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# Integrating Project-Based Learning with Palembang Culinary Context in Teaching Statistics for Supporting Pre-Service Teachers' Flexibility

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**ABSTRACT**

Flexibility is a crucial component of statistical reasoning, as it enables students to interpret data using multiple representations and adapt problem-solving strategies in different contexts. However, many pre-service teachers still demonstrate limited flexibility when learning basic statistics, often relying on procedural calculations rather than conceptual understanding. This study aims to develop a Project-Based Learning (PBL)-based instructional device integrated with the Palembang culinary context to support pre-service teachers' flexibility in learning statistics. This study employed a Research and Development approach using the ADDIE model, which includes analysis, design, development, implementation, and evaluation stages. The participants were pre-service mathematics teachers enrolled in a basic statistics course at a university in Indonesia. The developed learning tools consisted of Student Activity Sheets (LAM) and evaluation tasks supported by the Jamovi statistical application. Flexibility was operationally defined as the ability to use multiple representations, apply different solution strategies, and adapt statistical reasoning when analyzing data. The instruments included expert validation sheets, student response questionnaires, and a flexibility test developed based on representational, strategic, and conceptual indicators. The validation results obtained an average score of 86 (very valid), the practicality test reached 85.2 (very practical), and the field test showed an average flexibility score of 72.7 (good category). These results indicate that the developed instructional device is valid, practical, and effective. The novelty of this study lies in integrating project-based learning, culturally relevant culinary data, and Jamovi-assisted statistical analysis to foster flexible statistical thinking among pre-service teachers.

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## A. INTRODUCTION

In the era of data-driven decision making, statistical literacy has become an essential competence that mathematics teachers must possess and develop in their students. Statistical literacy enables individuals to interpret data, evaluate information critically, and make reasoned decisions based on evidence (Garfield & Ben-Zvi, 2008; Sharma, 2020). For pre-service mathematics teachers, mastering statistical literacy is particularly important because they will later guide students in understanding real-life phenomena through data analysis. Concepts such as data presentation and measures of central tendency mean, median, and mode serve as fundamental tools for analyzing and interpreting data in meaningful ways.

Despite its importance, many studies indicate that pre-service teachers still experience difficulties in understanding statistical concepts beyond procedural calculations. Research has shown that students often rely on mechanical procedures when computing statistical measures but struggle to interpret the meaning of these results or connect them with real-life situations (Chance et al., 2004; Zieffler et al., 2008). Similar findings have been reported in various educational contexts where statistics is frequently taught as a set of formulas rather than as a means for reasoning about data (Garfield & Ben-Zvi, 2008). Consequently, statistical learning in teacher education programs has not fully supported the development of deeper statistical reasoning and meaningful understanding.

One factor related to this issue is the limited flexibility in students' statistical thinking. Flexibility refers to the ability to use multiple representations, apply alternative strategies, and adapt reasoning when solving problems (Star & Rittle-Johnson, 2008). In statistics learning, flexibility allows learners to shift between representations such as tables, graphs, and numerical summaries, evaluate different analytical approaches, and adjust their reasoning according to the context of the problem (Pfannkuch & Wild, 2004). When learners lack flexibility, they tend to rely on a single procedure and encounter difficulties when facing unfamiliar or complex data situations. Therefore, developing flexibility becomes an important objective in statistics education, particularly for pre-service teachers who will later facilitate students' understanding of statistical concepts.

However, statistics learning practices in higher education are still frequently dominated by lecture-based instruction and routine exercises that emphasize formula application rather than conceptual exploration. Such decontextualized learning environments provide limited opportunities for students to analyze real data or interpret statistical results meaningfully. As a result, the statistical knowledge acquired often becomes inert and difficult to apply in authentic contexts (Segura & Ferrando, 2023). To overcome this challenge, instructional approaches that engage students in authentic problem-solving situations are needed.

Problem-Based Learning (PBL) has been widely recognized as an effective approach for promoting higher-order thinking skills. In PBL environments, learning begins with complex and authentic problems that require students to investigate, analyze information, and construct knowledge collaboratively (Barrows, 1986; Hmelo-Silver, 2004). Through this process, students develop critical thinking, problem-solving abilities, and cognitive flexibility. Several studies have reported that PBL can enhance conceptual understanding and encourage reflective reasoning in mathematics and statistics learning (Sahin & Yilmaz, 2022).

In addition to learning approaches, contextual relevance also plays an important role in supporting meaningful learning. Contextual Teaching and Learning emphasizes that students learn more effectively when academic concepts are connected to real-life experiences (Johnson, 2007). In statistics education, authentic contexts provide meaningful data sources that encourage students to interpret information based on real phenomena. Studies have shown that contextualized statistical tasks can enhance student engagement and improve their ability to reason about data (López-Martín & Albarracín, 2021; Albano & Dello Iacono, 2021).

Nevertheless, previous studies on Problem-Based Learning in statistics education have mainly focused on improving conceptual understanding or general problem-solving ability. Limited research has specifically examined how PBL can support the development of flexibility in statistical thinking among pre-service mathematics teachers. Furthermore, the integration of culturally relevant contexts in statistics learning, particularly local cultural contexts that are familiar to students, remains relatively underexplored in the literature.

To address this gap, this study integrates Problem-Based Learning with the culinary context of Palembang in statistics learning. Culinary products such as *pempek, tekwan,* and *pindang ikan* provide authentic data related to production, sales, ingredient composition, and consumer preferences. These real-life contexts can serve as meaningful problems in statistics learning, allowing pre-service teachers to analyze, represent, and interpret statistical information through multiple strategies and representations. Through this integration, students are expected to develop flexibility in statistical thinking while experiencing contextual and culturally meaningful learning.

Based on this background, the research questions guiding this study are formulated as follows: (1) How can a Problem-Based Learning instructional design integrated with the Palembang culinary context be developed for teaching statistics to pre-service mathematics teachers?; and (2)To what extent does the developed learning design support the development of pre-service teachers' flexibility in statistical thinking?. The novelty of this research lies not only in the use of a local cultural context but also in its conceptual contribution to statistics education. This study proposes a contextual PBL-based learning design that integrates authentic cultural data with statistical reasoning activities to support the development of representational, strategic, and conceptual flexibility among pre-service teachers. The findings are expected to contribute to the development of more contextual, flexible, and culturally responsive approaches to statistics education.

## B. METHODS

### 1. Research Design

This study employed a Research and Development (R&D) approach using the ADDIE development model, which consists of five main phases: Analysis, Design, Development, Implementation, and Evaluation. The ADDIE model was originally introduced by Reiser and Mollenda (1990) and has been widely adopted in instructional design because it provides systematic procedures for developing valid, practical, and effective learning products. Recent studies also highlight that the ADDIE framework remains relevant in contemporary instructional design due to its structured yet flexible development process that supports iterative revisions based on evaluation results (Branch & Dousay, 2020). In addition, the model allows instructional designers to refine learning products at each stage to ensure alignment between learning objectives, instructional strategies, and evaluation processes (Branch & Varank, 2009).

This development model was selected because it aligns with the objectives of this study, namely to develop student activity sheets (LAM) for statistics learning through a Problem-Based Learning (PBL) approach supported by the Jamovi application to enhance pre-service teachers' flexibility in statistical thinking. Research and development in education aims to produce instructional products that can improve learning effectiveness and be implemented in authentic educational settings (Gall & Borg, 2003). Therefore, the ADDIE model provides a systematic framework to guide the development and evaluation of the proposed learning tools. Figure 1 illustrates the operational procedures of the ADDIE model used in this study.

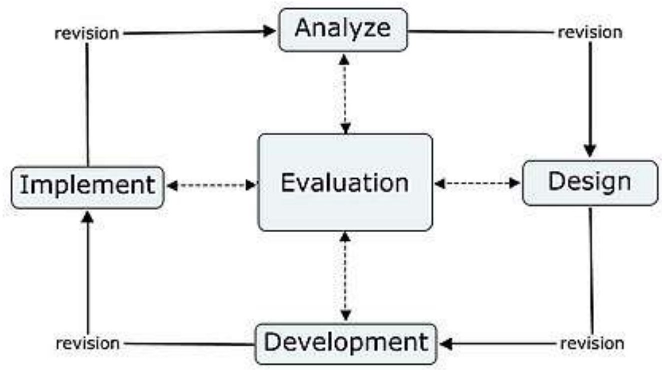



**Figure 1**. ADDIE Model Research and Development Process (Gall & Borg, 2003)

a. Analysis Stage
   The analysis stage aimed to identify learning needs, student characteristics, and problems encountered in statistics learning. Data were collected through classroom observations and interviews with lecturers teaching the Basic Statistics course. The findings revealed that learning activities were predominantly procedural and focused on formula application without connecting statistical concepts to real-life contexts. Needs analysis is an essential step in instructional development because it ensures that learning materials are designed based on learners' actual needs and learning difficulties (Branch & Varank, 2009).
b. Design Stage
   At the design stage, the structure of the learning device was prepared based on the results of the needs analysis. This stage included formulating learning objectives, designing Student Activity Sheets (LAM) based on the Problem-Based Learning model, developing contextual statistical problems using Palembang culinary data, and designing evaluation instruments to measure students' flexibility. The integration of contextual problems and statistical technology was intended to encourage students to analyze real data and develop deeper statistical reasoning skills (Garfield & Ben-Zvi, 2008).
c. Development Stage
   The development stage involved validating the initial prototype of the learning device through expert review. Three mathematics education experts evaluated the learning materials based on several aspects, including content relevance, clarity of language, contextual appropriateness, and alignment with flexibility indicators. Expert validation is an important procedure in development research to ensure the content validity of instructional products before they are implemented in real learning situations (Nieveen, 1999; Plomp, 2013).
d. Implementation Stage
   The implementation stage was conducted in two phases. First, a small-scale trial involving 10 students was carried out to examine the practicality of the developed learning device. Second, the revised learning device was implemented in a larger class consisting of 30 pre-service teachers enrolled in the Basic Statistics course. The learning

process was conducted in four meetings, including one meeting on data presentation, two meetings on measures of central tendency, and one meeting for the flexibility test.

e. Evaluation Stage

The evaluation stage aimed to assess the validity, practicality, and effectiveness of the developed learning device. Validity was measured through expert validation, practicality was assessed using student response questionnaires, and effectiveness was determined through the analysis of students' flexibility test scores. According to Nieveen (1999), these three criteria validity, practicality, and effectiveness are commonly used to evaluate the quality of educational products developed through design research.

## 2. Participants

The participants of this study were 30 pre-service mathematics teachers enrolled in a Basic Statistics course at a private university in Indonesia during the 2025–2026 academic year. Prior to the main implementation, a small-scale trial involving 10 students was conducted to examine the practicality of the developed learning device. The participants were selected using a cluster random sampling technique from twelve classes taking the Basic Statistics course. One class (Class 3D) was randomly selected as the research sample. All participants had previously taken introductory mathematics courses but had limited experience in using statistical software such as Jamovi.

## 3. Instruments

Three types of research instruments were used in this study: validation sheets, student response questionnaires, and flexibility tests**.**

a. Validation sheet

The validation sheet was used to evaluate the quality of the developed learning device. The validation instrument employed a four-point Likert scale, as shown in Table 1.

**Tabel 1.** Criteria Validation Instrument

| Score | Criteria |
|---|---|
| 1 | Not Appropriate |
| 2 | Less Appropriate |
| 3 | Appropriate |
| 4 | Very appropriate |

b. Test results (Field Test)

Data analysis of field test results can use percentage analysis (PA) for response questionnaires and descriptive analysis for student test results (Nieveen, 1999; Tessmer, 1993; Plomp, 2013). The field test results are analyzed based on the following flexibility indicator table adapted from Star (2018); Leikin (2013); Blöte & Klein (2020); Silver & Kenney (2019); Irawati & Wahyudi (2021); Putri & Zulkardi (2020), as shown in Table 2.

**Table 2**. Student Flexibility Ability Indicators

| Aspects Assessed | Flexibility Indicator |
|---|---|
| Representational Flexibility | Students are able to accurately display and switch between representations (tables, graphs, narratives, and symbols). |
| Strategic Flexibility | Students are able to use various strategies to solve problems. |
| Conceptual Flexibility | Students demonstrate the ability to understand concepts from various perspectives and explain the reasons behind their choices. |
| Reflective Flexibility | Students are able to evaluate and improve strategies or results obtained. |

The analyzed field test results are grouped based on the final category of student flexibility abilities, which can be seen in Table 3 below.

**Table 3.** Final Category Criteria for Flexibility Ability

| Final Score Range (Average) | Category |
|---|---|
| 76,0 – 100,0 | Very Good |
| 51,0 – 75,0 | Good |
| 26,0 – 50,0 | Enough |
| 1,0 – 25,0 | Less |

## C. RESULT AND DISCUSSION

### 1. Analysis Phase

The analysis phase is the first step in the ADDIE development model to identify the needs, problems, and characteristics of learners before designing an appropriate learning model. The results of observations and interviews with lecturers teaching the Educational Statistics course show that learning is still dominated by conventional methods that focus on formulas and procedures without relating them to real-life contexts. As a result, pre-service teachers are only able to calculate measures of central tendency such as mean, median, and mode mechanically, but are not yet able to interpret their meaning in the context of everyday problems. This condition indicates the low flexibility of students' thinking in dealing with various statistical problems, which is in line with Rahayuningsiha's (2025) findings that cognitive flexibility plays an important role in the ability to solve problems and adjust thinking strategies in mathematics and statistics learning.

In addition, the results of the context analysis show that statistics material has not been linked to the local culture that is close to students' lives. In fact, contextual learning can increase the meaning and engagement of learning (Johnson, 2007). Therefore, the application of Problem-Based Learning (PBL) based on the culinary context of Palembang is considered relevant to create an authentic learning experience. The use of culinary data such as raw material prices, sales volume, and consumer preferences can be a source of real problems to train data analysis skills while strengthening students' flexibility of thinking (Barrows & Tamblyn, 1980). The results of this analysis form the basis of the design phase for developing problem-based and locally contextual statistical learning tools.

## 2. Design Phase

The design phase was carried out after the needs analysis, with the aim of designing a systematic learning tool that was suitable for the characteristics of pre-service teacher students. At this phase, the researchers established a Problem-Based Learning (PBL) learning structure that was integrated with the use of the Jamovi application as a statistical data analysis tool. The design includes the preparation of Student Activity Sheets (LAM), evaluation questions, and instruments for assessing student flexibility. The first step in the design phase is to develop learning specifications that include learning outcomes, objectives, indicators, and a sequence of activities. LAM is designed to include contextual problem-based activities, using local cultural phenomena in Palembang, such as pempek sales data, pempek type preferences, and traditional culinary taste assessments. Each activity in the LAM is structured in phases to guide students in identifying problems, collecting data, analyzing it with Jamovi, and interpreting the results.

Furthermore, descriptive evaluation questions were also designed to assess students' ability to process, analyze, and interpret data using the Jamovi application. These questions were designed in line with the activities in LAM, both in terms of context and type of data representation, so that there was continuity between the learning process and assessment. In addition to the main tools, the design phase also includes the creation of supporting instruments such as expert validation sheets, practicality response questionnaires, and rubrics for assessing student flexibility skills. Each component is designed based on the principles of content validity, practicality, and learning effectiveness. The results of this design phase become the initial design of the product, which will then be validated by experts in the development phase to ensure the quality of content and appearance before being implemented in field trials.

## 3. Development Phase

At this phase, validation was carried out by an expert review consisting of three mathematics education lecturers, and the results can be seen in Table 4.

**Table 4.** Expert Review Results

| Validator | Main Comments | Implementation in Documents |
|---|---|---|
| **A** | Sequence of achievements–goals, add context, change wording to “conclude,” add instructions | The order has been improved, instructions and context have been added at the beginning of the activity, and the wording has been changed to “understand the discourse.” |
| **Y** | Compare the bar charts between LAM and test questions, add Jamovi skill indicators. | Bar charts are consistent, Jamovi instructions are clarified, skill indicators are added to midterm exam questions. |
| **R** | Add essential questions, design surveys, improve Jamovi instructions, deepen analysis, add presentations | Added phases 1–5 to the LAM and reflective presentation assignment |

Based on the comments from the expert reviewers, revisions were made to the LAM design that had been created. The results of the revisions can be seen in Figure 2.

Before Revision After Revision


**Figure 2.** Revised Results after Expert Review

The changes from the before and after images show an improvement in the quality of context presentation on the Student Activity Sheet (LAM) through the addition of photos of pempek sellers in the field. In the pre-revision version, information about the turnover of pempek sellers was only presented in the form of text discourse. This type of presentation risks making students understand the context abstractly because they do not have a concrete visual picture of the situation being discussed. After the revision, authentic photos of pempek sellers were added, which directly represent the local economic context of Palembang. The addition of this visual element serves to clarify the real situation that forms the background of the problem, helping students build a connection between mathematical concepts and everyday life. Through this visualization, students can more easily understand the meaning of the data used in the average calculation, while also increasing their engagement and interest in learning the material. Based on the validation analysis, an average score of 86 was obtained, which falls into the highly valid category.

## 4. Implementation Phase

At the implementation phase, to assess practicality, the LAM that had been created was given to a class of 10 students with a focus on observing student responses to the LAM that had been created and the learning that was carried out using the PBL model through a response questionnaire. The results of the analysis for practicality can be seen in Table 5 below.

**Table 5.** Practicality Analysis Results

| No | Participant | Score | Average | Criteria |
|---|---|---|---|---|
| 1 | Participant 1 | 80 | 85.2 | Very Practical |
| 2 | Participant 2 | 78 | | |
| 3 | Participant 3 | 90 | | |
| 4 | Participant 4 | 88 | | |
| 5 | Participant 5 | 82 | | |
| 6 | Participant 6 | 85 | | |
| 7 | Participant 7 | 86 | | |

| No | Participant | Score | Average | Criteria |
|---|---|---|---|---|
| 8 | Participant 8 | 88 | | |
| 9 | Participant 9 | 90 | | |
| 10 | Participant 10 | 85 | | |

The results of the practicality test of the learning tool that was trialed by ten participants showed that the tool was in the very practical category. Based on the calculations, the practicality scores given by each participant ranged from 78 to 90, with an overall average of 85.2, so it can be concluded that the tool is practical for use in the learning process. In general, these results indicate that students are able to understand the instructions, carry out activities, and use the Jamovi application well. Thus, the developed tool meets the practicality criteria and can be applied at a broader implementation phase with only minor refinements required based on field feedback. Next, the research was conducted on a large class that became the sample, namely class 3. D, which consisted of 30 students. Learning with the PBL model was conducted in 4 meetings, with 1 meeting for data presentation material, 2 meetings for data concentration material, and 1 meeting for field tests. The learning process can be seen in Figure 3 below.

**Figure 3.** Learning Process with JAMOVI-assisted PBL

Both images show the learning process that applies the Problem Based Learning (PBL) method assisted by the Jamovi application as a data analysis tool. It can be seen that students work collaboratively in small groups, discuss calculation results, and explore data using laptops. This activity demonstrates the active involvement of students in identifying problems, analyzing data, and interpreting results according to the real context provided in the activity sheet. In the first image, students are seen interacting intensively with their group members to read data, discuss calculation results, and record findings that emerge from Jamovi analysis. Meanwhile, in the second image, it appears that students have begun to process data independently through the application, demonstrating critical thinking skills and the use of statistical technology in line with learning objectives.

Overall, these two documents show that the application of Jamovi-assisted PBL can create an active, collaborative, and problem-solving-oriented learning environment. Students not only understand statistical concepts procedurally, but also learn to relate them to real phenomena through the interpretation of data generated by the software. This reinforces the evidence that problem-based learning with technological support can simultaneously improve students' conceptual understanding and analytical skills. In the fourth meeting, students were given a field test consisting of three essay questions to assess their understanding of the material and their flexibility after learning through the JAMOVI-assisted PBL model. The field test results were analyzed, and the scores obtained were converted into final flexibility categories in Table 6.

**Table 6.** Flexibility Ability Analysis Results

| Final Score | Students | Average | Category |
|---|---|---|---|
| 76,0 – 100,0 | 16 | 72,7 | Good |
| 51,0 – 75,0 | 13 | | |
| 26,0 – 50,0 | 1 | | |
| 1,0 – 25,0 | 0 | | |

Based on Table 6, the average score of 72.7 falls into the good category.

**5. Evaluation Phase**

The evaluation phase was conducted to assess the quality of Problem Based Learning (PBL) learning tools supported by the Jamovi application that had been developed. The validation results by three experts showed an average score of 86 in the highly valid category, which means that the content, language, and appearance of the tools were in line with the learning objectives and problem-based design principles. The practicality test through a student response questionnaire obtained an average score of 85.2 (very practical category). Students assessed the device as easy to use, with clear activity instructions and an interesting learning context that was relevant to everyday life. Meanwhile, the field test results showed that the average flexibility ability of students was 72.7, which is categorized as good, indicating that the device is capable of encouraging students to use various strategies and representations in solving statistical problems. Based on these three aspects, the learning device is declared valid, practical, and effective for application in Basic Statistics learning based on the local context of Palembang. Here is the analysis of the flexibility ability test results based on the indicators.

a. Representasional Flexibility

Representational flexibility refers to students' ability to display, interpret, and switch between different forms of mathematical representations, such as tables, graphs, narratives, and symbols (Star & Rittle-Johnson, 2008). This ability is important in statistics learning because understanding data often requires interpreting multiple interconnected representations. In this study, the indicator measured is students' ability to accurately present and connect various data representations. To identify this ability, students' responses to the given task were analyzed by examining how they read graphs, present data in other forms, and explain the meaning of the information obtained from those representations. An example of a student's response analyzed in this study is presented in the following Figure 4.

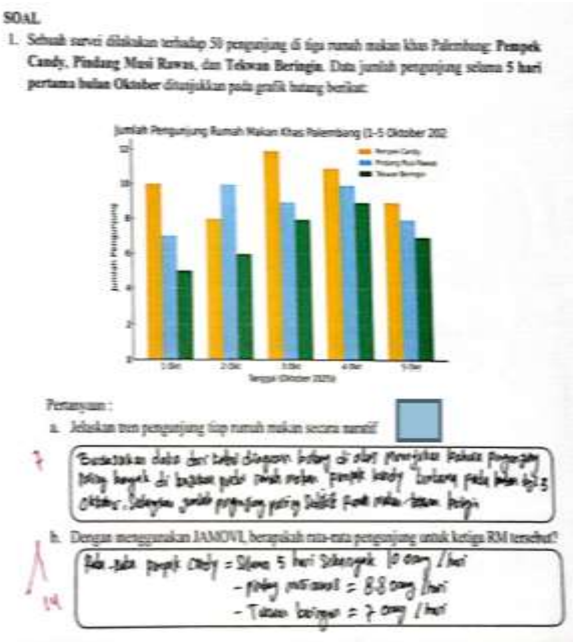
<table>
<tr>
<td></td>
<td>English Translation<br>A survey was conducted on 50 visitors at three Palembang specialty restaurants: Pempek Candy, Pindang Musi Rawas, and Tekwan Beringin. The data on the number of visitors over five days in early October are presented in the following bar chart.<br><br>Questions<br>a. Describe the visitor trends for each restaurant narratively.<br>Answer:<br>Narrative explanation of visitor trends<br>Based on the available data, it can be concluded that Pindang Musi Rawas is the restaurant most favored by visitors, with Pempek Candy ranking second, followed by Tekwan Beringin in third place.<br>b. Using JAMOVI, calculate the average number of visitors per day for each of the three restaurants.<br>Answer:<br>Average number of visitors (using JAMOVI)<br>The average number of visitors per day for five days is:<br>Pempek Candy : 10 visitors/day<br>Pindang Musi Rawas : 8.8 visitors/day<br>Tekwan Beringin : 7 visitors/day</td>
</tr>
</table>

**Figure 5.** The student response for question no 1

The student's response indicates an initial ability to interpret data presented in a graphical representation and translate it into a narrative explanation. Based on the bar chart showing the number of visitors to three Palembang specialty restaurants, the student concluded that *Pindang Musi Rawas* had the highest number of visitors, followed by *Pempek Candy* and *Tekwan Beringin*. This explanation demonstrates that the student was able to extract essential information from the graphical representation and communicate it descriptively. Such ability reflects an aspect of representational flexibility, particularly the capacity to interpret visual representations and express them in verbal form. In the second task, the student extended the analysis by calculating the mean number of visitors per day using statistical software (Jamovi). The student reported the average number of visitors for each restaurant, indicating the ability to convert graphical information into numerical statistical representations. This transition from graphical representation to numerical representation illustrates that the student was able to coordinate different forms of representation in order to support data interpretation.

The ability to move between graphical, numerical, and narrative representations reflects the development of representational flexibility in mathematical thinking. Previous studies emphasize that representational flexibility plays an important role in helping students construct meaningful connections between different mathematical representations. Hickendorff et al. (2021) explain that coordinating multiple representations supports deeper conceptual understanding in mathematics and statistics learning. Similarly, Garfield and Ben-Zvi (2022) highlight that interpreting data through multiple representations strengthens students' statistical reasoning and statistical literacy. Research in mathematics education also shows that flexible use of representations allows students to interpret data more meaningfully and develop stronger reasoning skills (Prodromou et al., 2023).

These findings are also consistent with studies conducted by Nopriyanti and colleagues, which emphasize that mathematical flexibility involves the ability to interpret problems using multiple representations and to transform those representations during problem solving. Studies published in *Infinity Journal*, *JTAM*, and *Kreano* report that students who demonstrate representational flexibility are able to translate information between visual, symbolic, and verbal forms when solving mathematical problems (Nopriyanti et al., 2020; Nopriyanti et al., 2021; Nopriyanti et al., 2022).

However, although the student was able to transform graphical information into narrative and numerical explanations, the interpretation provided remains largely descriptive. The student did not further analyze the variability of the data or provide deeper reasoning regarding visitor fluctuations across the five days. This finding suggests that while the student demonstrates emerging representational flexibility, further instructional support is needed to strengthen higher-level statistical reasoning, particularly in interpreting patterns and drawing more comprehensive conclusions from multiple data representations.

b. Strategic Flexibility

Strategic flexibility refers to students' ability to use and adapt various strategies in solving mathematical or statistical problems. This aspect reflects students' capacity to select appropriate procedures and modify their approaches according to the characteristics of the problem. In this study, the indicator measured is students' ability to employ different strategies to analyze the given data. The student response for question number 2 can be seen Figure 6.

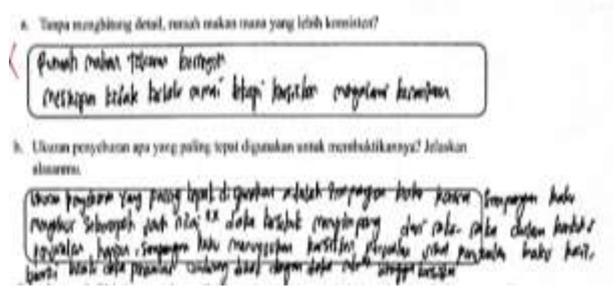
| | |
|---|---|
|  | **English Version**<br>**a.** Without calculating in detail, which restaurant appears to be more consistent?<br>Answer:<br>The Tekwan Beringin restaurant, although it does not always experience an increase, its visitor numbers tend to remain stable.<br><br>**b.** Which measure of dispersion is most appropriate to prove it? Explain your reason.<br>Answer:<br>The most appropriate measure of dispersion to use is the standard deviation, because the standard deviation can show how much the data deviates from the average value. Thus, it can indicate whether the visitor numbers fluctuate greatly or remain relatively stable. If the standard deviation value is small, it means that the data tends to be more consistent. |

**Figure 6.** The Student Response for Question No 2

Based on the student's response presented in the figure 6, the student used a specific strategy to determine the average number of visitors by utilizing statistical software (Jamovi) to compute the mean for each restaurant. The student then compared the resulting averages to determine which restaurant had the highest number of visitors. This approach indicates that the student applied a procedural strategy based on statistical calculation to support the interpretation of the graphical data. The use of digital tools in the analysis also shows that the student attempted to employ a structured method to obtain numerical evidence for the conclusion drawn from the graphical representation.

The ability to apply strategies such as calculating averages and comparing numerical results reflects an emerging form of strategic flexibility in statistical reasoning. Previous research suggests that strategic flexibility involves the ability to select and adapt problem-solving procedures in response to the demands of the task. Hickendorff et al. (2021) explain that flexible strategy use enables students to evaluate alternative procedures and choose the most appropriate strategy when solving mathematical problems. Similarly, studies on mathematical flexibility indicate that students who demonstrate strategic flexibility are able to combine different approaches, including procedural calculations and contextual interpretation, when analyzing data (Nopriyanti et al., 2025).

However, the strategy used by the student in this task remains relatively limited. The student relied solely on the mean value to compare visitor numbers and did not consider other statistical measures, such as median or data variability, which could provide a more comprehensive analysis of visitor trends. This finding suggests that although the student shows an initial ability to apply a problem-solving strategy, further instructional support is needed to encourage students to explore multiple analytical strategies when interpreting statistical data.

c. Conceptual Flexibility

Conceptual flexibility refers to students' ability to understand mathematical concepts from different perspectives and justify the reasoning behind their choices when solving problems. This aspect reflects how students connect conceptual understanding with the procedures they use in analyzing data. In this study, the indicator measured is students' ability to explain the reasons underlying the selection of statistical concepts used to interpret the data. The student response for question number 3a can be seen Figure 7.

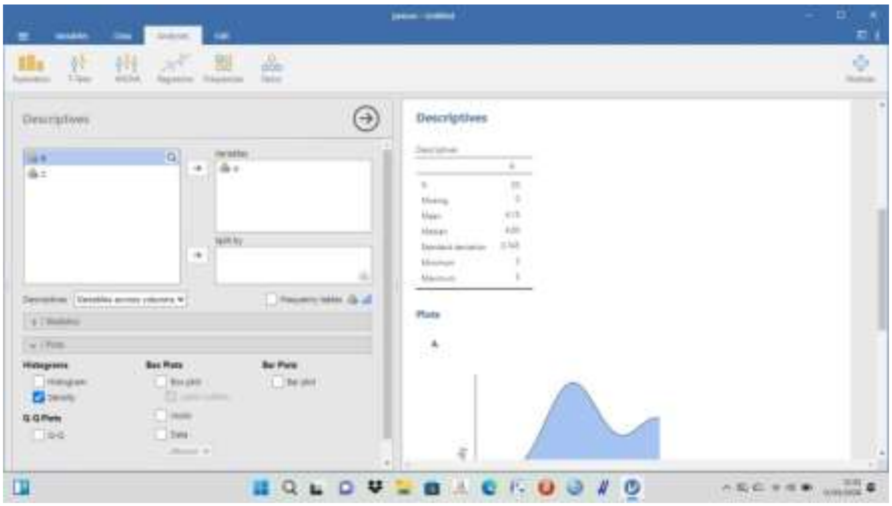


**Figure 7.** The student response for question number 3a

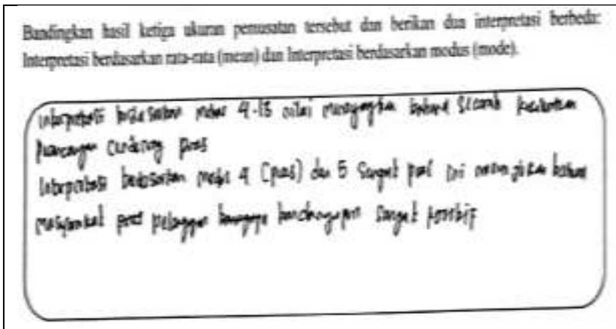
Based on the student's response, the student calculated the mean, median, and mode using the statistical software Jamovi and obtained values of mean = 4.15, median = 4, and mode = 4. The student then reported these results in the answer sheet, indicating that the student was able to use digital statistical tools to obtain descriptive statistics accurately. The ability to identify and compute different measures of central tendency demonstrates that the student understands that the center of a dataset can be described using multiple statistical concepts. This reflects an emerging form of conceptual flexibility, as students must recognize that each statistical measure represents a different perspective in describing the central tendency of the data.

The use of Jamovi in the analysis also illustrates how digital statistical tools can support students in understanding statistical concepts. Digital tools allow students to focus not only on procedural calculations but also on interpreting statistical outputs and connecting them with conceptual meanings. Previous studies have emphasized that integrating statistical software into learning environments can enhance students' statistical reasoning by enabling them to explore data and interpret statistical measures more meaningfully (Prodromou, Lavicza, & Zazkis, 2023). Similarly, research by Garfield and Ben-Zvi (2022) highlights that the ability to interpret multiple statistical measures is a key component of statistical reasoning, as it encourages students to view data from different conceptual perspectives.

However, although the student correctly obtained the statistical measures using Jamovi, the response only reports the numerical results without further elaborating on the conceptual differences between mean, median, and mode or explaining why these measures might produce slightly different values. This indicates that the student demonstrates procedural competence in obtaining statistical results but still requires further support in developing deeper conceptual interpretations of statistical measures. According to Hickendorff et al. (2021), conceptual flexibility develops when students are able to coordinate multiple mathematical concepts and explain the relationships between them during problem solving. These findings indicate that students demonstrate an emerging level of conceptual flexibility, particularly in applying multiple measures of central tendency through digital statistical tools.

d. Reflective Flexibility

Reflective flexibility refers to students' ability to evaluate the results obtained and provide different interpretations based on the analytical methods used. In statistics learning, reflective flexibility can be observed when students are able to interpret the same dataset using different statistical measures and explain how these measures lead to different perspectives on the data. The student response for question number 3a can be seen Figure 7.




**English Version**

**Question:**

Compare the results of the three measures of central tendency and provide two different interpretations: an interpretation based on the mean and an interpretation based on the mode.

**Answer:**

Interpretation based on the mean (4.15):
This value indicates that overall customer satisfaction tends to be positive.
Interpretation based on the mode (4):
Since the most frequent score is 4, this shows that most customers tend to give positive feedback regarding the service.

**Figure 7.** The student response for question number 3a

Based on the student's response, the student compared the results of the measures of central tendency obtained from the Jamovi analysis, namely the mean (4.15) and the mode (4). The student then provided two different interpretations of the dataset. First, based on the mean value, the student concluded that overall customer satisfaction tends to be positive. Second, based on the mode value, the student explained that most customers tend to give a satisfaction score of four, indicating that the majority of responses are clustered around this value. These two interpretations indicate that the student attempted to evaluate the dataset from different statistical perspectives and reflect on how different measures of central tendency may lead to different interpretations.

This ability reflects an aspect of reflective flexibility because the student was able to reconsider the results obtained and construct alternative explanations based on different statistical measures. Reflective thinking is an important component of statistical reasoning, as it enables students to critically interpret statistical outcomes and understand the implications of different analytical approaches. Previous studies emphasize that reflective reasoning helps students develop deeper understanding when interpreting statistical data, particularly when they are encouraged to compare multiple statistical measures and evaluate their meanings (Garfield & Ben-Zvi, 2022). In addition, research on mathematical flexibility highlights that reflective evaluation of results is essential for developing adaptive reasoning and flexible problem solving (Star & Rittle-Johnson, 2020).

However, although the student provided two interpretations, the explanations remain relatively brief and descriptive. The student did not further analyze how the slight difference between the mean (4.15) and the mode (4) reflects the distribution of the data or what implications this difference might have for interpreting customer satisfaction. This finding suggests that while the student demonstrates an emerging level of reflective flexibility, further instructional support is needed to encourage deeper reflection and more sophisticated interpretation of statistical results.

## 6. Discussion

The evaluation results show that the Problem-Based Learning (PBL) learning tool supported by the Jamovi application is highly valid, practical, and effective for use in Basic Statistics learning. The average validity score of 86 indicates that the content and structure of the tool are in line with learning design principles that emphasize contextual relevance, clarity of objectives, and media suitability. These results are in line with the opinions of Branch & Varank (2009); Dick et al. (2015) that valid learning tools must demonstrate harmony between the components of content, objectives, and learning strategies in order to be used effectively in the instructional process.

A practicality score of 85.2 in the very practical category indicates that the device is easy to use by students and lecturers during the learning process. Students' positive responses to the clarity of instructions and ease of use of the Jamovi application confirm that technological support can increase interactivity and facilitate the statistical data analysis process. These findings are in line with the studies by Alabdulaziz & Higgins (2025); Altınbaş (2025), which show that the integration of digital devices in mathematics learning plays an important role in increasing student engagement and strengthening conceptual understanding through direct experience with data.

In terms of effectiveness, the field test results show that students' flexible thinking skills reached an average of 72.7, which is considered good. This means that students are able to use various strategies and representations in solving statistical problems and adapt to different contexts. This finding supports the research of Star (2018); Leikin (2013), which states that flexible thinking is an important indicator in understanding mathematical concepts deeply and efficiently. This result is also consistent with the findings of Irawati & Wahyudi (2021), which show that problem-based activities can increase the representational and strategic flexibility of pre-service teacher students.

Achieving a good rating in flexible thinking skills also shows that problem-based learning with a local Palembang context such as sales data and pempek preferences can bridge statistical understanding with real-life phenomena. This reinforces the view of Putri & Zulkardi (2020) that the use of local contexts in learning pathway design can expand students' thinking space, facilitating the transition between contextual experiences and formal representations. Thus, the results of this study provide empirical evidence that the application of Jamovi-assisted PBL is not only effective in improving the practicality and validity of the tool, but also plays a role in developing students' flexible thinking skills in understanding statistical concepts in a meaningful way.

## D. CONCLUSION AND SUGGESTIONS

Addressing the gap in technology-integrated statistics learning, this study developed a Problem-Based Learning (PBL)-based instructional tool supported by the Jamovi application to enhance students' understanding of statistical concepts and flexibility in interpreting data. The findings show that integrating contextual problem solving with statistical analysis technology enables students to connect procedural calculations with conceptual interpretation of statistical measures. Through this approach, students were encouraged to analyze data using digital tools and interpret statistical results from multiple perspectives, thereby supporting the development of flexible statistical thinking in Basic Statistics learning.

Theoretically, this study contributes to the field of statistics education by demonstrating how the integration of PBL and digital statistical tools can support the development of conceptual understanding and flexibility skills in data analysis. Practically, the developed learning tool offers lecturers an alternative instructional design that integrates contextual learning with statistical software to support more meaningful statistics learning experiences. However, this study was conducted in a limited classroom context with a relatively small number of participants, which may limit the generalizability of the findings. Therefore, future research is recommended to examine the implementation of similar technology-integrated learning designs in broader educational settings and explore their impact on other statistical topics as well as higher-order statistical reasoning skills.

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