example in trade (weighing the number of goods), measuring length and others, then for the fraction worth material it will be easier if the material is presented using concrete models/images and in the presentation of this material the teaching materials developed must be interesting, not boring, help students to understand the fraction worth material, and can increase motivation and student learning outcomes.

Teaching materials are all materials (both information, tools, and text) that are arranged systematically, which display a complete figure of the competencies to be mastered by students and used in the learning process for the purpose of planning and reviewing the implementation of learning (Handayani, Diomara, and Elvia, 2022). Meanwhile, the development of teaching materials is to develop, add, or innovate existing teaching materials into a renewable material format with the aim of creating teaching and learning activities that are more effective, interesting, and meaningful than before, and do not conflict with the demands of the applicable curriculum (Prabasari, Muzzazinah, and Wahyuningsih, 2021). In developing teaching materials, one of the goals is to improve student learning outcomes. Mathematics learning outcomes are student achievements after studying mathematics in the form of mastery of mathematical calculations and mathematical reasoning which are reflected in the value of learning outcomes after undergoing the learning process on mathematics material within a certain period of time and measured by evaluation tools (Widyawati and Sjaifuddin, 2022).

Teaching materials to be developed must be teaching materials that are suitable for use by students, because they will affect motivation and learning outcomes. Many teaching materials are suitable to be developed, one of which is non-print teaching materials in the form of Electronic-based teaching materials. Handouts are learning teaching materials that are very concise, inexpensive, economical and practical. The function of the handout is as teaching material to support, clarify, and enrich the main teaching material (Saniyyah,

2023). Basically, Electronic Handouts are handout teaching materials in the form of digital or teaching materials that use digital devices in their use, for example cellphones, laptops, computers, and so on.

The advantage of this teaching material is that it can present more complete material than printed handouts, because in Electronic Handouts images, quiz links, videos and so on can be included which are interactive and will make it easier for students to understand the material, this is in accordance with the function of the handout which is to clarify the material (Ihsan, 2019). Because this handout is digital, it is very easy to use, which can save costs and can study wherever and whenever the handout teaching material is. Electronic Handout teaching materials can be made into print, but there are some drawbacks, namely users cannot access animations, videos, quizzes, because these features can only be accessed using digital devices (Nuryani, Fauziah, and Astutin, 2022).

Some studies that are relevant to this research are: Khotimah, Andayani, and Sudarman's research entitled "Handout Development with Indonesian Realistic Mathematics Education Approach to Facilitate Mathematical Communication Skills" (Khotimah, Andayani, and Sudarman, 2020). The results of this study indicate that the teaching materials developed have met the criteria for teaching materials that are suitable for use, namely valid, practical, and can improve students' concept understanding. The description is as a valid teaching material because it has been validated by 4 validators by obtaining an average score of 80.1%, these results indicate that this handout teaching material is in the valid category according to Ridwan that the value of 60-80% is said to be valid. As a practical teaching material because the average results of the questionnaire assessment are more than 61% according to Ridwan, namely the results of the questionnaire assessment of teacher practicalization 84.8% and student practicalization 84%. In addition, the teaching materials developed in this study have been able to improve students' concept understanding because in each indicator it obtained a value of more than 80%, namely the ability to restate a concept of 86.7% and the ability to choose procedures, namely 91.2% (Khotimah et al., 2020).

Based on research by Astriz Permata Mulia, Nila Kesumawati, and Ali Fakhrudin entitled "Development of Learner Worksheets (LKPD) Based on Visual Learning Style on Fraction Material for Grade IV SD". Based on the results of the study, the LKPD developed is a visual learning style-based LKPD on fraction material that is effective in supporting learning activities and can improve student learning outcomes. Because the LKPD has passed the validity, practicality, and effectiveness tests. By obtaining an average of 3.55% from media, material, and language experts, an average of 91.87% from the practicalization test of students and teachers who fall into the very practical category, and effective as evidenced by the increased learning outcomes of students as measured by pretest and posttest questions (Mulia, Kesumawati, and Fakhrudin, 2022).

Ade Sari Oktavia and Siti Quratul Ain's research entitled "Development of E-Modules Based on Inquiry Method on Fraction Material for Grade IV SD". Based on the results of this research, the development of teaching materials has achieved the goal of teaching materials that will be used in the learning process that can attract the attention and interest of students to learn. Because it has been tested for validity by experts, including material validation obtaining a percentage of 91%, language validation obtaining 87.77%, and design validation 96.3% (Oktavia, 2022).

In accordance with the above statement, the teaching material to be developed is Electronic Handout teaching material using a problem-based learning approach because the shortcomings of teaching materials are less than the advantages. Thus, the development of

Electronic Handout teaching materials into practical teaching materials aims to assist educators in using approaches that are in accordance with the curriculum, one of which is the problem-based learning approach and so that students are able to think critically in solving problems through this approach, students are able to increase their understanding of the material of fractions worth, solve problems regarding fractions related to everyday life, and can increase motivation and learning outcomes.

2. LITERATURE REVIEW

Electronic-based Handout Teaching Materials

The use of information and communication technology in the world of education continues to develop in various ways that should be grouped into the Electronic Learning (E-learning) system as a form of learning by utilizing electronic media (Taufiqurrahman and Wijaya, 2022).

Furthermore, the term mobile learning can be interpreted as a form of learning that utilizes electronic devices and mobile technology. Mobile Learning (M-Learning) is the development of E-learning. The term mobile learning refers to handheld and mobile information technology devices such as PDA (Personal Digital Assistant), cellular phones, laptops, tablet PCs, and so on. Mobile Learning can allow users to access learning content anywhere and anytime, without having to visit a place at a certain time (Qolbuani, Tahir, and Rosyidah, 2022).

Until now, electronic handouts have been developed in many disciplines. The electronic handout format has many advantages compared to conventional handouts. The advantages of electronic handouts are that they are easy to carry and do not require large storage space. They can be stored on computers, laptops, cell phones or electronic devices that specifically provide for storage and reading in electronic form.

Problem Based Learning

Problem Based Learning, hereinafter referred to as PBL, is one of the learning models that is based on students with various problems faced in their lives. With this learning model, students from the beginning have been exposed to various life problems that they might encounter later when they graduate from school (Mella, Wulandari, and Wiarta, 2022).

The Problem Based Learning (PBL) model is learning by exposing students to problems. Boud and Falletti in (Octavianis et al., 2022) suggest that problem-based learning is the most significant innovation in education.

Based on the above opinions, it can be concluded that in Problem Based Learning (PBL) students are expected to use their mental activities so that students can be active during the learning process, and are expected to improve student learning outcomes. Through PBL, a student will have skills in solving problems which he can then apply at this time facing real problems in society.

Learning Mathematics

As prospective teachers or teachers need to know some of the characteristics of learning mathematics in elementary school. Based on the characteristics that must be understood in mathematics, namely abstract, axiomatic and deductive, while elementary school students are at the age of 7–12 years and are still at the concrete operational stage who cannot think formally (Khotimah et al., 2020). Therefore, learning mathematics in elementary

schools is always inseparable from the nature of mathematics and the nature of children in elementary schools, in the sense that it always pays attention to this. A good teaching method is the key and infrastructure for students to learn well.

Learning is a complex aspect of human activity, which cannot be fully explained. Learning can simply be defined as a continuous interactive product between development and life experience. In another sense, learning means combining knowledge with existing intermediaries so that students get new experiences that can be useful later. M. Ali Hamzah and Muhlisrarini in (Nuryani et al., 2022), argue that mathematics as a deductive science means that mathematics requires proof of truth. Mathematics as a structured science means that mathematical concepts are arranged hierarchically and starting from undefined elements, defined elements, axioms, to mathematical theorems have regularity so that they can be generalized based on the patterns found, as well as from mathematical concepts that are still interconnected (Paloloang, 2014). Mathematics as a symbol language means that mathematics is written using symbols that apply thoroughly and have a solid meaning. Mathematics as the queen and servant of other sciences means that mathematics is independent of other fields of study, even mathematics is used as a service for the development of other sciences (Kurniawan et al., 2022)

The main principle in learning mathematics is to improve and prepare useful learning activities for students that aim to move from teaching mathematics to learning mathematics. Active student engagement in learning must provide specific learning activities so that they can do doing math to find and build mathematics with facilities by the teacher.

Based on this opinion, it can be concluded that mathematics learning is the process of providing definite learning experiences, be it symbols, symbols to students through a series of planned and structured activities so that students gain competence on the mathematical material they learn. In essence, mathematics is a science that is always connected to human life. In delivering abstract mathematical objects or symbols, a system is needed that is useful for delivering these mathematical objects to students (Mukni'ah, 2019). Media or teaching aids in mathematics whose use is integrated with learning objectives and content or in other words, tools used to facilitate teachers in explaining mathematical concepts or material to students. Learning media can be said to be good if the media used can maximize students' senses, especially vision and hearing. The use of media, especially in learning mathematics, is one of the important things.

3. METHODS

The method to be used in developing Electronic Handout teaching materials is to use the ADDIE method, there are several development models including the KEMP model, Dick and Carrey model, Assure model, Hannafin and Peck model, Gagne and Briggs model and ADDIE model. In this study, we used the development model, namely the ADDIE model. One of the functions of this model is generic learning design that facilitates a well-organized process in making learning media for classroom-oriented and online learning. The ADDIE model is a simple framework useful for designing learning where the process can be applied in a variety of settings due to its general structure, because the advantages of this method are that it is more systematic and evaluation can be carried out at all stages, so as to minimize errors and deficiencies in the resulting product. However, the development of this teaching material does not carry out all the stages contained in the ADDIE method because it is not possible to implement.

The stages of the ADDIE method consist of Analysis (curriculum analysis, material analysis and learner analysis), Design (handout design and material design), Development (development of how the Electronic Handout), Implementation, and Evaluation. The explanation is as follows (Indariani et al., 2018):

3.1. Analysis.

At this initial stage, a learning needs analysis is carried out which aims to compile or design Electronic Handouts that are in accordance with the needs of students. curriculum analysis, material analysis and learner analysis.

Curriculum analysis. At this stage what is used is the 2013 curriculum because this curriculum is widely applied, even though there is already an independent learning curriculum. In addition, analyze the syllabus such as KI/KD, indicators, regarding fractions worth material contained in class IV. Based on this statement in developing Electronic Handout teaching materials there are several KD and indicators to be developed.

Material analysis. The material to be used is material that is in accordance with KD, namely KD 3.1 grade IV math lessons, the material to be developed includes the concept of fractions, simplifying fractions, and comparing fractions.

Learner analysis. Learner analysis is carried out in order to determine the ability of students, so that the teaching materials to be developed achieve their goals.

3.2. Design

This Electronic Handout is in the form of a flipbook which is concisely designed to include the title or cover of the handout, KI/KD, learning objectives, concept map, material and videos, exercises and quizzes, and bibliography.

3.3. Development

The teaching material to be developed is an interactive Electronic Handout, in which there is not only writing but there are also pictures, videos, quizzes or exercises related to everyday life. The exercises contained in the Electronic Handout are that students are asked to learn first about fraction material, then students are asked in the Electronic Handout both the exercises that have been listed and the questions in the quizizz, which contain determining fractions worth, predicting about fractions such as being able to mention which denominator and numerator and so on, then students are asked to complete exercises that simplify and compare fractions and solve HOTS questions related to the reality of everyday life.

3.4. Implementation

The development of this teaching material does not carry out the implementation stage due to limited space and time so that it is not possible to apply it to MI/SD students, especially grade IV.

3.5. Evaluation

At the evaluation stage, the development of teaching materials is not by testing them with experts but with suggestions from lecturers and students both in terms of material, language, and design so that these teaching materials become even better teaching materials when they have been revised and become teaching materials that are feasible to be implemented in the field, especially for grade IV students.

The data collection techniques used in this research are questionnaires, and validation sheets. Survey is used to find out the needs of E-Handout, questionnaire is used to collect data on the feasibility and effectiveness of the media developed, interviews are used to find out what needs are needed to include the material in the E-Handout developed. The research instrument is a validation sheet used to determine the level of validity and feasibility of learning media in the form of E-Handout to be developed.

There are two data analysis techniques used in the development of this product, namely: 1) qualitative descriptive analysis techniques, 2) descriptive statistics. Qualitative data analysis was obtained from the results of interviews, criticisms and suggestions from material and media experts. While quantitative data (Rahayu et al., 2021).

Quantitative data is the main data in the study in the form of validation results by material and media experts. To get an assessment of the E-Handout developed, the quantitative data is analyzed and then converted using a Likert scale to calculate the validity level of the product made and test the feasibility of the product.

4. RESULTS AND DISCUSSION

Table 1 explain about basic competencies and materials, see **Table 1**.

Table 1. Basic Competency

Basic Competency
3.1 Explaining fractions worth with pictures and concrete models
4.1 Identifying fractions worth with pictures and concrete models

The material in the KD above is worth fractions which include the concept of worth fractions, simplifying fractions, and comparing fractions. The description of these materials are:

1. Understand the basic concept of fractions which is a number expressed as a/b with a and b are integers and $b \neq 0$. Number a is called the numerator and number b is called the denominator. For example, $\frac{1}{2}$ 1 is called the numerator and 2 is called the denominator. Fractions have many kinds, but the fractions studied in this KD are worth fractions. Fractions worth are two or more fractions that have the same value but in different forms. An example of a fraction worth is $\frac{4}{10} = \frac{2}{5}$
2. Simplifying fractions. To determine the fraction worth one of them by simplifying the fraction so that it becomes the same fraction, for example $\frac{4}{8} = \frac{2}{4}$ because the fraction can be simplified into the same fraction. And the way to simplify fractions is by dividing the numerator and denominator by the same number so that it cannot be divided again by another number, namely:
 $\frac{4}{8} : 4 = \frac{1}{2}$ ($4:4=1$ and $8:4=2$)
 $\frac{2}{4} : 2 = \frac{1}{2}$ ($2:2=1$ and $4:2=2$)
3. Comparing fractions is to find out the value of a fraction with other fractions, greater, smaller, or equal to. To compare fractions one of them is by equalizing the denominator, for example see **Figure 1**.

Contoh: $\frac{2}{3}$ dengan $\frac{1}{4}$

Menyamakan penyebut	Membandingkan pembilang
$\frac{2 \times 4}{3 \times 4} = \frac{8}{12}$ $\frac{1 \times 3}{4 \times 3} = \frac{3}{12}$ Penyebutnya sama-sama 12	8 lebih besar dari 3 $\frac{8}{12}$ lebih besar dari $\frac{3}{12}$ Jadi $\frac{2}{3}$ lebih besar dari $\frac{1}{4}$

Figure 1. Equalizing the denominator

The example of fraction comparison can seen in **Figure 2.**

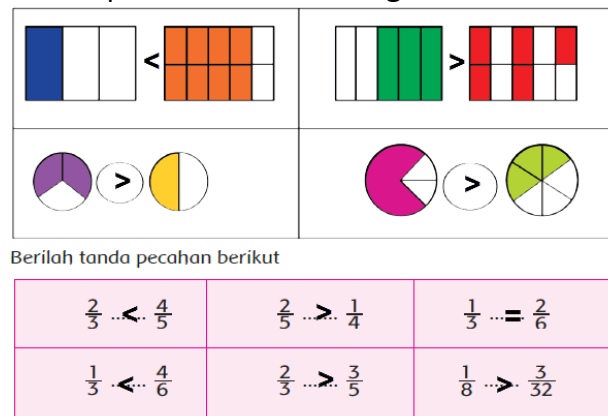


Figure 2. Fraction Comparison

Student Characteristics

The cognitive characteristics of grade IV children are based on the learning theory proposed by Jean Piaget that at the age of grade IV students between 10-11 years, at that time they are at the concrete operation stage of thinking, that at this stage the child's thinking ability is based on manipulation or physical imitation of concrete objects. The implementation of the concrete thinking operation stage in mathematics learning, especially on fractions worth material, for example, the teacher provides an illustration in various forms regarding fractions worth that $\frac{2}{4} = \frac{4}{8}$ and the material is not only limited to writing, so that students are easy to understand the material studied.

To apply the learning theory according to Jean Piaget, learning can be made student center where students will be the subject of learning not as an object, meaning that students will understand the concept of material from discoveries that are felt directly through concrete images of fractions worth material not only from teacher explanations (Ramadhan and Hidayah, 2022). In addition to using concrete objects, learning can also use problems in real situations or everyday life.

In terms of psychosocial according to the theory put forward by Erikson, grade IV students enter the stage of work versus feelings of inferiority or commonly referred to as the industry versus inferiority stage, namely in children aged 6—12 years. At this stage children prefer to learn by direct practice or not only theory, for example by producing a work together/in groups. However, children of this age have an inferiority complex that causes distrust if their abilities are not equal to their peers.

Therefore, in learning, teachers should use an approach that is in accordance with the cognitive and psychosocial characteristics above. That is by linking learning materials using concrete objects or by involving real situations in everyday life. In addition, teachers must

also use models, methods, and approaches that will foster a sense of willingness to work and confidence in children.

Steps of Problem Based Learning Approach

The steps of the PBL approach consist of 5 stages or phases, namely (1) orienting students to the problem; (2) organizing students to learn; (3) assisting individual and group investigations; (4) developing and presenting work; and (5) analyzing and evaluating the problem solving process. Explanation of PBL steps as follows (Zainal, 2022)

Student orientation to the problem. By presenting a problem that is in accordance with KI / KD and the ability of students so that students can solve problems through the teaching materials studied.

Organize students to learn. By organizing/arranging, giving tasks to students and ensuring that students understand the tasks given so that students can discuss to solve problems.

Helping individual and group investigations. At this stage the teacher has a role to guide and help learners both individually and in groups regarding difficulties in the steps of working on the task.

developing and presenting work. With the teacher guiding students in working on assignments and then students present the results of their work.

Analyzing and evaluating the problem-solving process. By observing the presentation, learners are encouraged to give appreciation and input to those who present, then conclude the material that has been learned.

Teaching Material Results

Product validation is carried out by experts, namely media experts and material experts, he is Dr. Nino Indrianto, M.Pd. as chairman of PPG UIN KHAS Jember and Dr. Hartono M.Pd. as chairman of PGMI UIN KHAS Jember, researchers chose him as an expert validator because he is competent in his field. The results of the validation, can see in **Table 2**:

Table 2. Results of the Validation

No.	Validator	Precentage	Criteria
1	Validator 1	86.6%	worthy
2	Validator 2	90%	Very worthy

The advantages of this research are that learners can easily access electronic handouts from their electronic devices such as smartphones, tablets, or laptops. This can make it easier for learners to access information and learning materials anywhere and anytime (Irmaningrum, Zativalen, and MZ, 2023). The use of electronic handouts can help learners to develop technological skills, such as the ability to use electronic devices, access information online, and communicate through digital media.

The limitations of this study are that the use of electronic handouts can also make learners more dependent on technology. This can be a problem if learners become too dependent on technology and lose the ability to learn in more traditional ways, Learners may face concentration problems due to potential distractions from electronic devices. Therefore, it is important for teachers and parents to supervise the use of electronic devices during learning, The use of electronic handouts requires adequate availability of electronic devices. Therefore, learners who do not have access to electronic devices may feel marginalized or have difficulty accessing learning materials.

The systematics of Electronic Handout teaching materials are cover or title of the handout, KI / KD, learning objectives, concept maps, material and videos, exercises and quizzes, and bibliography, can see in **Figure 3, Figure 4, Figure 5, Figure 6, Figure 7:**



Figure 3. Handout

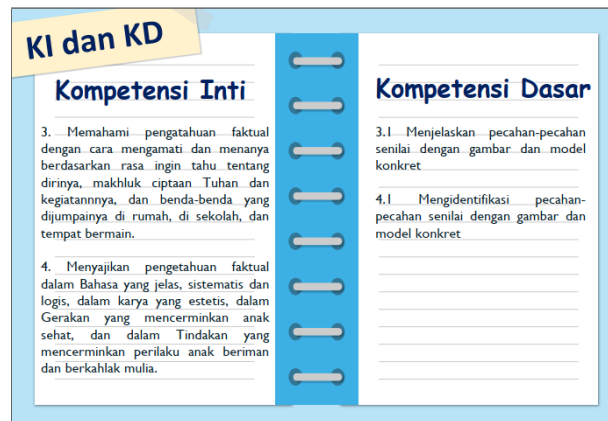


Figure 4. KI and KD

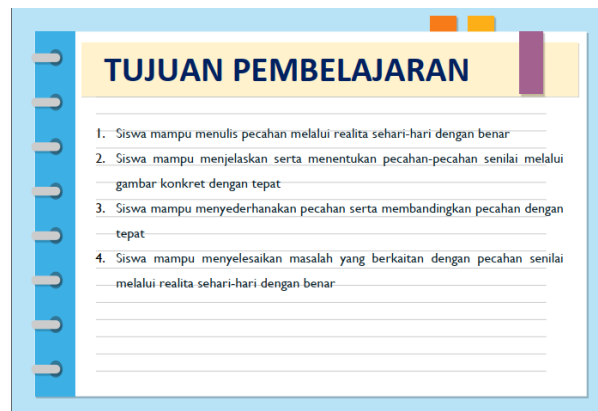


Figure 5. Learning Objectives



Figure 6. Concept Maps

MATERI

PECAHAN SENILAI

Pecahan Senilai adalah pecahan yang memiliki nilai yang sama namun dituliskan dalam bentuk yang berbeda.

Pecahan senilai akan memiliki nilai yang sama Ketika pembilang dan penyebut pecahan dikalikan atau dibagi dengan bilangan yang sama.

Misalnya pecahan $\frac{3}{5}$ dan $\frac{9}{15}$

Pecahan $\frac{3}{5}$ jika pembilang dan penyebutnya dikalikan 3 akan menghasilkan $\frac{9}{15}$

Contoh pecahan senilai dalam kehidupan sehari-hari

Ibu membeli martabak kemudian Ibu membagi martabak tersebut menjadi beberapa bagian yang sama untuk setiap anggota yang berjumlah 4 anggota, maka setiap anggota keluarga akan mendapatkan berapa bagian yang sama ya?

Dari pernyataan di atas maka setiap anggota keluarga akan mendapat 1 : 4 anggota keluarga = $\frac{1}{4}$ bagian. Jadi setiap anggota keluarga akan mendapat $\frac{1}{4}$ bagian martabak.

Jika martabak tersebut dibagi menjadi 8 bagian. Agar setiap anggota keluarga mendapat bagian martabak yang sama bagaimana caranya. Caranya cukup membagi 8 bagian martabak dengan jumlah anggota keluarganya, sehingga menjadi 8 : 4 = 2 bagian atau $\frac{2}{8}$ bagian.

Jika sebelum dibagikan martabak tersebut terlanjur dipotong potong menjadi 12 bagian yang sama besar. Maka tiap anggota mendapat berapa bagian ya? Caranya dengan membagi 12 potongan martabak dengan jumlah anggota keluarga, sehingga menjadi 12 : 4 = 3 bagian atau $\frac{3}{12}$ bagian.

Jadi dari 3 pernyataan di atas sebenarnya yang diterima tiap anggota keluarga tersebut sama banyak, sehingga $\frac{1}{4} = \frac{2}{8} = \frac{3}{12}$ ketiga pecahan ini merupakan pecahan senilai.

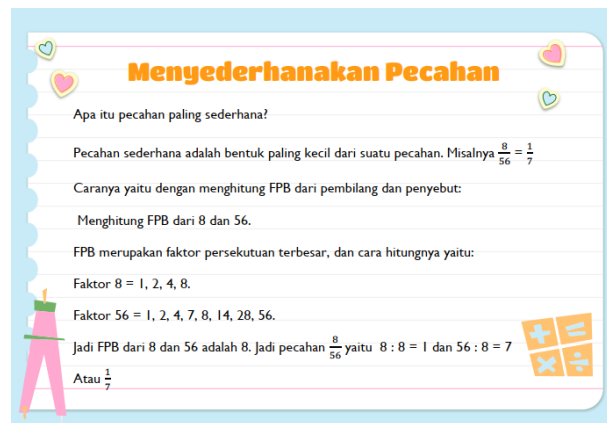


Table 7. Material and videos

5. CONCLUSION

The teaching materials to be developed in this study are Electronic Handout teaching materials in grade IV MI/SD worth fractions that are in accordance with KD 3.1 and 4.1 in mathematics learning. The approach used is the Problem Based Learning (PBL) approach with the aim of improving students' way of thinking, and the teaching material development method used is the ADDIE method, which consists of Analysis (curriculum analysis, material analysis and learner analysis), Design (handout design and material design), Development (development of how the Electronic Handout), Implementation, and Evaluation. The Electronic Handout developed is in the form of a flipbook which is concisely designed to include a cover or handout title, KI/KD, learning objectives, concept maps, material and videos, exercises and quizzes, and a bibliography.

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