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# Microlearning-based media of probability: An innovative student worksheet

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## Abstract

The constraint on reasoning ability among Indonesian mathematics students is a pressing issue. Several study results show that students' low mathematical reasoning is due to a lack of conceptual understanding of the material being studied. Probability is one of the materials that can help mathematical reasoning. There is a sample space that requires students' reasoning ability to determine all possible outcomes. This study aims to design a microlearning-based learning on probability material using the culinary tourism context of Prabumulih City that is integrated into student worksheet, which is valid and practical to help students learn the probability in phase E and train their reasoning skills by PMRI (Indonesian Realistic Mathematics Education). This study was a qualitative method of development study type, consisting of two stages: preliminary study and formative evaluation. The subject of this study was 36 tenth-grade. The data collection techniques were observation, tests, and interviews, which were analyzed descriptively. This research produced a student worksheet that was valid and practical and integrated with microlearning media (comic, video) on probability material using the culinary tourism context of Prabumulih City, Indonesia. Based on data analysis, this worksheet can improve students' conceptual understanding and reasoning abilities.

**Keywords:** design research; microlearning media; probability; reasoning ability

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## Introduction

Probability is the study of how likely something will happen, which is used to make a prediction or decision (Grove, 2018). Probability is also defined as a field of mathematics related to the probability of certain random events (Greenwood et al., 2011). From these two understandings, they agree that probability plays an important role in making predictions and decisions. Therefore, in learning probability, students' reasoning skills are needed.

In the curriculum in Indonesia, Merdeka Curriculum, probability is the content of the Compulsory Mathematics material for phases E and F. In this study, researchers focus on designing probability material in phase E. The curriculum regulates the learning outcomes of mathematics subject elements in each phase. In the data analysis and probability elements of phase E, the learning outcomes include students being able to explain probability from compound events (BSKAP, 2024). The concept of an event compares the number of event members and the number of sample space members.

According to Greenwood et al. (2011), the sample space is the list of outcomes from an experiment. An outcome is a possible result of an experiment, so students need to understand the sample space of a random experiment and the event. Therefore, students must reason to determine the sample space of a random experiment and its occurrence. Students need to imagine all the events that might happen if a random experiment is conducted. In this study, the experiment was to choose a random food menu in the context of culinary tourism in Prabumulih City. Culinary tourism is one of the contexts close to the real life of students, which is the subject of the researchers' research. The reader can adjust by using the tourism context in their city.

Apart from the curriculum, probability is also one of the contents in PISA questions, namely uncertainty and data. According to OECD (2023), topics included in the content are the definition of random events, random variations, their representations, chances, and frequency of expectation, as well as fundamental aspects of probability and conditional probability. Those topics align with the learning outcomes of phase E in the Merdeka Curriculum.

There are still difficulties for students in solving the problem of probability. The errors can caused by students' mistakes in reading the questions, which are caused by a lack of understanding of the meaning of the sentences in the story questions (Tanzimah & Sutrianti, 2023). In addition, they are also caused by a lack of understanding of students' concepts in the probability material (Astuti et al., 2020). From their study, we can conclude that, as teachers, we need to help students understand probability concepts and train their reasoning skills.

Several reports regarding the problem of students' reasoning abilities are still low and have not achieved optimal results. Ulfah et al. (2020) report that the low reasoning abilities of students were caused by the available learning tools still not supporting students in improving their mathematical reasoning. According to Saleh et al. (2018), reasoning abilities must be developed through learning processes designed in school. So, it can be said that reasoning skills should be taught through learning activities at school.

Furthermore, Islamiya et al. (2024) report that in classroom learning, teachers only use textbooks provided by the school; there are no other supporting books. Along with that,

Hiltrimartin et al. (2022) said that the student worksheet) used mostly emphasizes formulas and contains material summaries, does not contain the context of daily life, and the questions given are not related to real problems, so they do not encourage students to solve the problem given.

From the problem described, relevant to the results of PISA 2022 decreases for mathematics content. The result of PISA 2022 shows that Indonesia's ranking increased by 5 – 6 places compared to 2018 but decreased by 13 points internationally for mathematics content (OECD, 2023). Of course, this concerns teachers because PISA results are also a benchmark for the quality of mathematics education in Indonesia.

One of the efforts that can be made is to implement effective learning by using media and learning approaches that use context. Learning media can help teachers in conveying information on mathematics material to students. For mathematical information to be conveyed properly, focusing on mathematical concepts, the material should be fragmented so students can easily remember and understand it.

Learning media that can be used to convey brief information is microlearning-based. Dolasinski and Reynolds (2020) said that microlearning is a concept-focused approach that utilizes multisensory and multimodality in a short and focused time. According to Aldosemani (2019) and McNeill & Fitch (2023), microlearning helps connect topics and ideas when learning and can improve students' focus, concentration, and knowledge retention. Thus, it can be said that with microlearning, the material is delivered in short information so that the material is not too dense, making the learning more effective and helping increase the focus and retention of students' knowledge.

The approach that can be used in mathematics learning is PMRI, Indonesia Realistic Mathematics Education. PMRI is a didactic approach for the mathematics domain adapted from RME, Realistic Mathematics Education (Zulkardi et al., 2020). Many contexts have been used in several studies using PMRI. Those contexts are presented in the student worksheet LKPD by displaying an image with some information in the fairly long text.

Many contexts used in probability materials, there are sudoku and snakes and ladders (Wijaya et al., 2021), snake and ladder games (Sari et al., 2022), dice (Armiati et al., 2022), maritime context (Malalina et al., 2024). In this study, researchers used the context of culinary tourism in Prabumulih City, which was packaged in microlearning media that integrated into the student worksheet described previously.

Although the use of context in probability learning with the PMRI approach has been widely used to solve contextual problems, the context is only presented in images and worksheets with some information. This study context is presented in microlearning media so students can understand the concept more easily—using microlearning media as an innovation in learning.

The novelty of this study is that the researchers display the context of media microlearning, like comics and videos, and then integrates them into student worksheets. Student worksheets are a discussion and collaboration room for students in groups to understand the probability learning material well. It could help train the student's reasoning skills.

## Methods

This study used the design research method with the type of development studies as the main framework, which consists of preliminary study and formative evaluation (Tessmer, 1993). The preliminary study was done by analyzing the curriculum, theory, and students and then designing the material. The formative assessment emphasized the prototyping process, which consists of expert review, one-to-one, small group, and field tests. In this article, the field test was skipped. The subject of this study is students in grade 10 SMAN 6 Prabumulih, South Sumatra, Indonesia, consisting of 36 students.

In the preliminary study, the researchers identified the problems in the probability material in phase E relevant to today's educational situation through a literature review, previous studies, theories, and books. Furthermore, analyze the curriculum related to the probability content and determine the learning objective for the learning is provided. The researchers also observed culinary tourism in Prabumulih City, which will be used as context in the learning material.

Zulkardi and Putri (2020) explained that teaching materials can use the real context of students. The use of context is one of the characteristics of the PMRI approach. Through culinary tourism, students are led to understand the concept of probability material and can train their reasoning skills so that mathematics learning becomes more meaningful.

After that, researchers analyzed the students' diagnostic assessment. So that the researchers could find out the characteristics of the students in the phase E class, especially those who are the subject of this study, the researchers have done a diagnostic assessment through observation during teaching and learning carried out in the classroom so the researchers can predict students' skills, and then used in designing teaching probability materials that are accordance with the characteristic of students, so that learning becomes quality. It is in line with Waheed et al. (2023), saying that data collected from teaching and learning activities can be a tool to improve the quality of education.

Finally, the researchers began to design student worksheets integrated with microlearning media (comic and video learning). Student worksheets are discussion and collaboration rooms for students; meanwhile, microlearning media is the primary material that makes learning easy.

In formative evaluation, the researchers did a self-evaluation, expert review, one-to-one, and small group. In self-evaluation, the researchers independently evaluate the prototype produced from the preliminary study through discussion with the supervisor. The outcome of the researchers' self-evaluation was to produce prototype 1.

In the expert review stage, the researchers submitted prototype 1 and some assessment sheets to the validators. The assessment sheets submitted are an assessment of microlearning media and a student worksheet. The validator validates the prototype 1 instrument so that the researchers can refine the product. They were focused on the content of microlearning-based media and student worksheets and the compatibility of content with microlearning-based media and student worksheets.

During the validation process, the researchers conducted a one-to-one stage by testing prototypes with 1 to four students who did not study the subjects. During the trial, the

researchers observed the process of working on prototype 1 by four students. The researchers observed the difficulties faced by the students. In addition, researchers also interviewed with open-ended questions after they finished working on the student worksheets. Thus, the researchers could find out the advantages and disadvantages of prototype 1 to become a guideline for the researcher in revising.

At the revision stage, the researchers analyzed the results of validation and observation during the prototype 1 trial. The researcher uses the analysis results as a basis for a revision, as an improvement on prototype 1 in the form of prototype two that has been validated.

In the small group stage, prototype two was tested on four students who were not the subject of the study. Researchers did the same thing as the previous stage: observation and interviews. The researchers used the field records obtained as a basis for making improvements. After testing prototype 2 with a group of students, the researchers revised it to improve prototype two outcomes, prototype 3, valid and practical.

## Results

In a preliminary study, the researchers produced learning objectives that were adjusted to learning outcomes in the Merdeka curriculum, namely: (1) students can determine the sample space of a random experiment; (2) students can determine the number of members of an event from various situation; (3) students can determine the probability of a compound event.

Then, researchers produced prototype 1, which consists of two activities on a student worksheet. Previously, researchers produced comic education as microlearning-based media containing material about sample space, which was then integrated into the student worksheet as activity 1, as seen in Figure 1.

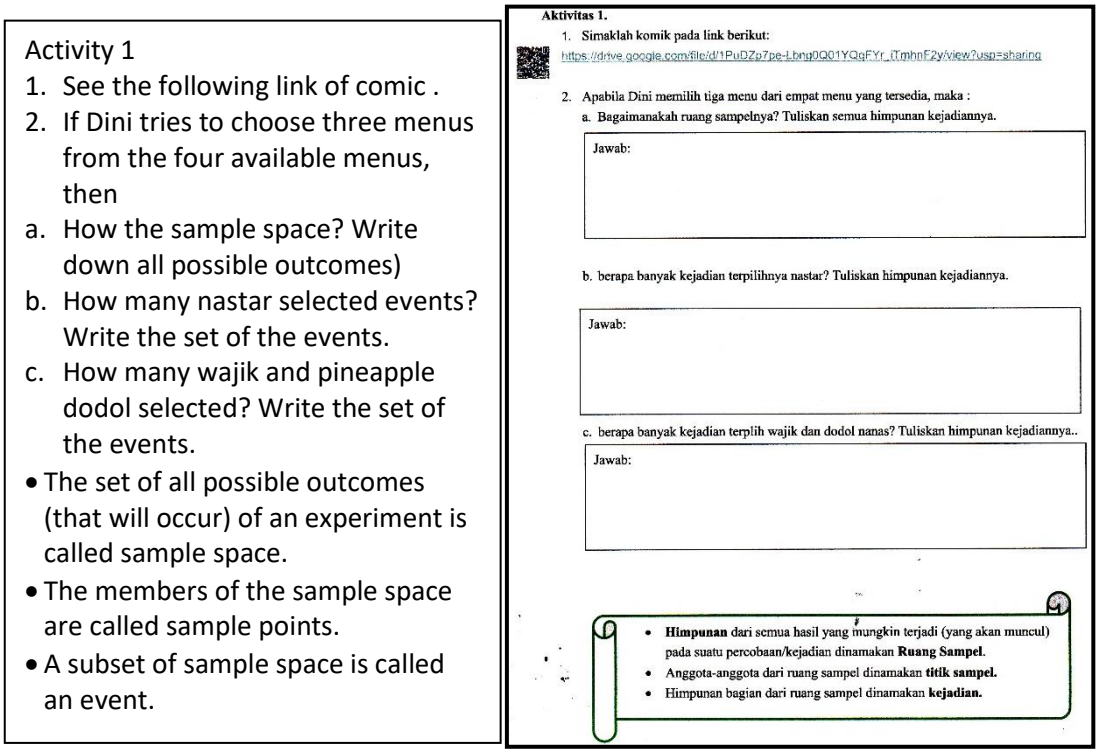



**Figure 1**. Activity 1 on student worksheet

Figure 1 shows three problems in Activity 1. Firstly, students are asked to determine the members of the sample space and events. There are three problems given to students about sample space. Students are asked to determine all the outcomes by selecting three menus from the four available menus. Then, they are asked to determine the event by choosing one of the menus and writing down the set of events. Finally, students are given definitions of sample space, points, and events. In the beginning, you can see that there is a link and barcode to go to the educational comic, which can be seen in Figure 2.


**Figure 2**. Comic education

The comic guides students in understanding the sample space researchers use as microlearning media (see the comic link). Through this comic, students can focus on the brief material provided. McNeill and Fitch (2023) conveyed that microlearning can make learning more effective and help improve students' focus and knowledge retention. (Chu & Toh, 2020) said that using real-world contexts with comics will focus students' attention more on one source. So, it can be said that using real contexts in comics in learning can help students understand the subject matter more easily.

Meanwhile, activity 2, which the researchers designed, can be seen in Figure 3.

**Activity 2.**

Complete the following table.

| Experiment | Sample Space | Events | Events that Occur | Many Events | Many Sample Space | Probability of event $=\frac{many\ events}{many\ sample\ space}$ |
|---|---|---|---|---|---|---|
| Select one menu from the four available menus | | Selected nastar | | | | |
| | | Selected wajik or dodol | | | | |
| | | Selected odd numbered menu or pineapple roll cake | | | | |
| | | Selected even numbered menu and nastar | | | | |
| | | Selected prime or odd numbered menu | | | | |

**Definition**: A combination of two events $A$ and $B$, expressed by the symbol $\boldsymbol{A \cup B}$, is an event that contains all the elements included in $A$ or $B$.
Which of the events above is a combination of two events? Explain your answer.

**Figure 3**. Activity 2 on student worksheet

From Figure 3, we can see the content of prototype 1. There are seven columns in Activity 2. Students must complete five columns that are still empty. Students are asked to complete a table based on the experiment and several available events. Activity 2 aims to enable students to understand events and determine the probability of an event occurring.

Through activities 1 and 2, students are led to find the concept of sample space, events, and probability. As defined by Greenwood et al. (2011), sample space is a list of the results of an experiment. Thus, students' reasoning skills are needed to determine the sample space to determine the events and probability.

In expert review, the researchers obtained validator assessment results in the form of comments written on an observation sheet. The results summarized by the researchers are shown in Tables 1 and 2.

**Table 1.** Summarize of validator assessment to comic education

| Formulation of Outline Objectives | Already Appropriate |
|---|---|
| Comic content | There needs to be an explanation and reinforcement so that the details in the students worksheet are related to the sample space, how to write it, because this is very crucial. |
| Comic characterization illustration | Already appropriate |
| Template design | Quite clear |
| Relevance between content, illustration, and background | Already appropriate |
| Aesthetics elements | quite good |
| Design or layout | Good |
| Legibility | Good |
| Formulation of outline objectives | Already appropriate |

Table 1 shows the results of expert validation of the comic. Eight components make up the assessment. Of the eight components, the comic content section garnered the most comments. Researchers must affirm the sample space because it is crucial to the probability material.

**Table 2**. Summarize of validator assessment to student worksheet

| No. | Validated Objects | Comment |
|---|---|---|
| 1 | student worksheet contents aspect | |
| | a. Does the content of student worksheet with the PMRI approach contain mathematics material that is in acordance with the *Merdeka* Curriculum? | Yes |
| | b. Does the content of student worksheet with the PMRI approach contan the mathematics material that should be tought to grade 10 students (Phase E)? | Yes |
| 2 | Characteristcs aspects of PMRI | |
| | Does the Student Worksheet reflect the characteristics of PMRI (Indonesian Reaistic Mathematics Education) Realistik Indonesia)? Characteristics of PMRI: | |
| | a. Using contextual problems | Yes |
| | b. Using a model that emphasizes informal solutions before using formal methods | Yes |

| No. | Validated Objects | Comment |
|---|---|---|
| | c. Respecting language diversity and student contribution | Yes |
| | d. Interactivity | Yes |
| | e. Integrated with other learning topics | Yes |
| 3 | Media aspect and relevance | |
| | a. Are the media aspect used in this student worksheet well provided | Yes |
| | b. Is the content of this student worksheet relevant to the formulated learning objectives? | Yes |

Table 2 shows a summary of the validators for the student worksheet. Three points are assessed, namely in terms of content, PMRI characteristics, media aspect, and relevance. All assessments show that they are in accordance.

**Table 3**. Summarize of validator assessment to video learning

| Category | Comment |
|---|---|
| Cover design | good |
| Theme design | good |
| Video design | good |
| Contents : | |
| • Suitable of topic selection with the microlearning concept; | good |
| • Readability of the material (point to point, supporting image design) | good |
| • Video presentation of speaker | good |

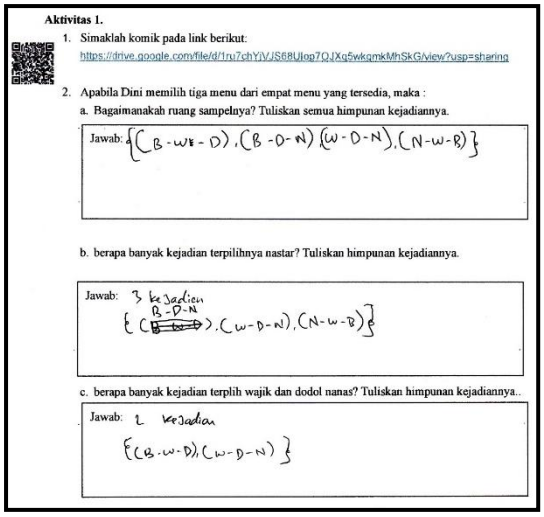
Table 3 summarizes the validators for video learning as microlearning media. There are four categories in which learning videos are assessed. The four categories correspond to the microlearning video researchers have produced.

In the one-to-one stage, researchers observed the work on prototype 1 with four students who did not study the subjects, as seen in Figure 4.

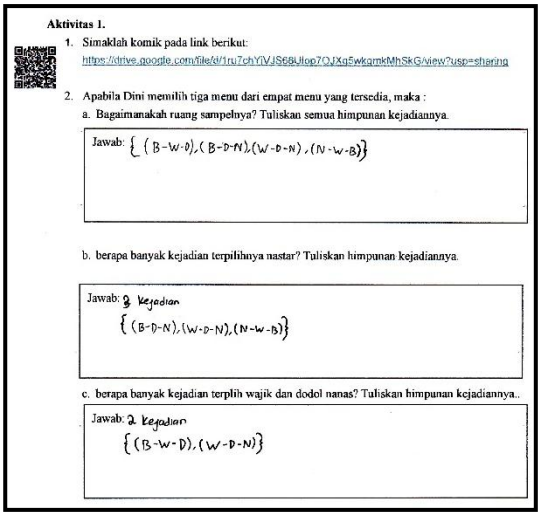
**Figure 4**. One-to-one process

Figure 4 shows that students work individually on student worksheets, and the researchers observe the work process. Each student works on the worksheet individually and asks the researchers when they have problems. Students write their answers on the student worksheet.

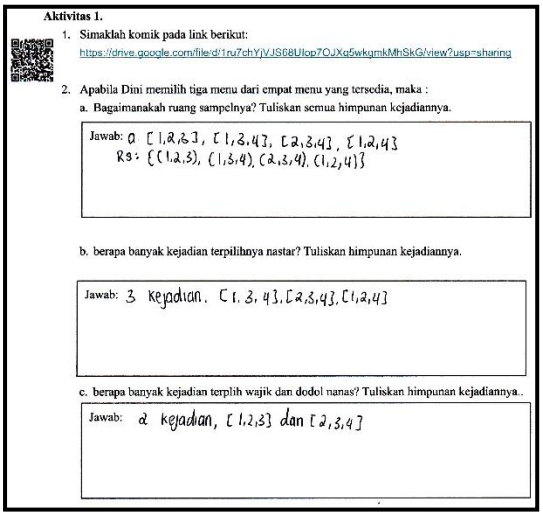
In addition, researchers produced notes from the results of observations and interviews and the answers of four students who were not the subject of this study. The results of students can be seen in Figure 5.



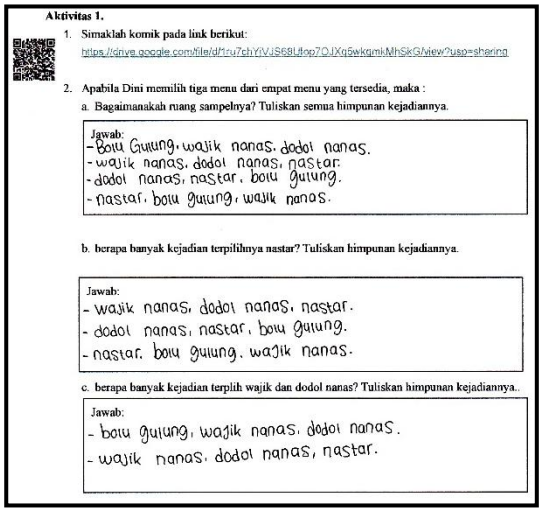

Answer of Student A




Answer of Student B




Answer of Student C




Answer of Student D

**Figure 5**. Students' answers to activity 1

Figure 5 shows students' answers to activity 1 in a worksheet. It can be seen that three students (A-C) used the model to write down the members of the sample space. Students A and B represent the four available menus using letter symbols: letter B for roll cake, W for walk, D for dodol, and N for nastar. Meanwhile, student C uses number 1 for roll cake, 2 for wajik, 3 for dodol, and 4 for nastar. At the same time, student D wrote it completely but forgot to make curly brackets as a set symbol.

In activity 2, the answers generated were almost the same, so the researchers only displayed one, as seen in Figure 6. From Figure 6, we can see the students' answers to Activity 2 in the student worksheet. Students are asked to complete a table based on the experiment and several available events. From their answer, it can be seen that they assume that an event consisting of two members is a combination of two compound events (see the section marked with a red box). It is because they do not yet understand the concept of compound events. However, in the end, after the work, they realize the mistake.

**Activity 2.**

Complete the following table.

| Experiment | Sample Space | Events | Events that Occur | Many Events | Many Sample Space | Probability of event $= \frac{many\ events}{many\ sample\ space}$ |
|---|---|---|---|---|---|---|
| Select one menu from the four available menus | pineapple roll cake<br>pineapple wajik<br>pineapple dodol<br>nastar | Selected nastar | $\{n\}$ | 1 | 4 | $\frac{1}{4}$ |
| | | Selected wajik or dodol | $\{w, d\}$ | 2 | 4 | $\frac{2}{4}$ |
| | | Selected odd numbered menu or pineapple roll cake | $\{b, d\}$ | 2 | 4 | $\frac{2}{4}$ |
| | | Selected even numbered menu and nastar | $\{n\}$ | 1 | 4 | $\frac{1}{4}$ |
| | | Selected prime or odd numbered menu | $\{b, w, d\}$ | 3 | | $\frac{3}{4}$ |

**Definition**: A combination of two events $A$ and $B$, expressed by the symbol $\boldsymbol{A \cup B}$, is an event that contains all the elements included in $A$ or $B$.
Which of the events above is a combination of two events? Explain your answer.

$W \cup D$: due to a combination of two events $A$ and $B$, $A = W, B = D$

$B \cup D$: due to a combination of two events $A$ and $B$, $A = B, B = D$

**Figure 6**. Students' answers to activity 2

In the revision stage, the researchers refined prototype 1 based on the results obtained from the expert review and one-to-one to produce a valid prototype 2. The revision that the researchers made can be seen in Table 4.

**Table 4**. Revision prototype 1 to prototype 2

| Prototype 1 | Prototype 2 |
|---|---|
| Only one experiment: Dini choose three available menus. | Two random experiments:<br>1. Dini choose two different menus at random from the four available menus.<br>2. Dini choose three different menus at random from the four available menus |
| *Microlearning* is just comic | The microlearning media are comic (sample space material) and video (tree diagrams). |

In small groups, the researchers tested prototype 2 on a group of four students with high, medium, sufficient, and low abilities. They were not the subject study. Each student is given a student worksheet; they work on it, as seen in Figure 7.

**Figure 7**. Small group

Figure 7 shows that they worked on the student worksheet individually, even though they were sitting in a group. They can ask each other before going to researchers if they have difficulties. The results of students' answers can be seen in Figures 8 and 9.

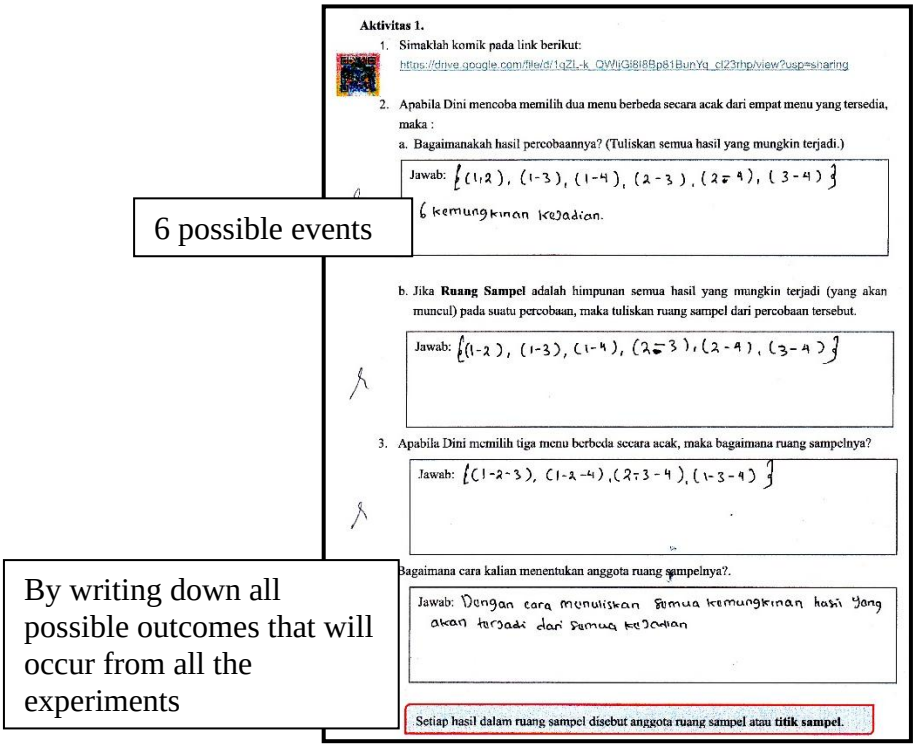



**Figure 8**. Answer of student on activity 1 from small group

Figure 8 shows the answers to the results of a group discussion of students at the small group stage. They consisted of two boys and two girls. The results of students' answer activity 2 can be seen in Figure 9.

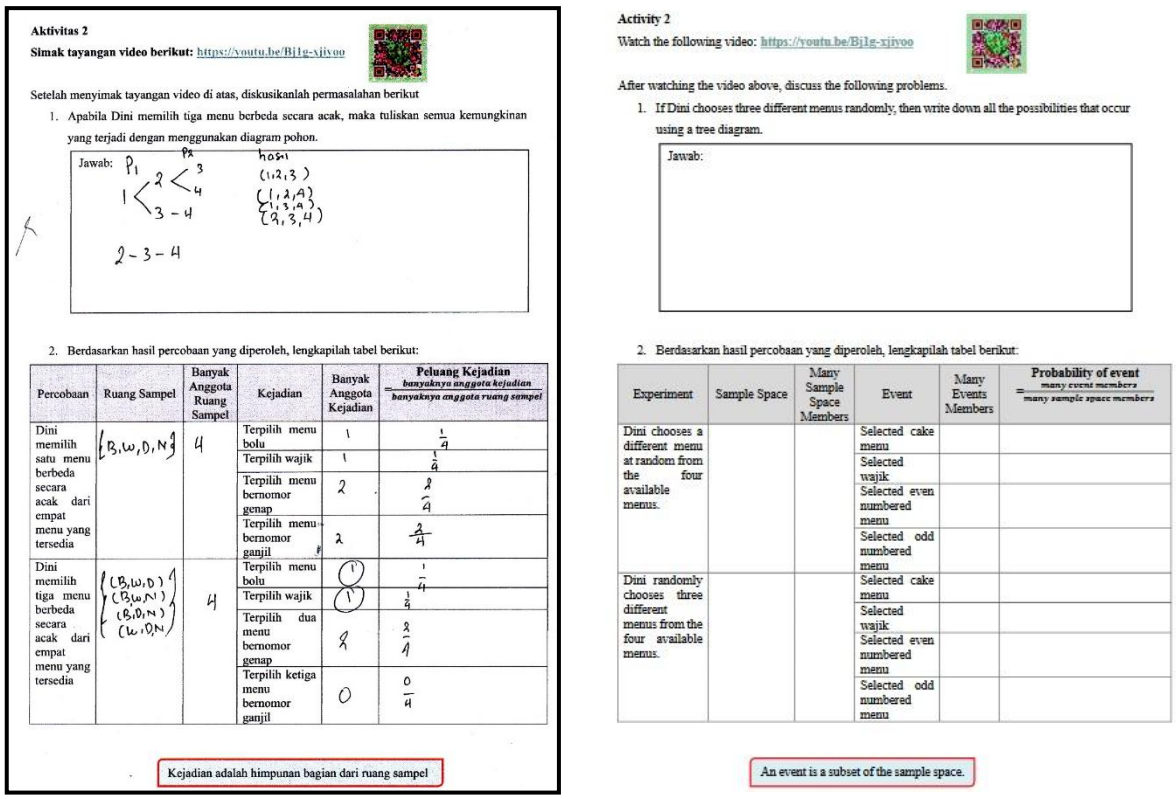



**Figure 9**. Answer of student on activity 2 from small group

Figure 9 shows the students' group answer to activity 2 contained in prototype 2. Observation data was analyzed descriptively, which describes the situation while students were working on LKPD and the difficulties faced by students on LKPD. In activity 2, researchers added a learning video about tree diagrams, which can be accessed at the link tree diagrams. Through the video, students will be able to compare the results of the sample space obtained from activity 1 to find a more structured way to determine the sample space.

## Discussion

This study developed a student worksheet integrated with microlearning-based media, namely comic education and video learning, on the probability material for phase E, using the context of culinary tourism in Prabumulih City. The characteristics of microlearning-based media that researchers produce are using the context of culinary tourism integrated with student worksheets, containing two activities as a discussion space and group collaboration to guide students to understand the concept of probability and train students' reasoning skills.

According to Samarawickrama et al. (2023), comics, in essence, are a medium for depicting specific scenarios to the readers through the art of the author. Comics are usually intended for entertainment, and in general, people are interested in comics, follow the storyline, and even idolize the character. Comics can also be informative and educational mediums used in learning (Shomad & Rahayu, 2022). Using comics in learning can be an educational entertainment medium from those two opinions. Throw the comic produced by researchers, and students read the storyline about sample space. When they read it, they seemed to be in that real situation.

The use of microlearning learning video allows for the delivery of information that is easy to understand. In this study, students understand the concept of tree diagrams. Students are led from informal mathematics to formal mathematics, known as the mathematization process. Arifin et al.(2021) said that in a realistic mathematical view, the process of conveying ideas in models, schemes, and symbolizations is called the mathematization process.

Microlearning provides a valuable and efficient strategy for delivering student content (McNeill & Fitch, 2023). Students who initially struggled with the material but completed more microlearning improved their performance with a higher score Nowak et al., (2023). The use of context is one of the PMRI approach's characteristics, making learning more meaningful. The use of context can help improve problem-solving skills. It is related to Sutarni et al. (2024), who said that integrating real-life context in mathematics education allows direct involvement with authentic events and facilitates the development of students' knowledge and skills. Researchers found that students' problem-solving abilities in solving problems given in LKPD also show their reasoning skills. Thus, students' reasoning skills can be trained through microlearning-based learning integrated into student worksheets with the PMRI approach.

The researchers produced student worksheets that integrated microlearning-based media (comic and video learning), which is valid and practical. Before designing comic and video learning, the researchers analyzed students, curriculum, content, and media. The researchers conducted student analysis through observation in learning activities so that the researchers

could find out the characteristics of students, especially those who would be the subject of the research study.

The researchers found that the students usually use formulas directly in mathematics learning. They seldom or never use context in learning. Thus, the students' reasoning skills have not been optimally empowered. From the analysis of the Merdeka Curriculum, the material in phase E, probability, is contained in the data and probability content, with learning outcomes referring to the described probability material. Unlike the previous curriculum, where the material on probability is only studied in grade 12, the Merdeka curriculum divides the component content into two.

It is one of the government's breakthroughs so that students can obtain basic material in depth in phase E. As said, (by Martatiyana et al., 2023), the Merdeka curriculum focuses more on essential materials and developing student competencies according to their phase. The goal is that learning is not rushed to complete the material so that the students can enjoy the learning process through more meaningful learning. Comics, video learning, and student worksheets that have been designed are called prototypes that researchers will evaluate.

The prototypes are discussed with the supervisor until there is a revision to improve the prototype, called prototype 1. Furthermore, it was validated and tested on four heterogeneous students at the one-to-one stage. Based on the analysis of the validators' assessment results, the researchers need to emphasize the content of the sample space, which, in theory, the experiment in probability carried out are random experiments, and the dialogue used in the comic is made more flowing. As conveyed by (Suharsono et al., 2023), teachers must continue to learn and develop their abilities so that students can understand the material presented challenging material.

The result of prototype 1 improvements produced a valid prototype 2. Furthermore, prototype 2 was tested on four students with heterogeneous abilities. Each student was given a student worksheet, and they worked individually. If a student had difficulty, he/she did not hesitate to ask his/her friends. If a student with high ability had finished work, the researcher asked him/her to pay attention to his/her friend's work and asked about the difficulties faced when parts were not answered. After they were finished, they discussed and deliberated to determine whose work would be collected. In group learning, students can communicate with each other, collaborate, and share ideas or knowledge (Wardani et al., 2023). The student worksheet researchers designed an open space for students to discuss and collaborate.

## Conclusion

Student worksheet integrated microlearning-based media of probability material on phase E with the context of culinary tourism in Prabumulih City, which was developed valid and practical with characteristics: (1) microlearning-based media uses the context of culinary tourism integrated with student worksheet, contains activities as a space for discussion and group collaboration to led students to understand the concept of probability, and train students' reasoning skills; (2) The construct used by PMRI approach; (3) The answers to the problems given are in the form of students answers models which are as students contribution, thus

leading students to understand the concept of sample space and probability an event, which at the same time trains their reasoning skills; (4) The resulting microlearning products are in the form of comic and video learning (using the researchers' original voice). Comic media aims to make students understand the concept of sample space, while video learning makes students understand the presentation of sample space in tree diagrams. Students can find the concept of an event's probability through some questions in the student worksheet.

The microlearning media for probability material integrated into student worksheets can help train students' reasoning abilities. Students can estimate all the possible outcomes from an experiment to determine the probability of an event.

The student worksheet that researchers developed can help train students' reasoning abilities. Unfortunately, this study's microlearning media has not used interactive media. For further research, we can use interactive media to increase student involvement in learning.

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## Conflicts of Interest

The authors declare no conflict of interest regarding the publication of this manuscript.

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## Author Contributions

**Novi Komariyatiningsih:** Developt, collecting, analyzing data; **Yusuf Hartono:** Advising, revising the manuscript; **Ratu Ilma Indra Putri:** Advising, revising the manuscript; **Cecil Hiltrimartin:** Advising, revising the manuscript.

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