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Supporting statistical literacy skills for prospective teachers: A learning trajectory used South Sumatra local wisdom context through hybrid learning

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Abstract

In an era where data is increasingly prevalent, statistical literacy skills are essential for active citizenship and informed decision-making. For future generations, prospective teachers play a role in developing this skill. However, current instructional approaches often overlook the integration of practical applications and local wisdom, limiting students' ability to connect abstract statistical concepts with real-world experiences. The objective of this research is to design a Learning Trajectory (LT) that supports the statistical literacy skills of prospective teachers by utilizing a hybrid learning strategy that integrates local knowledge from South Sumatra as context. A total of 60 prospective teachers from a mathematics education study program participated in this study. A design research method was employed, specifically utilizing a validation study. The research unfolded in three stages: preparation for the experiment, the experimental design, and the retrospective analysis. Data collection techniques included student activity sheet assessments, classroom observations, and interviews. Data analysis involved comparing the Hypothetical Learning Trajectory (HLT) with the Actual Learning Trajectory (ALT) in the retrospective analysis stage to develop the LT. The results indicate that the designed LT guided students through five activities that support statistical literacy: reading and interpreting data tables using statistical situations with local wisdom from South Sumatra as context, interpreting graphs, analyzing and reflecting, exploring outliers, and making conclusions and presenting findings. These findings highlight the importance of integrating local wisdom contexts into statistical education, as well as the relevance and applicability of mathematical concepts for prospective teachers. This research contributes to the design of a learning trajectory based on a local wisdom context that can be applied in statistical literacy learning.

Keywords:
Hybrid learning, Learning trajectory, Local wisdom context, Prospective teachers, Statistical literacy

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1. INTRODUCTION

In the current era of rapid technological advancement and data-driven decision-making, statistical literacy has become a critical skill for navigating the complexities of modern life (Johannssen et al., 2021). Individuals are constantly exposed to vast amounts of information, much of it presented in the form of data (Monteiro & Carvalho, 2023). The ability to interpret, analyze, and make informed decisions based on data is essential for active citizenship in a world characterized by digitalization and the proliferation of data sources (Gal, 2019). Citizens require comprehensive statistical literacy to make educated decisions (Ünal et al., 2023; Wallman, 1993), critically assess data (Weiland, 2017), and minimize misinformation in domains such as health, politics, and economics (Coleman et al., 2013). This enables them to participate in public discussions in a meaningful way, understand risks, and navigate a world increasingly dominated by data.

In line with the importance of statistical literacy, the development of this skill becomes even more crucial for prospective mathematics teachers (Muñiz-Rodríguez et al., 2020). As the future educators, they are responsible for cultivating the statistical proficiency of their students, who are the next generation of citizens (Lukman et al., 2022; Prince Robert et al., 2021). In addition to having a strong foundation in mathematics, these future teachers must also be able to foster statistical thinking in ways that are applicable to the real-world experiences of their students (Hidayat et al., 2023; Utari, Putri, Zulkardi, et al., 2024). In addition, Learning Trajectory (LT) is important as it provides a systematic framework for designing learning activities that support the development of statistical literacy (Büscher, 2022). Moreover, Bakker (2018) stated LT is a theoretical framework that outlines the progression of students' understanding and skills in a specific content area, particularly in mathematics education. It encompasses a sequence of learning goals, instructional activities, and anticipated student responses that guide educators in designing effective teaching strategies. LT assists educators in designing and implementing structured learning activities that connect statistical concepts with real-life contexts and local wisdom, thereby supporting student understanding (Gravemeijer & Cobb, 2006).

To enhance the effectiveness of statistical literacy education, hybrid learning emerges as a viable solution (Kuntze et al., 2017). Hybrid learning, which combines face-to-face instruction with online learning, allows for a more flexible and engaging educational experience (Raes et al., 2020; Zitter & Hoeve, 2012). This approach can facilitate the integration of local wisdom and real-world applications into the curriculum, making statistical concepts more relatable to students. For instance, educators can use online platforms to provide access to data analysis tools and resources, enabling students to engage in collaborative projects that apply statistical methods to local issues (Chen & and Chiou, 2014; Utari, Putri, Zulkardi, et al., 2024). This not only enhances their understanding of statistical concepts but also fosters critical thinking and problem-solving skills (Kuntze et al., 2017).

Despite these advancements, significant challenges remain in effectively integrating mathematics with real-life contexts and local wisdom in Indonesia. Initiatives such as the *Pendidikan Matematika Realistik Indonesia (PMRI)* have sought to address these approached (Zulkardi et al., 2020). However, disparities persist in how these skills are taught to prospective mathematics teachers, particularly in culturally relevant contexts (Gonda et al., 2022). Instructional methods often emphasize theoretical aspects of statistics while neglecting the integration of local wisdom and real-world applications, which can hinder students' ability to connect abstract concepts with their daily lives (Chick & Pierce, 2012). Furthermore, curriculum aimed at fostering statistical literacy often fail to interact meaningfully with students' cultural backgrounds, therefore constraining their capacity to relate statistical concepts to their personal experiences (Delport, 2023; Setiawan, 2021). Therefore, an innovation in statistical literacy learning is needed.

Integrating local wisdom into statistical literacy learning enhances student engagement by providing culturally relevant contexts, fostering critical thinking, and enabling practical application of statistical concepts (Adger et al., 2018; Britton & Anderson, 2020). This approach not only strengthens students' comprehension and data interpretation skills but also contributes to the development of a more informed and capable society (de Waard et al., 2022). Research indicates that while many students can modify statistical definitions and algorithms, they often struggle to apply these principles to real-world situations (Andriatna & Kurniawati, 2021). This gap highlights the need for interventions in statistical literacy learning that not only address the theoretical aspects of statistical education but also comprehensively analyze the challenges faced by practitioners in the field, to ensure that educational interventions are aligned with the actual needs of students and educators (Gal, 2002; Mahyudi et al., 2024).

Based on the preceding discussion, this research aims to bridge the existing gap by designing Learning Trajectory that supports the statistical literacy of prospective teachers through hybrid learning approaches and preserving and developing local wisdom. The novelty of this study lies in its approach to designing a Learning Trajectory that specifically integrates South Sumatran local wisdom, utilizing culturally embedded knowledge and practices to create meaningful learning experiences. Unlike previous studies, such as those by Kuntze et al. (2017), which primarily focus on general educational frameworks without specific cultural contexts, this research emphasizes the importance of local relevance in statistical education. The distinctiveness of this study arises from the integration of South Sumatran local wisdom, which utilizes culturally embedded knowledge and practices to create meaningful learning experiences. This educational design through LT design aims to build connections between abstract statistical concepts and students' real-life experiences by utilising local contexts, including South Sumatran customs and empirical data.

2. METHOD

2.1. Research Design

This study employs design research methods with validation study approach, this research focuses on o develop theories about the learning process and the tools designed to support that learning (Bakker, 2018; Gravemeijer & Cobb, 2006). The aim of this research is to design a Hypothetical Learning Trajectory (HLT) that evolves into a comprehensive Learning Trajectory (LT). A learning trajectory refers to a structured series of steps designed to facilitate the learning process of students in a systematic manner (Bakker, 2018). The main objective of designing a learning trajectory is to create learning experiences that enhance students' understanding of the concepts being taught while also identifying and addressing potential barriers that students may encounter during the learning process (van Dijke-Droogers et al., 2022).

This research incorporates hybrid learning and integrates local wisdom from South Sumatra, specifically the *Bekarang Iwak* tradition, as the contextual framework (Utari, Amalia, et al., 2024). The design research methodology is organized into cyclic phases: (1) preparing for the experiment, (2) the design experiment (teaching experiment phase) included: pilot experiment (cycle 1) and teaching experiment (cycle 2), and (3) conducting retrospective analyses (Gravemeijer & Cobb, 2006). Figure 1 illustrates the cumulative cyclical process inherent in design research (Gravemeijer & Cobb, 2006).

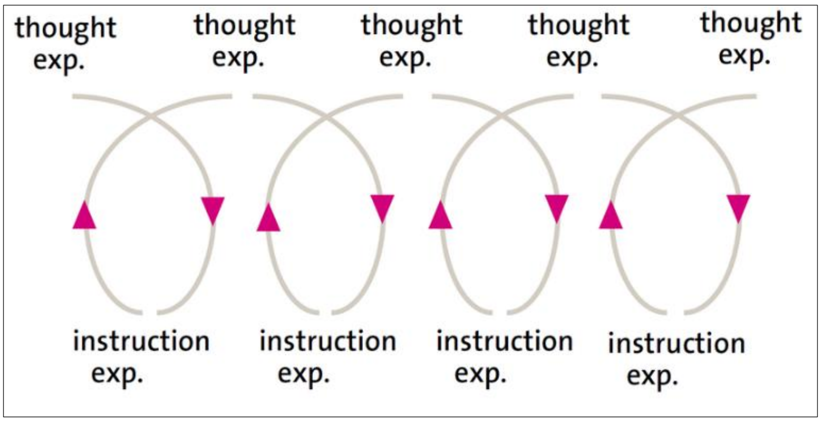
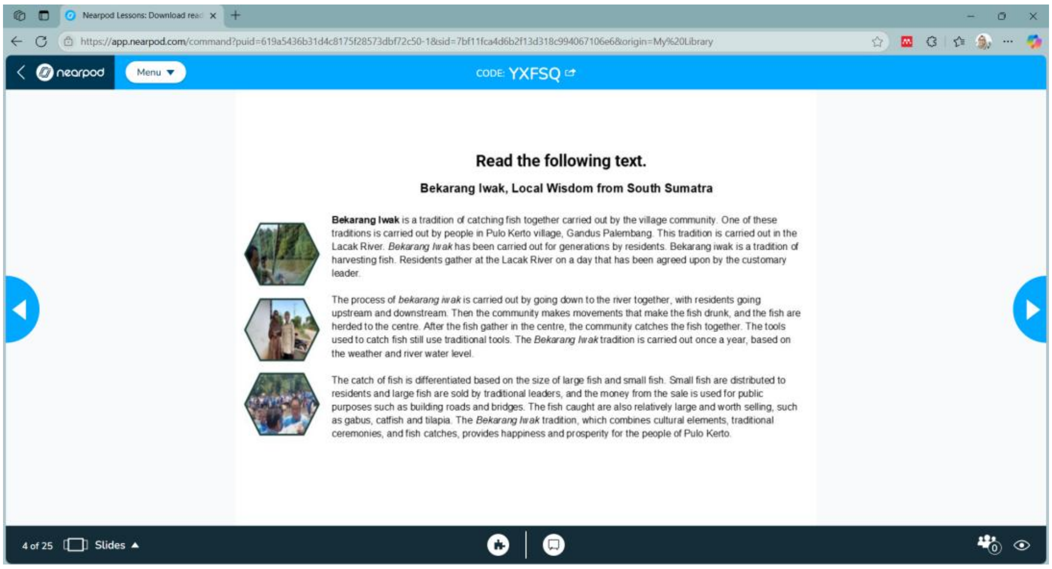


Figure 1. The cumulative cyclical process in design research

Figure 1 demonstrates that the phases of preparation or planning, implementing, and retrospective analysis are integral cycles within the iterative cumulative cyclical process of design research. Each cycle contributes to the development of the LT, with results from one cycle informing refinements in the subsequent cycle (Gravemeijer & Cobb, 2006). Knowledge and findings accumulate progressively, thereby strengthening the research outcomes over time. LT pertains to the learning process and the resources that facilitate this learning (Bakker, 2018). Consequently, this research was initially inspired by a literature survey about statistical literacy, local context, hybrid learning, and the teaching experiment, which culminated in the preliminary conjecture for statistical literacy that facilitates learning. In the course of this literature evaluation, the researcher commenced the design of the learning activities. Learning theories related to *Pendidikan Matematika Realistik Indonesia (PMRI)* were used in designing the lessons. This collection of educational activities, encompassing the assumptions of prospective instructors' cognition and methodologies, was created, and functioned as the preliminary HLT. This HLT is adaptable and can be modified to align with the actual learning progression of the prospective teachers during the design experiment.

2.2. Instructional Design

HLT serves as a framework for designing statistical literacy education within the context of South Sumatra through hybrid learning approaches. In this study, the researcher used PMRI approach, the context of *Bekarang Iwak*, for which exploratory research had previously been conducted (Utari, Putri, & Zulkardi, 2024). Researchers use applications such as youtube, zoom, excel, Nearpod to carry out hybrid learning (Cahyono & Asikin, 2019; Hakami, 2020; Zitter & Hoeve, 2012). The following Figure 2 is the lesson preview of *Bekarang Iwak* as the context which researchers display in the Nearpod worksheet.



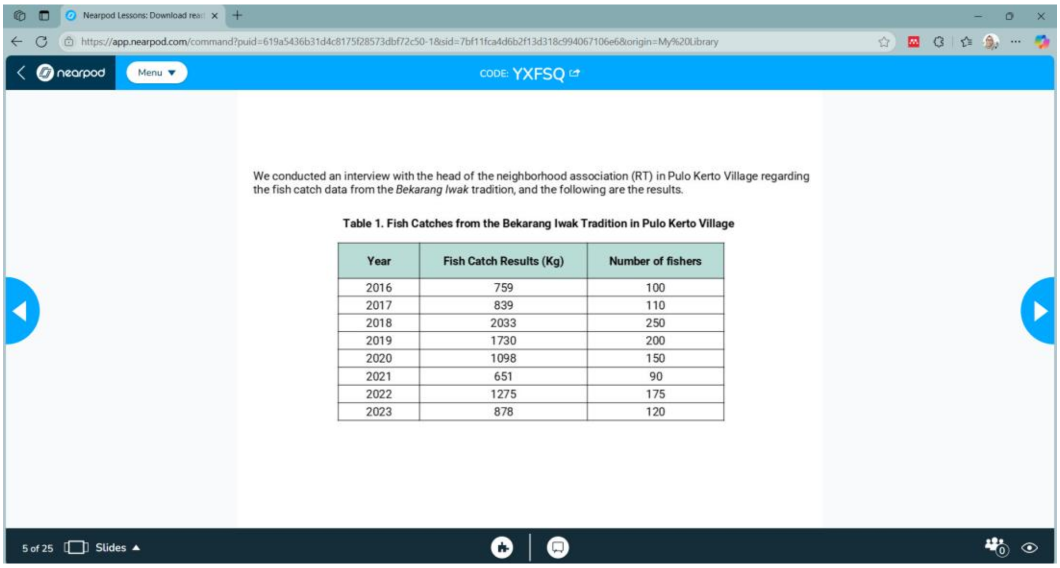


Figure 2. The lesson preview in Nearpod

Based on Figure 2 related to the *Bekarang Iwak* tradition in South Sumatra. The researcher together with the lecturer designed the HLT. Consequently, the HLT of this study comprises an instructional sequence of five activities designed to fulfill the learning objectives. Table 1 describes the HLT comprises five components: learning step, description, learning goal, example of activities, and prospective teachers' conjectured thinking described in each learning activity.

Table 1. The HLT for learning the statistical literacy

Learning Step	**Description**	**Learning Goal**	**Example of activities**	**Conjectures of prospective teachers thinking**
1. Reading and interpreting data table (situational or informal mathematics)	Prospective teachers analyze a data table on fish catches from *Bekarang Iwak* to extract key information, identify trends, patterns, and use the concept / knowledge of statistics. They work with data in a real-world context before using any mathematical models.	Develop prospective teachers' ability to extract and analyze key information from a data table, identifying trends, patterns, and use the knowledge of statistics.	Prospective teachers answer questions based on a provided data table, such as identifying the year with the lowest and highest fish catches and calculating the average catch per fisher.	• Some prospective teachers may correctly identify trends and key statistics. • Others may struggle to interpret the data accurately.
2. Intepreting a graph (Graph as a model)	Prospective teachers analyze a graph showing the relationship between the number of fishers and fish caught from 2016 to 2023, identifying trends, and making predictions. The graph serves as a model of the data, helping transition from raw numbers to a visual representation.	Develop prospective teachers' ability to analyze graphical representations of data, identify trends, and intepret based on visual information.	Prospective teachers interpret trends, identify outliers, and predict future patterns from a provided graph.	• Some prospetive teachers recognize patterns and correlations correctly. • Others may misinterpret the data or fail to see important trends.
3. Analyzing and reflecting (Using graph and table as model for critically evaluate data)	Prospective teachers critically evaluate data, identify trends, and reflect on their implications for sustainable fishing practices. They begin using graphs and tables as tools to analyze and explain relationships within the data, making the shift to a model for reasoning.	Encourage prospective teachers to develop critical thinking skills in analyzing statistical data and understanding its real-world implications.	Prospective teachers analyze trends in fish catches and participation, then discuss the factors influencing the data, such as environmental changes or fishing regulations.	• Some prospetive teachers can identify possible causes and implications of trends. • Others may struggle to connect statistical data to real-world contexts.
4. Exploring possible outliers (formal mathematics)	Prospective teachers examine data for anomalies and explore potential extreme value. At this stage, they begin applying formal statistical concepts such as	Engage prospective teachers in identifying outliers in data and understanding their	Prospective teachers explore possible outliers using statistical concept,	• Some correctly explore and using statistical concept to find outliers. • Others may misattribute

Learning Step	Description	Learning Goal	Example of activities	Conjectures of prospective teachers thinking
	average, deviation standar, zscore, and outliers.	statistical significance.		outliers to random chance or errors.
5. Making conclusion and presenting finding	Prospective teachers summarize their data interpretations and propose evidence-based recommendations for managing *Bekarang Iwak* sustainably. They use formal mathematical reasoning and statistical methods to communicate their findings.	Develop prospective teachers' ability to communicate statistical findings clearly and make data-driven recommendations.	Prospective teachers prepare a short presentation covering trends, concerns, and proposed solutions for sustainable fishing.	• Some effectively summarize insights and propose practical recommendations. • Others may struggle to present a coherent and well-supported argument.

2.3. Participants

The research was conducted with 60 prospective teachers in the mathematics education study program at Sriwijaya University who had completed the introductory statistics course. In order to comprehend fundamental concepts and cultivate technical skills in data analysis, they must initially acquire a rudimentary understanding of statistics (Rumsey, 2002). The significance of this is that it enables them to accurately interpret data and employ statistics in real-world scenarios by fostering statistical literacy (van Dijke-Droogers et al., 2017). A total of 10 prospective teachers participated in the pilot experiment (first cycle), which was designed to ascertain the pre-existing knowledge of them, test the initial design, and make some modifications to the initial Hypothetical Learning Trajectory (HLT). Furthermore, an additional 50 prospective teachers were involved in the teaching experiment (second cycle). In this cycle, the revised HLT was trialled again in the classroom, and the HLT was compared with the Actual Learning Trajectory (ALT) to become the Learning Trajectory. Although these 60 students enrolled in the mathematics education programme in the same semester, they were in different classes.

2.4. Data Collection and Analysis

In this study, data were collected using multiple instruments to gain qualitative insights into prospective teachers' experiences, employing a design research methodology focused on validation studies. The primary instruments included semi-structured interviews, observations, and worksheets as assessments, each serving a distinct purpose in understanding the educational process and outcomes. Semi-structured interviews were conducted to explore participants' understanding of statistical concepts and the relevance of local cultural elements to their learning. Observations during learning process focused on participants' engagement and interaction with the material, utilizing a structured observation guide to document key behaviors and responses to the hybrid learning model.

Worksheets were also employed as assessment tools to evaluate participants' understanding and application of statistical concepts. This multifaceted data collection process was guided by principles of reflexivity, emphasizing the importance of researchers being aware of their biases and positionality in relation to participants. Data analysis involved coding and categorizing qualitative data from interviews and observations, allowing for the identification of patterns and themes that inform the iterative cycles of design and refinement. Ultimately, these methods provided a comprehensive view of prospective teachers' experiences, ensuring that the findings were credible and relevant, thereby contributing to the validation of the educational intervention.

3. RESULTS AND DISCUSSION

3.1. Results

3.1.1. Preparation for the experiment

The preparation for the experiment phase was conducted to ensure that the design of the Hypothetical Learning Trajectory (HLT) and research instruments aligned with the learning objectives of statistical literacy to support prospective teachers' competencies. During this phase, the researchers consulted with lecturers teaching statistics courses in the Mathematics Education Study Program to collaboratively design the learning process. The learning process was designed using a hybrid learning approach, integrating Universitas Sriwijaya's e-learning platform with Nearpod, Zoom, YouTube, and Excel to facilitate interactive and technology-enhanced learning activities in the classroom. These tools were utilized to support students in engaging with statistical concepts through visualization, simulations, and collaborative discussions.

The initial design of the HLT and learning activities was developed based on the *Pendidikan Matematika Realistik Indonesia (PMRI)* framework, incorporating five main learning trajectories, namely: reading and interpreting data tables, interpreting graphs, analyzing and reflecting, exploring outliers, and presenting findings. Each activity in the HLT was designed to support prospective teachers' statistical literacy by utilizing contextual data from fish catches in *Bekarang Iwak*. Additionally, this phase finding in the designed of research instruments, including observation sheets, and interview sheets, all of which were designed to assess the effectiveness of the instructional approach in supporting statistical literacy.

3.1.2. The design experiment

At the stage of the design experiment (implementing the design), the researcher and the lecturer conducted a trial of the designed Hypothetical Learning Trajectory (HLT) in two cycles. The first cycle, commonly known as the pilot experiment, involved 10 prospective teachers with heterogeneous mathematical abilities. In this cycle, the prospective teachers were divided into two groups. The designed HLT was implemented in the classroom to be compared with the Actual Learning Trajectory (ALT). Afterward, a retrospective analysis was conducted to refine the HLT, adjusting it according to the prospective teachers' abilities during the pilot experiment.

The revised HLT was then re-implemented in a different class (within the same semester), a stage known as the teaching experiment. In this stage, a total of 50 prospective teachers participated. With diverse mathematical abilities, they were divided into 10 groups. The revised HLT was tested again at the teaching experiment stage. The HLT was compared with the ALT for retrospective analysis. This process is referred to as the iterative process. The findings from each instructional step in both the pilot experiment and teaching experiment were described the iterative process below.

Reading and interpreting data table

The first activity begins with providing information about the *Bekarang Iwak* tradition, a local wisdom of South Sumatra (See Figure 2). In the PMRI approach, this stage is known as contextual or situational, as it presents a real-world problem context. This annual tradition involves community members catching fish, generating statistical data. The data includes the year of implementation, the number of fish caught, and the number of participants involved in the activity. Figure 3 is the result of the implementation of learning activities at the stage of understanding and interpreting data table, showing the results of prospetive teachers' answers during the pilot experiment and teaching experiment.

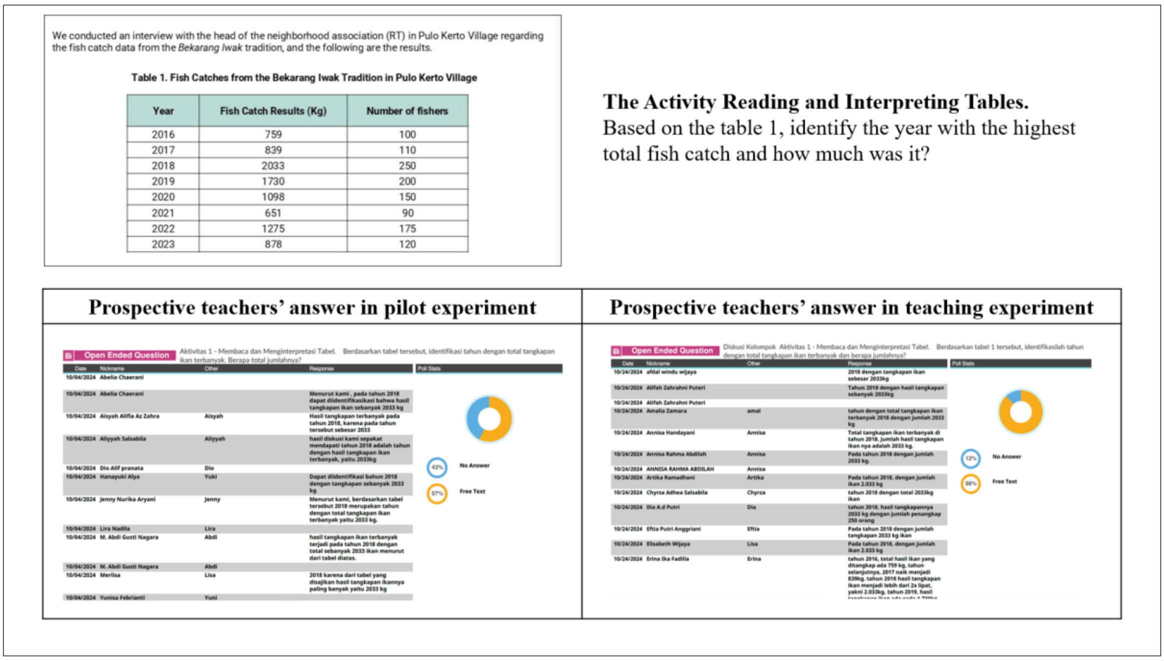


Figure 3. Examples of prospective teachers' answers at the pilot experiment and teaching experiment stages in Nearpod report in Activity 1

Figure 3 illustrates that during the pilot experiment, 57% of prospective teachers responded to Activity 1. A retrospective analysis was conducted in collaboration with the lecturer to examine these results. The analysis revealed that while these students were able to interpret the data presented in the table, the remaining 43% either struggled to comprehend the questions or ran out of time when responding on Nearpod. As a result, the Hypothetical Learning Trajectory (HLT) and instructional strategies were revised to enhance clarity and improve engagement. Specifically, prospective teachers were given additional time for group discussions to support their understanding. These modifications were implemented in the teaching experiment phase, leading to a significant improvement, with 88% of prospective teachers successfully completing Activity 1.

This process of refinement is referred to as an iterative process. As a result, the instructional steps for "Reading and Interpreting Data Tables," which were implemented during the teaching experiment phase, are presented in Table 2. Table 2 provides Iterative Improvements in Learning Steps: From Pilot to Teaching Experiment.

Table 2. Iterative improvements in learning steps: reading and interpreting data table

Indicators/ learning step	Pilot experiment implementation	Observations & prospective teachers' thinking conjectures	Teaching experiment refinements	Impact on student learning
a. Prospective teachers identify the year with the highest total fish caught and determine the total amount.	Prospective teachers were asked to determine the year with the highest total fish caught.	Some misidentified the year due to difficulties in reading the data table.	Provided clearer instructions	Improved accuracy in identifying the correct year.
b. Prospective teachers identify the year with the lowest fish catch and compare it to the average fish per fisher that year.	Prospective teachers identified the lowest fish catch and compared it to the average per fisher.	Some struggled with the concept of comparing totals to averages.	Introduced guiding questions and step-by-step prompts.	Enhanced understanding of comparisons between totals and averages.
c. Prospective teachers analyze the trend in the number of fishers over five years and explore possible reasons for the changes.	Prospective teachers analyzed fisher trends in group.	Some struggled to describe trends using appropriate terms (e.g., increasing, decreasing, fluctuating).	The lecturer introduced guiding questions, particularly emphasizing the term *fluctuating* to help students articulate trends accurately.	Improved ability to describe and interpret trends in data.
d. Prospective teachers examine whether there is a pattern between the number of fishers and the total fish caught, explaining any connections or lack thereof.	Prospective teachers explored the relationship between the number of fishers and total catch.	Some had difficulty recognizing patterns in the data and formulating conjectures.	Refined conjectures and introduced guiding questions to help students identify and articulate patterns.	More structured reasoning and improved pattern recognition.

Based on Table 2 the iterative refinement process between the pilot and teaching experiments primarily focused on supporting prospective teachers' ability to describe trends and identify patterns in data. While no significant modifications were made in Steps 1 and 2, substantial adjustments were implemented in Steps 3 and 4. During the pilot experiment, some prospective teachers encountered difficulties in accurately describing trends using appropriate terminology, such as increasing, decreasing, or fluctuating. To address this challenge, the lecturer introduced guiding questions, with a particular emphasis on the term fluctuating, to support their understanding and improve their ability to articulate trends. Similarly, in Step 4, some prospective teachers struggled to recognize patterns within the data and formulate conjectures. To facilitate this process, guiding questions were incorporated to help them systematically identify and explain observed patterns. These refinements in the teaching experiment led to a more structured analytical approach, improved data interpretation skills, and a deeper conceptual understanding among prospective teachers.

Interpreting graph

In the second activity, prospective teachers interpret graph depicting the relationship between the number of fishers and the total fish caught from 2016 to 2023. This stage aligns with the graph as a model phase in the PMRI approach, which is known as the model of phase. In this phase, graphical representation serves as an abstraction of raw data, facilitating the transition from numerical data to a visual format. As a result, the learning steps for interpreting a graph that were applied during the teaching experiment phase are summarized in Table 3, which highlights the iterative refinements made from the pilot experiment to the teaching experiment.

Table 3. Iterative improvements in learning steps: interpreting graph

Indicators/ learning step	Pilot experiment implementation	Observations & prospective teachers' thinking conjectures	Teaching experiment refinements	Impact on student learning
a. Prospective teachers use graph as a model to help visualize the relationship between the number of fishers and the total of fish caught (see the trend).	Prospective teachers analyzed the graph and attempted to describe the relationship between the number of fishers and total fish caught.	Some prospetive teachers misinterpreted the relationship, assuming a direct proportionality.	Introduced guiding questions to help students describe trends accurately and understand possible reasons for fluctuations.	Improved ability to recognize and describe trends, leading to a deeper understanding of how changes in the number of fishers impact fish catch.
b. Prospective teachers use graph as a model to identify any outlier or unsual point might explain the variation.	Prospective teachers were asked to identify any points in the graph that deviated significantly from the overall trend.	Some prospetive teachers did not initially recognize outliers or struggled to explain their significance. Others incorrectly identified normal variations as outliers.	Provided explicit instructions on how to identify outliers and discuss their potential causes, along with examples of real-world variations.	Increased awareness of outliers, improved reasoning skills, and enhanced ability to critically analyze deviations in data.
c. Prospective teachers use graph to predict what might happen if both number incrases and support prediction using graph.	Prospective teachers made predictions about future trends based on the given data.	Some prospetive teachers struggled to justify their predictions with evidence from the graph. Others made predictions without considering possible influencing factors.	Revise the conjectures by adding prompts encouraging prospective teachers to base their predictions on observable trends and discuss external factors that might impact future outcomes.	Strengthened data-driven reasoning and enhanced the ability to make informed predictions supported by graphical evidence.

Table 3 presents the iterative improvements in learning steps for interpreting graphs, focusing on how prospective teachers develop their understanding through the teaching experiment. Initially, in the pilot experiment, prospective teachers analyzed the graph to visualize the relationship between the number of fishers and the total fish caught. However, some misinterpreted the relationship as directly proportional, leading to the introduction of guiding questions in the teaching experiment to help them recognize trends and fluctuations more accurately. Additionally, when identifying outliers, many prospective teachers either failed to recognize significant deviations or mistakenly considered normal variations as outliers. To address this, explicit instructions and real-world examples were provided, enhancing their ability to critically analyze data deviations. Furthermore, while making predictions based on the graph, some prospective teachers struggled to justify their reasoning with evidence, or they overlooked external influencing factors. To refine this skill, prompts were added to guide them in making data-driven predictions supported by observable trends. These refinements led to a stronger understanding of graphical interpretation, improved analytical reasoning, and a more structured approach to making evidence-based predictions.

In Activity 2: Interpreting Graph, examples of prospective teachers' responses after the teaching experiment are presented. These responses highlight their improved ability to analyze graphs following guided instruction during the learning process. Figure 4 illustrates Activity 2, which focuses on interpreting graphs, along with selected responses from prospective teachers based on the given graph. These results reflect the outcomes of the teaching experiment phase.

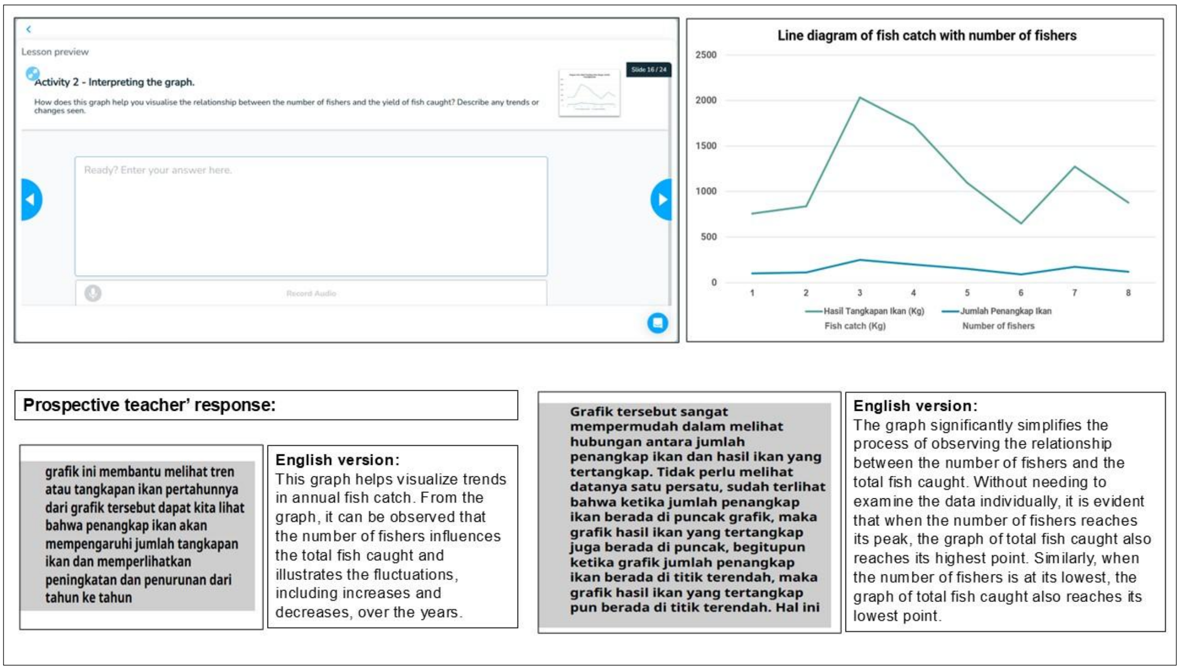


Figure 4. Prospective teachers' answers at teaching experiment stages in Nearpod in Activity 2

Figure 4 illustrates Learning Activity 2, where prospective teachers engage in interpreting a graph that depicts the relationship between the number of fishers and the total fish caught from 2016 to 2023. At this stage, the model of phase in the PMRI approach has been implemented, helping prospective teachers transition from raw numerical data to a visual representation. To facilitate their understanding, they were asked, "How does the graph help you visualize the relationship between the number of fishers and the total fish caught?". Their responses indicate that the graph effectively enhances their ability to recognize patterns and trends. Some noted that the graph helps visualize annual fluctuations in fish catch, showing that the number of fishers influences the total fish caught. Others highlighted that the graph simplifies data interpretation by making it evident that when the number of fishers is at its peak, the total fish caught also reaches its highest point, and conversely, when the number of fishers is at its lowest, the total fish caught also decreases. These insights suggest that graphical representation supports prospective teachers in analyzing data trends, recognizing correlations, and developing a structured understanding of statistical relationships.

Analysing and reflecting

The third activity is related to analysing and reflecting, where this learning step is related to the model for in PMRI. In this activity, prospective teachers use statistical models to make decisions and predictions about the *Bekarang Iwak* tradition. This activity consists of two learning steps designed for prospective teachers. First, they analyze the data from the *Bekarang Iwak* table and are required to provide recommendations regarding the number of participants in the following year, determining whether it should be limited or increased. These recommendations must be supported by statistical models they have developed. Second, based on their statistical analysis and modeling, prospective teachers are reflected and expected to formulate strategies to enhance the sustainability of a healthy fish population in the future. Consequently, the learning steps for analysis and reflection implemented during the teaching experiment phase are summarized in Table 4, showcasing the iterative improvements made from the pilot experiment to the teaching experiment.

Table 4. Iterative improvements in learning steps: analysing and reflecting

Indicators/ learning step	Pilot experiment implementation	Observations & prospective teachers' thinking conjectures	Teaching experiment refinements	Impact on student learning
a. Prospective teachers use statistical models to analyze the data recommendations regarding the number of participants in the following year.	Some prospective teachers attempted to analyze data but struggled to establish a statistical model.	Some prospective teachers faced difficulties in modeling, realizing the need for correlation and regression analysis to examine relationships between variables.	Guided questions were provided to help prospective teachers identify variable relationships using correlation and regression analysis.	Prospective teachers were able to construct statistical models and analyze data to make informed recommendations.
b. Prospective teachers reflected and expected to formulate strategies to enhance the sustainability of a healthy fish population in the future.	Some prospective teachers proposed general strategies without integrating external influencing factors.	Some prospective teachers overlooked external factors such as weather, climate, and rainfall, which could impact the sustainability of this tradition.	Improvements were made to the activity instructions by incorporating clues about internal and external factors.	Through discussion, prospective teachers successfully formulated strategies to support sustainability.

Table 4 highlights the iterative improvements in prospective teachers' learning processes related to analyzing data and reflecting on sustainability strategies. Initially, many struggled to construct statistical models due to a lack of understanding of correlation and regression analysis, which is essential for examining relationships between variables. To address this, guided questions were introduced in the teaching experiment, enabling them to identify and analyze these relationships more effectively, leading to data-driven recommendations regarding participant numbers in future years. Similarly, when formulating sustainability strategies, prospective teachers initially overlooked external factors such as weather, climate, and rainfall, which significantly impact long-term fish population sustainability. Refinements in the instructional design included explicit cues on internal and external factors, prompting a more comprehensive analysis.

As a result, prospective teachers developed a stronger ability to construct statistical models, critically analyze data, and formulate evidence-based strategies for maintaining a sustainable fish population, demonstrating an overall improvement in their analytical and reflective skills. Figure 5 presents the responses of prospective teachers during the teaching experiment stage in completing Activity 3, which focuses on analysis and reflection.

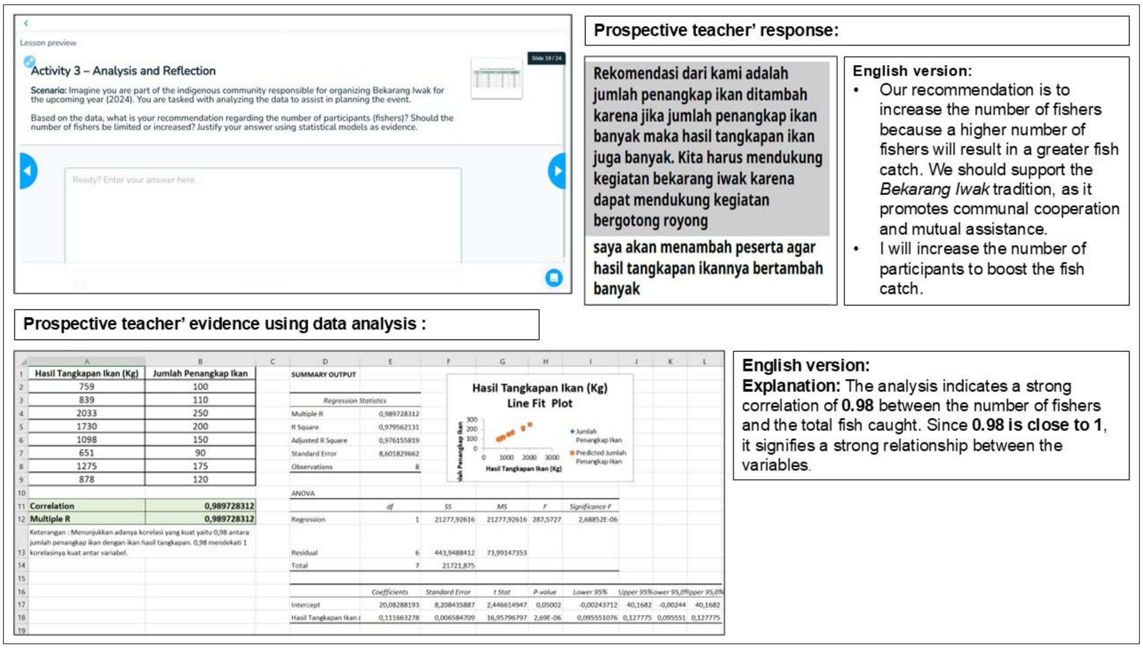


Figure 5. Prospective teachers' answers at teaching experiment stages in Nearpod in Activity 3

Figure 5 illustrates the responses of prospective teachers in completing Activity 3, where they applied statistical models, specifically correlation and regression, by analyzing data in Excel. This analysis aimed to determine whether a relationship exists between the number of fishers and the total fish caught. With a strong correlation close to 1, prospective teachers concluded that increasing the number of fishers would lead to a higher fish catch, as the two variables exhibit a positive correlation. These findings indicate that prospective teachers can utilize statistical models, such as correlation and regression, to systematically analyze data and provide evidence-based recommendations.

Exploring possible outliers

The fourth activity focuses on exploring the possibility of outliers (extreme values) in the dataset. To formally identify outliers, in PMRI using formal mathematics. A mathematical approach using the z-score method is applied, which relies on the mean and standard deviation as the basis for calculation. Exploring outliers is crucial because extreme values can affect descriptive statistics, such as the mean and standard deviation, potentially leading to significant changes in data analysis and statistical models. Therefore, this activity is designed to enhance prospective teachers' understanding of statistical concepts related to outliers and their application in data analysis, enabling them to criticallythe data set. Table 5 presents the iterative process in Activity 4.

Table 5. Iterative improvements in learning steps: exploring possible outliers

Indicators/ learning step	Pilot experiment implementation	Observations & prospective teachers' thinking conjectures	Teaching experiment refinements	Impact on student learning
Prospective teachers use the statistical concept to explore the possible outlier to critically thinking about the data set.	Prospective teachers initially identified outlier (extreme values) by visually inspecting the graph, without applying statistical calculations.	Prospective teachers observed extreme values from the given graph without calculating z-scores to formally determine whether a point is an outlier.	The conjecture of prospective teachers thinking was refined by guiding them to use the mean and standard deviation to compute z-scores for identifying outliers.	Prospective teachers developed a deeper understanding of outlier detection using statistical methods, improving their analytical skills in data interpretation.

Table 5 illustrates the iterative improvements in the learning process as prospective teachers explore possible outliers in a dataset. Initially, they identified extreme values solely through visual inspection of graphs, without applying formal statistical calculations. Their observations indicated a reliance on intuitive judgments rather than quantitative methods like z-scores. To refine their thinking, they were guided to use the mean and standard deviation to calculate z-scores, allowing for a more precise determination of outliers. As a result, prospective teachers developed a deeper understanding of statistical outlier detection, enhancing their analytical skills and improving their ability to interpret data systematically.

Making Conclusion and present the finding

In Activity 5, prospective teachers were tasked with drawing conclusions based on their prior data interpretation in previous activity. At this stage, they formulated evidence-based recommendations for the sustainable management of *Bekarang Iwak*. This process involved applying formal mathematical reasoning and statistical methods to ensure that their findings were communicated clearly and accurately. Additionally, prospective teachers were encouraged to connect their findings with relevant statistical concepts, such as trend analysis, correlation, and data distribution. Through this activity, they developed skills in systematically presenting statistical analyses and making data-driven recommendations that could inform decision-making. As part of the learning process, they also prepared a short presentation covering data trends, potential issues, and proposed solutions to support more sustainable fishing practices. With guidance on structuring strong arguments based on statistical evidence, prospective teachers became more capable of effectively communicating their analytical findings in a structured and in-depth manner. Table 6 illustrates the iterative process in Activity 5.

Table 6. Iterative improvements in learning steps: making conclusion and presenting finding

Indicators/ learning step	Pilot experiment implementation	Observations & prospective teachers' thinking conjectures	Teaching experiment refinements	Impact on student learning
a. Prospective teachers summarize data interpretations and propose evidence-based recommendations for sustainable fishing management.	Prospective teachers provided general conclusions without strong statistical evidence to support their recommendations.	Some prospective teachers struggled to use formal mathematical reasoning and statistical methods to justify their conclusions.	Prospective teachers were guided to integrate statistical analysis (e.g., mean, trend analysis, correlation) to strengthen their conclusions.	Prospective teachers improved their ability to communicate statistical findings clearly and formulate data-driven recommendations.
Prospective teachers present their findings using structured arguments.	Presentations lacked a structured approach, and explanations were mostly descriptive rather than analytical.	Some prospective teachers found it challenging to organize statistical evidence logically in their presentations.	Instructional scaffolding was introduced, emphasizing structured presentation formats that include trends, concerns, and proposed solutions.	Prospective teachers demonstrated improved clarity in communicating statistical findings and developed stronger argumentation skills.

Table 6 showed the iterative improvements in prospective teachers' ability to make conclusions and present findings based on statistical analysis. Initially, they provided general conclusions without strong statistical justification and faced difficulties in integrating formal mathematical reasoning. To refine their thinking, they were guided to incorporate statistical methods such as mean calculations, trend analysis, and correlation, leading to clearer data-driven recommendations. Similarly, their presentations lacked structure and were largely descriptive rather than analytical. To address this, instructional scaffolding emphasized structured presentation formats, including trends, concerns, and proposed solutions. As a result, prospective teachers improved their ability to communicate statistical findings effectively and develop stronger argumentation skills, demonstrating enhanced data literacy and analytical reasoning.

3.1.3. The restropective analysis

The retrospective analysis did based on data in Tables 2 to 6, the development of the learning trajectory in data-driven instruction has undergone significant refinement through the design research approach. In accordance with the principles of design research, this process was conducted iteratively, where each instructional stage followed a cycle of pilot experiments, testing the hypothesized learning trajectory (HLT), comparing HLT with the actual learning trajectory (ALT), and subsequently refining or revising HLT based on observational data. The HLT was revised through strategic refinements and impact evaluations on student learning.

In the initial design phase, prospective teachers encountered challenges in reading and interpreting data, recognizing trends in graphical representations, and applying statistical concepts such as correlation and regression. These difficulties indicated the need for adjustments in instructional approaches to support evidence-based reasoning more systematically. Through a series of HLT revisions, including the implementation of guiding questions, conceptual scaffolding, and explicit instruction in statistical analysis, prospective teachers demonstrated notable improvements in their ability to read data, identify patterns, recognize outliers, and construct data-driven arguments. The designresearch approach ensured that learning was not solely outcome-oriented but also focused on continually refining instructional methods based on authentic learner feedback. Ultimately, the designed learning trajectory enabled prospective teachers to support their statistical literacy skills.

3.2. Discussion

The implementation of design research, with the Hypothetical Learning Trajectory (HLT) as the instructional framework, integrating the local context of South Sumatra, hybrid learning, and the use of Nearpod, offers approach to supporting statistical literacy among prospective teachers. This aligns with the principles of design research, where localized and technology-enhanced interventions are developed and refined to enhance the quality of learning (Bakker, 2018; Gravemeijer & Cobb, 2006; Reeves, 2006). The local context, particularly the *Bekarang Iwak* tradition, provides authentic, culturally relevant data, making statistical learning more meaningful and accessible. This is consistent with previous studies indicating that context-based mathematics instruction enhances students' understanding and engagement by connecting mathematical concepts to real-life experiences (Rawani et al., 2023; Riyanto et al., 2019; Utari, Putri, Zulkardi, et al., 2024).

Integrating local wisdom into educational practices has been shown to improve students' academic performance and motivation. Research by Pesurnay (2018) indicates that cultural identity education can significantly enhance students' learning motivation and reduce anxiety, leading to better academic outcomes. In this context, the *Bekarang Iwak* tradition serves as a culturally relevant practice that can make learning statistics more engaging and meaningful. This tradition, which involves communal fish harvesting, provides authentic real-world data sets that allow students to explore statistical concepts in a familiar and contextually rich setting. By analyzing data derived from this tradition, such as fish counts, weight distributions, or environmental factors, prospective teachers not only develop a deeper understanding of statistical methods but also strengthen their connection to their cultural heritage. This integration transforms the learning process into a didactic phenomenon, where students actively construct knowledge through culturally meaningful experiences, fostering both academic and personal growth (Van den Heuvel-Panhuizen & Drijvers, 2014).

By using statistical concepts-such as data types, average, graph visualization, colleration and regression, populations and samples, and trend prediction-in a local context, prospective teachers not only learn technical skills but also gain a deeper understanding of how statistical analysis can be applied to community-based activities. This context-based approach can help foster a greater appreciation of the importance of statistics in addressing local issues, thus creating more engaged and informed future teachers (Aslan, 2019; Gal, 2019; Ulia et al., 2023). This is in line with research conducted Muñiz-Rodríguez et al. (2020) by that engaging prospective teachers with problems in the local environment causes them to be more aware of the environment in which they live, leading to a critical attitude in solving problems.

Hybrid learning, supported by tools such as the Nearpod app, offers significant advantages in making this learning experience interactive and flexible. Nearpod's features, such as real-time feedback, interactive quizzes, and multimedia presentations, can be effectively used to guide teacher candidates through the stages of data collection, reading and intepreting data, visualization, and analysis, which are aligned with HLT objectives. These stages align with the principles of Hypothetical Learning Trajectory (HLT), a framework that outlines the expected learning paths students may take to reach specific mathematical understanding. By integrating Nearpod into this process, educators can scaffold students' learning experiences and adapt instruction based on their progress, ensuring alignment with the intended learning goals. Research has shown that the use of Nearpod in mathematics education enhances student engagement, promotes active learning, and improves conceptual understanding (Hakami, 2020), further supporting its role in facilitating effective hybrid learning. In summary, by situating statistical education within a local context and leveraging innovative technological tools, we can better prepare prospective teachers to not only master statistical techniques but also to apply them meaningfully in their communities. This approach not only enriches their educational journey but also empowers them to become proactive contributors to the societal issues they will encounter in their professional lives.

4. CONCLUSION

This study demonstrates that the designed learning trajectory (LT) effectively supports prospective teachers' statistical literacy. The learning trajectory bridges abstract statistical concepts with real-life student experiences through the integration of local contexts, such as South Sumatran customs and empirical data. The iterative design research approach enabled the continuous refinement of the learning trajectory, significantly enhancing statistical literacy. The five key activities incorporated into the learning trajectory include reading and interpreting data tables using statistical situations within the local wisdom of South Sumatra as context, interpreting graphs, analyzing and reflecting, exploring outliers, and making conclusions and presenting findings. Additionally, the integration of the *Bekarang Iwak* tradition provides a culturally relevant foundation for learning, making statistical concepts more meaningful and accessible. The use of hybrid learning, supported by tools such as Nearpod, enhances engagement and interactivity, facilitating a more dynamic and applied learning experience.

Although this study highlights the effectiveness of the learning trajectory in supporting prospective teachers' statistical literacy, there are limitations in the assessment instruments, as they primarily rely on qualitative analysis and observational data. Future research should consider the integration of technology-based evaluation tools, such as learning analytics or data-driven monitoring systems, to track the real-time development of statistical understanding, providing a more comprehensive and objective measurement of learning progress.

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Declarations

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