Mathematics Education Journal
ISSN: 2549-1040 (e) | 1978-0044 (p)
https://doi.org/10.22342/mej.v19i3.pp527-546

Designing Learning Trajectory on Data Distribution Measurement through PMRI

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Abstract

The concept of data distribution measures plays a pivotal role in statistical education, fostering students' data literacy, critical thinking, and evidence-based decision-making. Despite its importance, many students continue to struggle with interpreting statistical data, demonstrating low levels of statistical reasoning and limited ability to apply these concepts to real-world contexts. Addressing this gap, this study introduces a culturally grounded and context-based instructional design that integrates the traditional Javanese calendar system, *Pranata Mangsa*, into the learning of data distribution measures. The objective of this research is to develop a learning trajectory that supports students' conceptual understanding of data distribution through meaningful and realistic mathematical experiences. This study involved 32 eighth-grade students from a junior high school in Central Java and employed a design research methodology encompassing three phases: preparation for the experiment, experimental design, and retrospective analysis. The instructional activities were implemented using the Video-assisted *Pendidikan Matematika Realistik Indonesia* (PMRI) approach. The resulting learning trajectory comprises three interconnected activities, namely analyzing *Pranata Mangsa* video content to gather and present data, deriving formulas for data distribution measures, and solving contextual problems linked to the cultural theme. The findings indicate that the integration of culturally relevant contexts and visual media in PMRI effectively enhances students' comprehension of statistical concepts. This research contributes to the field by offering a novel approach that bridges ethnomathematical elements with formal statistical instruction and serves as a reference for future studies seeking to incorporate local wisdom into mathematics education.

Keywords: Cultural Diversity, Data Distribution, Design Research, *Pranata Mangsa* Context, PMRI

How to Cite: Nurysahidah, F., Albab, I. U., & Rubowo, M. R. (2025). Designing learning trajectory on data distribution measurement through PMRI. *Mathematics Education Journal, 19*(3), 527-546. https://doi.org/10.22342/mej.v19i3.pp527-546

INTRODUCTION

Statistics is a scientific discipline concerned with the systematic processes of collecting, analyzing, interpreting, and drawing inferences from data (Mesghina et al., 2024; Zapata-Cardona & Martínez-Castro, 2023). The study of statistics equips students with essential competencies in analytical reasoning, problem-solving, and data interpretation, which are critical across a wide range of academic disciplines and professional domains (Horton & Hardin, 2021; Weiland & Sundrani, 2022; Weiland & Williams, 2024). A key component within the statistical curriculum is the concept of data distribution measurement, which serves as a foundational element in developing data literacy (Johannssen et al., 2021), enhancing statistical literacy, fostering critical thinking and informed decision-making (Koga, 2025), strengthening computational thinking (Çetinkaya-Rundel & Ellison, 2021; Donoghue et al., 2021; Kim & Henke, 2021), and supporting progression to more advanced statistical content (Zapata-Cardona & Martínez-Castro, 2023).

Despite its recognized significance, statistics continues to pose substantial challenges for learners (Dahlstrom-Hakki & Wallace, 2022; Steinberger, 2020). Difficulties often stem from students' limited understanding of fundamental statistical concepts, which impedes their ability to grasp more complex

Received June 19, 2024; Revised April 22, 2025; Accepted June 23, 2025

material (Mazouchová et al., 2021). Moreover, the abstract nature of statistical formulas and the cognitive demand associated with performing intricate calculations frequently lead to cognitive overload and decreased learner confidence (Da Silva et al., 2021). Students also struggle to contextualize theoretical statistical knowledge within real-life scenarios, which contributes to decreased motivation and engagement (Silva et al., 2022). As a result, learners often exhibit inadequate abilities in data interpretation, weak statistical reasoning, and a limited capacity to apply statistical knowledge to authentic problems (Ramadhani et al., 2022; Wahba et al., 2024).

Several factors contribute to students' difficulties in learning statistics, one of which is the limited number of mathematics teachers with specialized expertise in teaching statistical content. As a result, instructional delivery often lacks depth and comprehensiveness (Rubel et al., 2021). Furthermore, students' negative perceptions of statistics—as an abstract and cognitively demanding subject—tend to diminish their intrinsic motivation to engage with the material (Huang et al., 2023). These challenges are further compounded by the use of pedagogical approaches that are neither sufficiently interactive nor grounded in student-centered learning, thereby reducing students' active involvement in the learning process (Suarez-Rivera & Langan, 2022).

To address these issues, it is imperative for mathematics educators to employ instructional strategies that are both engaging and contextually relevant, in order to enhance students' comprehension and appreciation of statistical concepts. One promising pedagogical framework is *Pendidikan Matematika Realistik Indonesia* (PMRI), adapted from RME that emphasizes the use of real-world contexts as a starting point for mathematical learning (Freudenthal, 1991). The core principles of PMRI adapted from RME include didactic phenomenology, model development, the active role of students, interactivity, and the horizontal and vertical mathematization of concepts (Treffers, 1987). Empirical evidence supports the effectiveness of PMRI in fostering students' engagement, motivation, conceptual understanding, and critical thinking skills (Meryansumayeka et al., 2022). In addition, PMRI has been shown to enhance learners' problem-solving and analytical abilities (Andzin et al., 2024; Nursyahidah et al., 2025). By integrating real-life contexts into the mathematics classroom, PMRI contributes to a more meaningful and authentic learning experience (Putri et al., 2021; Zulkardi & Setiawan, 2020).

In the context of PMRI, "context" refers to problem situations derived from real-life experiences or students' immediate environments that are familiar and meaningful to them. These contexts serve as the foundation for mathematical activities and concept development (Gravemeijer & Doorman, 1991). Utilizing such contexts in instructional settings enhances conceptual understanding and promotes student engagement (Nursyahidah, Albab, & Mulyaningrum, 2023). In this study, the selected context is *Pranata Mangsa*, a traditional Javanese calendar system that regulates agricultural seasons based on recurring natural phenomena. The system divides the year into several distinct seasons, each associated with specific environmental patterns and durations (Prahmana et al., 2021). To enhance accessibility and clarity, this context is presented to students through animated video media. The video visually illustrates the cyclical nature of seasons and the number of days in each, while also integrating case-based applications in agriculture, thereby supporting students' understanding of statistical concepts related to data distribution.

The use of animated videos in mathematics education has demonstrated substantial pedagogical benefits. By integrating visual and auditory elements, animated videos create dynamic and interactive learning experiences that can effectively capture and sustain students' attention (Feeley et al., 2023). Empirical studies have shown that animated videos contribute positively to learning outcomes, increase student engagement (Ridha et al., 2022), enhance interest in the subject matter (Songkhro et al., 2022), and stimulate creativity (Zheng et al., 2023). Additionally, they support conceptual understanding (Aripin et al., 2025) and foster the development of problem-solving abilities (Hardiyanto et al., 2024; Nursyahidah, Albab, & Rubowo, 2023).

Previous research has implemented the PMRI approach in statistics education using various real-life contexts, such as sports (Uyen, 2021), traditional foods (Ramadhani et al., 2024), and consumer behavior like candy purchasing (Aripin et al., 2025). These studies have shown that contextual learning facilitates conceptual comprehension and improves learning outcomes. However, the integration of the *Pranata Mangsa* context and animated video media in the teaching of statistical content—particularly in data distribution—has not yet been explored. While Prahmana et al. (2021) previously investigated *Pranata Mangsa* from an ethnomathematical perspective, the focus was limited to modular arithmetic and not extended to classroom implementation in statistics education.

Building on this foundation, the present study aims to design and develop learning materials on data distribution measurement for eighth-grade students, grounded in the context of *Pranata Mangsa*. The instructional design is constructed following the Hypothetical Learning Trajectory (HLT) framework and is enriched with animated video content aligned with the core tenets of PMRI. The overarching objective is to construct a pedagogical pathway that enhances students' comprehension of statistical distribution in an engaging and contextually meaningful manner.

METHODS

This study employed the design research methodology, a systematic approach characterized by iterative cycles of design, development, evaluation, and refinement aimed at generating educational interventions that address complex problems in educational practice (Plomp & Nieveen, 2013). Design research is distinguished by its interventionist nature, process orientation, reflective inquiry, cyclical structure, and strong theoretical grounding (Gravemeijer & van Eerde, 2009). Specifically, this study adopted the validation studies approach, encompassing three interconnected phases: (1) preparing for the teaching experiment, (2) conducting the teaching experiment, and (3) retrospective analysis (Gravemeijer & Cobb, 2006).

Preliminary Design

In the initial phase, the researcher conducted an extensive literature review focusing on prerequisite statistical concepts, the principles of PMRI, and the content of eighth-grade statistics as outlined in the independent curriculum. This review informed the development of a HLT, which served as a pedagogical framework consisting of intended learning goals, a sequence of designed instructional activities, and predicted student responses. The HLT guided the formulation of the initial instructional theory and the design of prototype learning materials. These initial designs were subject to ongoing refinement throughout the research process in response to empirical findings emerging from each subsequent phase.

Teaching Experiment

The experimental phase was implemented in two stages: the pilot experiment and the teaching experiment. Each stage involved the enactment of three consecutive 40-minute learning activities designed to explore and validate the instructional theory. The pilot experiment functioned as a preliminary trial to identify and address potential issues within the learning trajectory. This stage involved thirty-two students from Class VIII B, with the researcher assuming the instructional role. Based on the outcomes and student responses, the HLT and associated learning activities were refined. The revised instructional design was subsequently implemented during the teaching experiment, which involved another group of 32 students from Class VIII F. Here, a collaborating classroom teacher served as the model teacher, delivering instruction while the researcher observed.

Data sources included student work on activity sheets, classroom video recordings, field notes, and semi-structured interviews with both students and the teacher. Research instruments—comprising observation protocols, interview guides, and student worksheets—were validated by subject matter experts, including mathematics educators and practicing mathematics teachers. Emphasis was placed on identifying students' problem-solving strategies and challenges, which informed ongoing modifications to the HLT. Data collection techniques incorporated focused classroom observations, video documentation, and trajectory tracking.

Retrospective Analysis

The final phase involved a retrospective analysis of the data collected during the teaching experiment. This process entailed a comparative evaluation of the enacted learning trajectory against the initial HLT predictions. Student strategies and problem-solving difficulties were systematically analyzed to assess the extent to which the instructional goals were achieved. Through this analytical comparison, insights into the development of students' mathematical thinking were gained, thereby enabling the refinement of both the instructional theory and the HLT. The research questions were addressed through this iterative and theory-driven interpretive process.

RESULTS AND DISCUSSION

The findings of this study present a detailed learning trajectory for teaching statistical concepts through the cultural context of *Pranata Mangsa*, supplemented by animated video media. The results are structured into three primary phases, as delineated below.

Preliminary Design Phase

During this initial stage, the researchers conceptualized an instructional design for statistics learning grounded in the *Pranata Mangsa* system. This traditional Javanese calendrical system was selected as a contextual foundation due to its potential to represent categorical and numerical data relevant to the teaching of statistics. The division of time in *Pranata Mangsa* into distinct seasons with varying durations offers a meaningful context to introduce and explore key statistical concepts.

Subsequently, the researchers developed a HLT to guide the instructional design. The formulation of the HLT was informed by an extensive review of existing literature, empirical observations, and alignment with the national curriculum. This involved identifying appropriate learning objectives, instructional content, and expected student learning outcomes. The HLT consists of three core learning activities, as summarized in Table 1.

Table 1. Hypothetical learning trajectory

Learning Activity	Learning Objectives	Student Conjectures
Observing *Pranata Mangsa* video	To identify, collect, and organize data	• Students are able to extract and summarize data from the animated video on *Pranata Mangsa*. • Students can represent the data in tabular format. • Students can sequence the data in ascending order.
Constructing data distribution formulas	To find the range formula To find the quartile formula To find the quartile range formula To find the quartile deviation formula	• Students can determine the minimum and maximum values within a dataset. • Students can calculate the range of data. • Students can identify the median to divide the data set into two equal parts. • Students can determine the lower quartile (Q1), median (Q2), and upper quartile (Q3). • Students can apply the concept of range in quartiles. • Students are able to compute the quartile deviation.

Learning Activity	Learning Objectives	Student Conjectures
Solving contextual problems	To solve contextual problems	• Students are capable of solving real-world problems related to data dispersion and distribution measures.

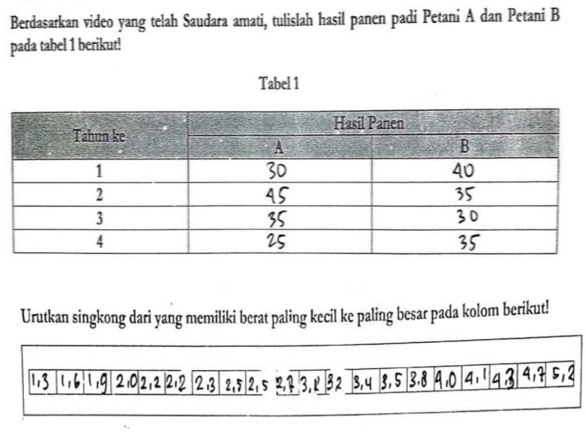
Teaching Experiment

Activity 1. Observing Pranata Mangsa Videos to Identify, Collect, and Present Data

The activity commenced with the students being divided into eight groups, each consisting of four members. Following this, the teacher introduced the lesson by presenting animated videos related to the Pranata Mangsa system. An example of the video display is shown in Figure 1.

Figure 1. Example of the video observed by the students

Upon completion of the video presentation, a brief discussion ensued between the students and the teacher regarding the significance of understanding the *Pranata Mangsa* system for farmers and fishermen, particularly in optimizing agricultural yields or fish catches. This discussion was intended to highlight the practical application of statistical concepts in real-world contexts. Afterward, the teacher provided each group with a worksheet focused on data collection and presentation. An example of the student responses on the first worksheet is presented in Figure 2.



Berdasarkan video yang telah Saudara amati, tulislah hasil panen padi Petani A dan Petani B pada tabel 1 berikut!

Tabel 1

Tahun ke	Hasil Panen	
	A	B
1	30	40
2	45	35
3	35	30
4	25	35

Urutkan singkong dari yang memiliki berat paling kecil ke paling besar pada kolom berikut!

1,3 | 1,6 | 1,9 | 2,0 | 2,2 | 2,2 | 2,3 | 2,5 | 2,5 | 2,7 | 3,1 | 3,2 | 3,4 | 3,5 | 3,8 | 4,0 | 4,1 | 4,3 | 4,7 | 5,2

English Version:
Based on the observed video, record the rice harvests of farmers A and B in the Table 1.

Year	Harvest	
	A	B
1	30	40
2	45	35
3	35	30
4	25	35

Sort the cassava weights from the smallest to the largest in the following column.

1.3	1.6	1.9	2	2.2
2.2	2.3	2.5	2.5	2.7
3.1	3.2	3.4	3.5	3.8
4	4.1	4.3	4.7	5.2

Figure 2. Sample student responses to data collection and presentation task

As evidenced in Figure 2, the students were able to collect data from the two videos they observed. Moreover, the students demonstrated proficiency in presenting the data in tabular form or by arranging the values in ascending order. The animated videos played a significant role in capturing the students' attention, which contributed to their engagement in the learning process. An interview excerpt with one of the students further supports this observation:

Researcher : *"How did you collect the data?"*

Student : *"I obtained it from the video provided by the teacher."*

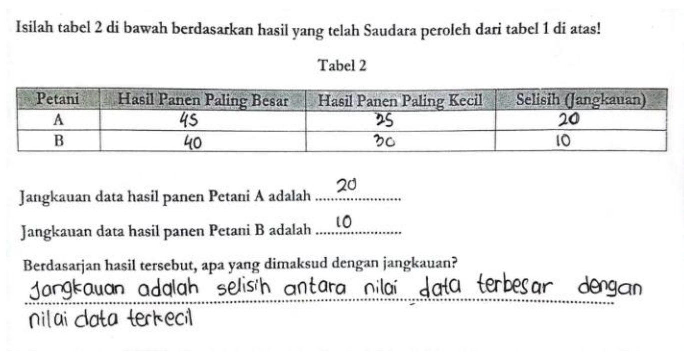
Researcher : *"How did you present the data from the video?"*

Student : *"By observing and taking notes on each data point presented in the video, I identified and ordered the data from smallest to largest, then presented it in the table."*

From the interview above, it is evident that the students successfully collected, identified, and presented the data using the animated video as a tool. This activity laid the foundation for subsequent learning on data distribution measurement by providing students with concrete data for analysis. Furthermore, the integration of animated videos was shown to be an effective strategy for enhancing data collection and presentation skills among students.

Activity 2. Deriving the Formula for Measuring Data Distribution

After completing the first worksheet, students were provided with a second worksheet containing material on the range, quartiles, quartile range, and quartile deviation. The teacher circulated among the groups to offer guidance as students worked through the worksheet. An example of the student responses regarding the formula and definition of the range can be seen in Figure 3.


Isilah tabel 2 di bawah berdasarkan hasil yang telah Saudara peroleh dari tabel 1 di atas!

Tabel 2

Petani	Hasil Panen Paling Besar	Hasil Panen Paling Kecil	Selisih (Jangkauan)
A	45	25	20
B	40	30	10

Jangkauan data hasil panen Petani A adalah 20

Jangkauan data hasil panen Petani B adalah 10

Berdasarjan hasil tersebut, apa yang dimaksud dengan jangkauan?
Jangkauan adalah selisih antara nilai data terbesar dengan nilai data terkecil

English Version:
Fill in Table 2 based on the results you have obtained from Table 1 above!

Farmer	Maximum result	Minimum result	Range
A	45	25	20
B	40	30	10

The range of Farmer A's crop yield = 20
The range of Farmer B's crop yield = 10
What is meant by range?
The range is the difference between the highest and lowest data values.

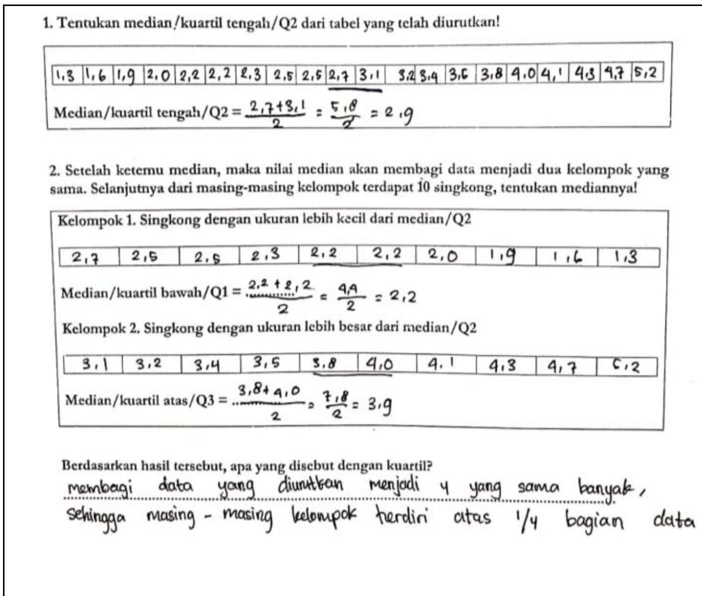
Figure 3. Student responses regarding the range concept

As shown in Figure 3, students were able to identify both the maximum and minimum values from the data. They were also able to compute the difference between the maximum and minimum values, successfully defining the range. The following discussion further supports this observation:

Researcher : "How did you determine the maximum value, minimum value, and range?"

Student : "First, we look at the data. Then, we identify the highest value and the smallest value. Once found, the highest value is the maximum, and the smallest value is the minimum. To determine the range, we subtract the minimum from the maximum value."

The interview confirms that students were able to calculate the maximum and minimum values, then find the range by subtracting them, demonstrating their ability to apply theoretical knowledge to real-world contexts. Next, students were instructed to arrange the data in ascending order. Building upon their understanding of the median from the previous activity, students divided the dataset into two groups to identify the middle quartile. The first group consisted of data values less than the median, while the second group contained values greater than the median. Students were then tasked with calculating the medians for each group to determine the lower and upper quartiles. The students' responses are presented in Figure 4.


1. Tentukan median/kuartil tengah/Q2 dari tabel yang telah diurutkan!

1,3	1,6	1,9	2,0	2,2	2,2	2,3	2,5	2,5	2,7	3,1	3,2	3,4	3,6	3,8	4,0	4,1	4,3	4,7	5,2

Median/kuartil tengah/Q2 = $\frac{2,7+3,1}{2} = \frac{5,8}{2} = 2,9$

2. Setelah ketemu median, maka nilai median akan membagi data menjadi dua kelompok yang sama. Selanjutnya dari masing-masing kelompok terdapat 10 singkong, tentukan mediannya!

Kelompok 1. Singkong dengan ukuran lebih kecil dari median/Q2

2,7	2,5	2,5	2,3	2,2	2,2	2,0	1,9	1,6	1,3

Median/kuartil bawah/Q1 = $\frac{2,2+2,2}{2} = \frac{4,4}{2} = 2,2$

Kelompok 2. Singkong dengan ukuran lebih besar dari median/Q2

3,1	3,2	3,4	3,5	3,8	4,0	4,1	4,3	4,7	5,2

Median/kuartil atas/Q3 = $\frac{3,8+4,0}{2} = \frac{7,8}{2} = 3,9$

Berdasarkan hasil tersebut, apa yang disebut dengan kuartil?
membagi data yang diurutkan menjadi 4 yang sama banyak, sehingga masing-masing kelompok terdiri atas 1/4 bagian data

English Version:
Determine the median/middle quartile/Q2 of the sorted data!

1.3	1.6	1.9	2	2.2
2.2	2.3	2.5	2.5	2.7
3.1	3.2	3.4	3.5	3.8
4	4.1	4.3	4.7	5.2

Median/middle quartile/Q2 = 2.9
After finding the median, the data is divided into two groups, each containing 10 data points.
Group 1. Cassava with a size smaller than the median

1.3	1.6	1.9	2	2.2
2.2	2.3	2.5	2.5	2.7

Lower quartile/Q1 = 2.2
Group 2. Cassava with a size larger than the median

3.1	3.2	3.4	3.5	3.8
4	4.1	4.3	4.7	5.2

Upper quartile/Q3 = 3.9
Based on these results, what is meant by quartiles?
Quartiles divide the sorted data into four equal parts, such that each group contains one-quarter of the data.

Figure 4. Student responses regarding the quartile concept

Figure 4 illustrates that students were able to find the median (Q2) from the sorted data. After identifying the median, students correctly divided the data into two groups, where they were able to find the new medians (Q1 and Q3) for each group. Furthermore, students demonstrated a clear understanding of quartiles. The following interview further clarifies this process:

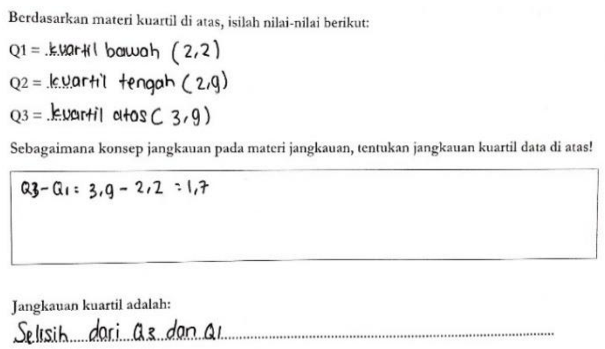
Researcher : "How did you determine the location and value of the middle quartile (Q2)?"

Student : "First, we sorted the data. Then, we determined the median. Since there are 20 data points, the median lies between the 10th and 11th data points. To find the value, we averaged the 10th and 11th data values, obtaining a value of 2.9."

Researcher : "How did you determine the location and value of the lower and upper quartiles?"

Student : *"After obtaining the median, we divided the data into two groups. The first group consists of the 1st to 10th data points, while the second group consists of the 11th to 20th data points. To find the lower quartile, we applied the median concept to the first group, while for the upper quartile, we applied the same concept to the second group. The lower quartile (Q1) is found by averaging the 5th and 6th data values, yielding 2.2. The upper quartile (Q3) is found by averaging the 15th and 16th data values, yielding 3.9."*

The interview confirms that students successfully determined Q1, Q2, and Q3, demonstrating their ability to apply the median concept to both the full dataset and the subsets. Subsequently, students were instructed to calculate the quartile range using the data obtained from the previous step. Their responses, which demonstrate their understanding of this concept, are presented in Figure 5.


Berdasarkan materi kuartil di atas, isilah nilai-nilai berikut:
Q1 = kuartil bawah (2,2)
Q2 = kuartil tengah (2,9)
Q3 = kuartil atos (3,9)
Sebagaimana konsep jangkauan pada materi jangkauan, tentukan jangkauan kuartil data di atas!
Q3 − Q1 = 3,9 − 2,2 = 1,7
Jangkauan kuartil adalah:
Selisih dari Q3 dan Q1

English Version:

Based on the quartile material, fill in the following values.
Q1 = lower quartile (2,2)
Q2 = middle quartile (2.9)
Q3 = upper quartile (3.9)
As with the range concept, determine the quartile range of the data above.
Q3 – Q1 = 1.7
The quartile range is:
Difference from Q3 and Q1

Figure 5. Student responses regarding the quartile range concept

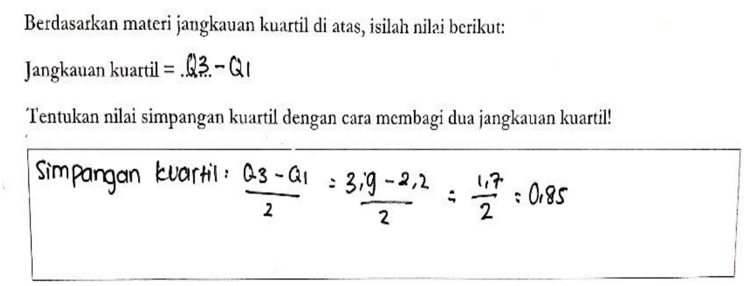
Students were able to compute the quartile range by applying the concept of range and quartiles (Q1, Q2, and Q3). They also correctly defined the quartile range, as demonstrated in Figure 5. The following interview confirms this:

Researcher : *"How do you determine the quartile range"*

Student : *"The range is the difference between the highest and lowest values. Quartiles include the lower, middle, and upper quartiles. Therefore, the quartile range is the difference between the upper quartile (Q3) and the lower quartile (Q1), which is 1.7."*

The interview confirms that students successfully determined the quartile range. This calculation involved ordering, summing, and dividing the number of farmer's harvests, demonstrating their ability to apply theoretical knowledge to practical contexts.

Subsequently, students were instructed to explore the concept of quartile deviation. The students' answers illustrating these methods are presented in Figure 6.



Berdasarkan materi jangkauan kuartil di atas, isilah nilai berikut:

Jangkauan kuartil = Q3 – Q1

Tentukan nilai simpangan kuartil dengan cara membagi dua jangkauan kuartil!

Simpangan kuartil: $\frac{Q3 - Q1}{2} = \frac{3,9 - 2,2}{2} = \frac{1,7}{2} = 0,85$

English Version:

Based on the quartile range material above, fill in the following values.
Quartile range = Q3 – Q1
Determine the quartile deviation value by dividing the value of the quartile range by two.
Quartile deviation = 0.85

Figure 6. Student answers regarding the quartile deviation concept

After understanding the quartile range, students successfully calculated the quartile deviation, as shown in Figure 6. The following interview further clarifies this process:

Researcher : *"How do you determine quartile deviation?"*

Student : *"First, we found the value of the quartile range, then we divided that value by two, yielding a quartile deviation of 0.85."*

The interview confirms that students successfully determine quartile deviation. This calculation involved subtracting and dividing the number, demonstrating their ability to apply theoretical knowledge to practical contexts.

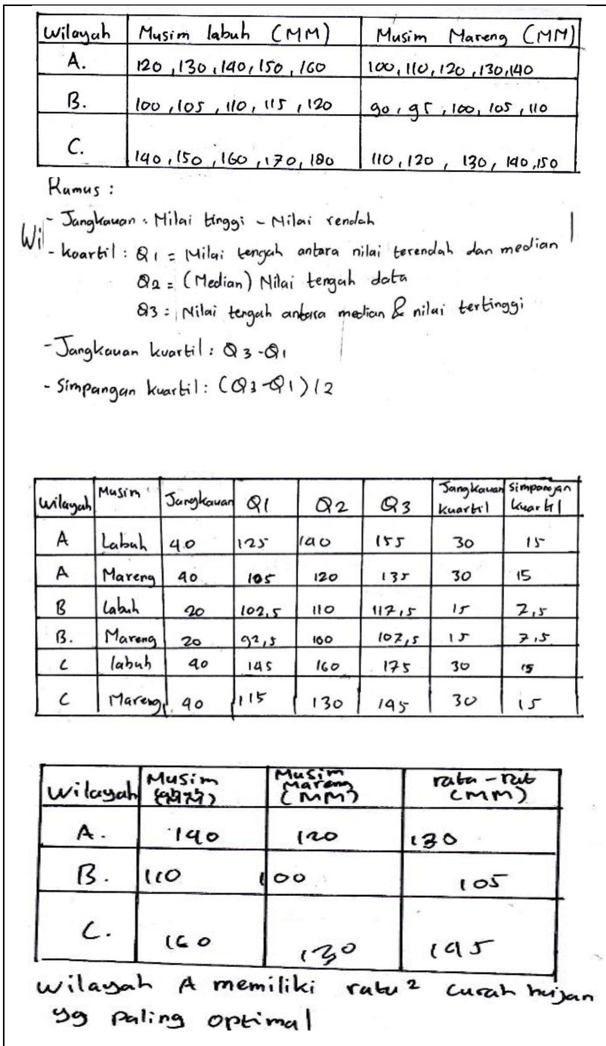
In summary, the activity, facilitated by the teacher and supported by group discussions, enabled students to explore the concepts of range, quartiles, quartile range, and quartile deviation. By working collaboratively and engaging in both peer and teacher-guided discussions, students were able to apply their theoretical knowledge to practical contexts. The final group presentation provided an opportunity for students to verify and correct their answers, reinforcing the learning process.

Activity 3. Solving Contextual Problems Involving Measures of Data Distribution

In this activity, students were provided with a third assignment sheet comprising contextual problems grounded in real-life scenarios involving measures of data distribution. They were instructed to complete the worksheet by applying the statistical concepts and procedures previously introduced in earlier activities. Students' responses to the contextual problem-solving task are illustrated in Figure 7.

Farmers use rainfall data in the *Pranata Mangsa* tradition to determine the proper planting time. The rainfall data (in mm) for 5 months in three different areas during the *Labuh* and *Mareng* seasons are as follows. The rainfall in the *Labuh* season in area A is 150, 160, 120, 130, and 140; in areas B, 110, 115, 120, 100, 105; and in areas C, 170, 150, 180, 140, and 160. The rainfall in the *Mareng* season in area A is 120, 130, 140, 100, 110; in area B is 95, 105, 110, 90, 100; and in region C is 120, 110, 150, 130, and 140.

a. Calculate the range, quartiles (Q1, Q2, Q3), quartile range, and quartile deviation for rainfall data in each region's *Labuh* and *Mareng* seasons.
b. Based on rainfall data, recommend the area with the most stable rainfall conditions for rice planting. Provide logical reasons.
c. If the average water requirement for rice is 600 mm for 5 months, determine which region is the most optimal for harvesting with an average rainfall close to that requirement.



Wilayah	Musim labuh (MM)	Musim Mareng (MM)
A.	120, 130, 140, 150, 160	100, 110, 120, 130, 140
B.	100, 105, 110, 115, 120	90, 95, 100, 105, 110
C.	140, 150, 160, 170, 180	110, 120, 130, 140, 150

Rumus :
- Jangkauan : Nilai tinggi – Nilai rendah
- Kuartil : Q1 = Nilai tengah antara nilai terendah dan median
  Q2 = (Median) Nilai tengah data
  Q3 = Nilai tengah antara median & nilai tertinggi
- Jangkauan kuartil : Q3 - Q1
- Simpangan kuartil : (Q3-Q1)/2

Wilayah	Musim	Jangkauan	Q1	Q2	Q3	Jangkauan kuartil	Simpangan kuartil
A	Labuh	40	125	140	155	30	15
A	Mareng	40	105	120	135	30	15
B	labuh	20	102,5	110	117,5	15	7,5
B.	Mareng	20	92,5	100	107,5	15	7,5
C	labuh	40	145	160	175	30	15
C	Mareng	40	115	130	145	30	15

Wilayah	Musim (MM)	Musim Mareng (MM)	rata-rata (MM)
A.	140	120	130
B.	110	100	105
C.	160	130	145

Wilayah A memiliki rata2 curah hujan yg paling optimal

English Version:

Area	*Labuh* season (mm)	*Mareng* season (mm)
A	120, 130, 140, 150, 160	100, 110, 120, 130, 140
B	100, 105, 110, 115, 120	90, 95, 100, 105, 110
C	140, 150, 160, 170. 180	110, 120, 130, 140, 150

Formula:
Range: The highest value – the lowest value
Quartiles:
Q1 = Midpoint between lowest value and median
Q2 = (median) middle value of data
Q3 = Midpoint between median and highest value
Quartile range: Q3 – Q1
Quartile deviation: $\frac{(Q3-Q1)}{2}$

Area	Season	Range	Q1	Q2	Q3	Quarrtile Range	Quartile deviation
A	Labuh	40	125	140	155	30	15
A	Mareng	40	105	120	135	30	15
B	Labuh	20	102.5	110	117.5	15	7.5
B	Mareng	20	92.5	100	107.5	15	7.5
C	Labuh	40	145	160	175	30	15
C	Mareng	40	115	130	145	30	15

Region B has the most stable range and quartile deviation.

Area	*Labuh* season (mm)	*Mareng* season (mm)	Mean (mm)
A	140	120	130
B	110	100	105
C	160	130	145

Region A has the most optimal average rainfall.

Figure 7. Student answers regarding contextual problem-solving

Figure 7 demonstrates that students were capable of solving contextual problems related to measures of data distribution. The process began with calculating key statistical indicators, including the range, quartiles (Q1, Q2, and Q3), interquartile range, and quartile deviation. The following interview excerpt provides insight into the student's reasoning and problem-solving process.

Researcher : *"How do you determine the range, quartiles (Q1, Q2, and Q3), interquartile range, and quartile deviation?"*

Student : *"Firstly, I make a table in order of numbers of rainfall data from the smallest to the most significant value for each season in each area, then I write the formula and calculate one by one for each region."*

Researcher : *"How do you determine the area with the most stable rainfall conditions for rice planting? Please explain your answer."*

Student : *"By looking at the table value of range and quartile, I am looking for the smallest range value to stabilize this condition. I get region B, which has the smallest range and quartile deviation."*

Researcher : *"How do you determine which region is the most optimal for harvesting with an average rainfall close to that requirement?"*

Student : *"I calculate the average rainfall first, 600mm divided by 5 months, and I get the rainfall should be 120 mm each month. Then, I calculate the rainfall average for each region and get region A with the closest value of 120 mm, which is 130 mm."*

The interview data confirm that students were able to successfully solve contextual problems involving statistical measures such as the range, quartiles (Q1, Q2, Q3), interquartile range, and quartile deviation. The computational processes undertaken by the students—such as organizing data in ascending order, summing values, performing subtraction and division—demonstrate their capability to translate theoretical mathematical knowledge into practical, real-world applications. This indicates not only procedural fluency but also conceptual understanding of data distribution measures within meaningful contexts.

The effectiveness of this learning outcome is closely linked to the implementation of the PMRI approach. PMRI fosters the development of mathematical concepts by encouraging students to initially engage with informal strategies before transitioning to formal methods. Additionally, the approach promotes the interconnectedness of mathematical topics, supports interactive and collaborative learning environments, and values students' reasoning and contributions. These pedagogical principles significantly contribute to enhancing students' problem-solving abilities and their capacity to contextualize mathematical concepts in everyday situations.

Retrospective Analysis

The HLT presented in Table 1 served as a structured guide to achieving the intended learning objectives and anticipating potential learning challenges. It was utilized as a framework to interpret and analyze students' cognitive strategies and conceptual understanding in measuring data distribution through the contextual lens of *Pranata Mangsa*. The comparison between the anticipated HLT and the actual student responses indicated a strong alignment, reflecting the effectiveness of the instructional design in guiding students' learning processes.

In the first instructional activity, students observed an animated video illustrating the *Pranata Mangsa* system to support their data collection and presentation efforts. This contextualized media proved effective in facilitating students' ability to gather and organize data, as depicted in Figure 2. Through this contextual visualization, students were able to engage more meaningfully with the task, leveraging real-world relevance to structure their statistical thinking.

During the second learning activity, students successfully identified the definition and formula for the range (Figure 3) and demonstrated the ability to determine the first, second, and third quartiles (Q1, Q2, and Q3) as shown in Figure 4. Subsequently, students accurately calculated the interquartile range (Figure 5) and quartile deviation (Figure 6). The collaborative group learning model, supported by teacher facilitation, significantly contributed to the development of students' mathematical reasoning. Peer-to-peer interactions and teacher scaffolding enabled deeper engagement with the tasks, culminating in students solving context-based problems related to measures of data dispersion in the final activity (Figure 7).

The overall progression through activities 1 to 3 illustrates that students were able to grasp statistical concepts, particularly in measuring data distribution, within the context of the *Pranata Mangsa* framework by employing the PMRI approach. The integration of contextual and technological elements supported a more accessible, engaging, and meaningful learning experience. This approach cultivated students' problem-solving abilities by embedding learning in culturally relevant contexts, particularly the seasonal cycles associated with agricultural practices in *Pranata Mangsa*.

The learning design aligned with the intended HLT and was effectively implemented in the classroom, demonstrating both pedagogical feasibility and instructional validity. Furthermore, the retrospective analysis offers insights into the influence of context, animated media, and the PMRI framework on student engagement and comprehension.

The use of PMRI in conjunction with technological tools—specifically animated videos—facilitated deeper conceptual understanding. PMRI has been widely recognized for its potential to enhance students' critical thinking and conceptual clarity in solving real-life mathematical problems (Putri et al., 2021, 2020; Silva et al., 2022). Prior research has shown that PMRI fosters student engagement, makes mathematical concepts more accessible, and promotes contextual problem-solving (Nursyahidah & Albab, 2021). In particular, Andzin et al. (2024) and Hardiyanto et al. (2024) emphasize the role of PMRI in enhancing conceptual understanding, especially in abstract topics such as data distribution.

Technological integration through animated video media significantly enriched students' learning experiences. By transforming abstract statistical concepts into concrete and relatable visual representations—such as visualizing harvest cycles through *Pranata Mangsa*—students were better able to internalize and apply their understanding. This finding is in line with the work of Nursyahidah et al. (2025), who highlighted the effectiveness of video media in engaging students and making mathematical content more relatable. Similar study result reported that video-based learning can significantly enhance students' depth of understanding and critical thinking abilities (Wirth & Greefrath, 2024).

In addition to technological and pedagogical strategies, the incorporation of cultural context—specifically the *Pranata Mangsa* system—provided a meaningful and culturally relevant dimension to the learning process (Nursyahidah et al., 2024; Prahmana et al., 2021). Embedding mathematical content in students' cultural environments has been shown to improve both comprehension and appreciation for the discipline (Prahmana & D'Ambrosio, 2020; Nursyahidah & Albab, 2021). Empirical evidence supports the notion that real-life and cultural contexts enhance mathematical skills (Zulkardi & Putri, 2020) and reveal culturally embedded mathematical knowledge (Meeran et al., 2024; Prahmana & D'Ambrosio, 2020). This approach further nurtures computational thinking (Harper et al., 2023), problem-solving (Putri et al., 2022), numeracy (Putri et al., 2025), and higher-order thinking skills (Malalina et al., 2023). Finally, Bermudez et al. (2023) also affirmed the importance of culturally grounded content in fostering children's mathematical and scientific reasoning.

In summary, the integration of the PMRI framework, animated instructional videos, and local cultural contexts offers an innovative and effective pedagogical model for teaching statistical concepts, particularly measures of data distribution. This multidimensional approach enhances students' conceptual understanding, increases engagement, and equips learners with the skills needed to address real-world mathematical problems. The findings of this study align with and extend existing literature, affirming the value of context-rich, technology-assisted, and culturally responsive mathematics education.

CONCLUSION

This study successfully developed a structured learning trajectory for teaching data distribution concepts within the framework of PMRI, utilizing animated videos contextualized in the *Pranata Mangsa* system. The trajectory consists of three sequential activities: observing videos to collect and present data, deriving formulas for data distribution measures, and solving contextual problems related to these measures. These activities were designed to strengthen students' conceptual understanding of key mathematical principles associated with data distribution, while also fostering connections between mathematics and local cultural heritage. The integration of culturally relevant content significantly enriched students' engagement and comprehension of the material.

However, despite these positive outcomes, several limitations of the study warrant consideration. The research is confined to the cultural context of the *Pranata Mangsa* system, which may restrict its applicability to other cultural settings and student populations. Additionally, the study's focus was primarily on conceptual understanding, with limited attention given to other essential dimensions of mathematics learning, such as procedural fluency and students' affective engagement with the subject. Furthermore, the relatively small sample size and short duration of the intervention may constrain the generalizability of the findings and the long-term impact of the proposed approach. These limitations suggest the need for further studies to refine and expand the applicability of this educational approach.

Future research should aim to address these limitations by broadening the cultural scope of the study, allowing for the exploration of how PMRI and technological tools can be adapted to different cultural contexts. Additionally, a more comprehensive investigation into other dimensions of learning, such as students' attitudes towards mathematics, problem-solving skills, and collaborative learning outcomes, would provide valuable insights into the full potential of this educational approach. Increasing the sample size and extending the duration of interventions are also recommended to enhance the validity and generalizability of the results, ensuring the broader applicability of PMRI-based teaching strategies across diverse educational settings.

ACKNOWLEDGMENTS

The authors would like to extend their sincere gratitude to the Lembaga Penelitian dan Pengabdian kepada Masyarakat (LPPM) of Universitas PGRI Semarang for their financial support through the Regular Research Grant (029/SKK/LPPM-UPGRIS/REG/II/2024).

DECLARATIONS

Author Contribution	:	FN: Conceptualization, Writing – Original Draft - Review and Editing. IUA: Methodology. MRR: Formal analysis.
Funding Statement	:	This research was funded by the LPPM Universitas PGRI Semarang, which provided the Regular Research Grant with the number 029/SKK/LPPM-UPGRIS/REG/II/2024.
Conflict of Interest	:	The authors declare no conflict of interest.
Additional Information	:	Additional information is available for this paper.

REFERENCES

Andzin, N. S., Sari, P. Y. P., Widodo, R. C., Sukowati, D. I., Indriastuti, S., & Nursyahidah, F. (2024). Arithmetic Sequences and Series Learning Using Realistic Mathematics Education Assisted by Augmented Reality. *Jurnal Pendidikan Matematika*, *18*(1), 139–148. https://doi.org/10.22342/jpm.v18i1.pp139-148

Aripin, U., Rosmiati, T., Rohaeti, E. E., & Hidayat, W. (2025). Learning Trajectory for Teaching the Mean Concept Using Problem-Based Learning and Animated Video. *Jurnal Pendidikan Matematika*, *19*(1). https://doi.org/10.22342/jpm.v19i1.pp181-196

Bermudez, V. N., Salazar, J., Garcia, L., Ochoa, K. D., Pesch, A., Roldan, W., Soto-Lara, S., Gomez, W., Rodriguez, R., Hirsh-Pasek, K., Ahn, J., & Bustamante, A. S. (2023). Designing culturally situated playful environments for early STEM learning with a Latine community. *Early Childhood Research Quarterly*, *65*, 205–216. https://doi.org/10.1016/j.ecresq.2023.06.003

Çetinkaya-Rundel, M., & Ellison, V. (2021). A Fresh Look at Introductory Data Science. *Journal of Statistics and Data Science Education*, *29*(sup1), S16–S26. https://doi.org/10.1080/10691898.2020.1804497

Da Silva, A. S., Barbosa, M. T. S., De Souza Velasque, L., Da Silveira Barroso Alves, D., & Magalhães, M. N. (2021). The COVID-19 epidemic in Brazil: How statistics education may contribute to unravel the reality behind the charts. *Educational Studies in Mathematics*, *108*(1–2), 269–289. https://doi.org/10.1007/s10649-021-10112-6

Dahlstrom-Hakki, I., & Wallace, M. L. (2022). Teaching Statistics to Struggling Students: Lessons Learned from Students with LD, ADHD, and Autism. *Journal of Statistics and Data Science Education*, *30*(2), 127–137. https://doi.org/10.1080/26939169.2022.2082601

Donoghue, T., Voytek, B., & Ellis, S. E. (2021). Teaching Creative and Practical Data Science at Scale. *Journal of Statistics and Data Science Education*, *29*(sup1), S27–S39. https://doi.org/10.1080/10691898.2020.1860725

Feeley, T. H., Keller, M., & Kayler, L. (2023). Using Animated Videos to Increase Patient Knowledge: A Meta-Analytic Review. *Health Education & Behavior*, *50*(2), 240–249. https://doi.org/10.1177/10901981221116791

Freudenthal, H., 1991. *Revisiting Mathematics Education: China Lectures.* Dordrecht: Kluwer Academic Publishers. https://link.springer.com/book/10.1007/0-306-47202-3

Gravemeijer, K., & Cobb, P. (2006). Van den Akker, J., Gravemeijer, K., McKenney, S., & Nieveen, N. (Eds.) Educational Design Research (1st ed.). Routledge. https://doi.org/10.4324/9780203088364

Gravemeijer, K., & Doorman, M. (1999). Context Problems in Realistic Mathematics Education: A Calculus Course as an Example. *Educational Studies in Mathematics*, *39*(1/3), 111–129. http://www.jstor.org/stable/3483163

Gravemeijer, K., & van Eerde, D. (2009). Design Research as a Means for Building a Knowledge Base for Teachers and Teaching in Mathematics Education. *The Elementary School Journal*, *109*(5), 510–524. https://doi.org/10.1086/596999

Hardiyanto, D., Asokawati, I., Majid, P. M., Maesaroh, A. T., & Nursyahidah, F. (2024). Learning Reflection Using Realistic Mathematics Education Assisted by GeoGebra Software. *Jurnal Pendidikan Matematika*, *18*(1). https://doi.org/10.1063/5.0242442

Harper, F. K., Caudle, L. A., Flowers, C. E., Rainwater, T., & Quinn, M. F. (2023). Centering teacher and parent voice to realize culturally relevant computational thinking in early childhood. *Early Childhood Research Quarterly*, *64*, 381–393. https://doi.org/10.1016/j.ecresq.2023.05.001

Horton, N. J., & Hardin, J. S. (2021). Integrating Computing in the Statistics and Data Science Curriculum: Creative Structures, Novel Skills and Habits, and Ways to Teach Computational Thinking. *Journal of Statistics and Data Science Education*, *29*(sup1), S1–S3. https://doi.org/10.1080/10691898.2020.1870416

Huang, W., London, J. S., & Perry, L. A. (2023). Project-Based Learning Promotes Students' Perceived Relevance in an Engineering Statistics Course: A Comparison of Learning in Synchronous and Online Learning Environments. *Journal of Statistics and Data Science Education*, *31*(2), 179–187. https://doi.org/10.1080/26939169.2022.2128119

Johannssen, A., Chukhrova, N., Schmal, F., & Stabenow, K. (2021). Statistical Literacy—Misuse of Statistics and Its Consequences. *Journal of Statistics and Data Science Education*, *29*(1), 54–62. https://doi.org/10.1080/10691898.2020.1860727

Kim, B., & Henke, G. (2021). Easy-to-Use Cloud Computing for Teaching Data Science. *Journal of Statistics and Data Science Education*, *29*(sup1), S103–S111. https://doi.org/10.1080/10691898.2020.1860726

Koga, S. (2025). Lessons to Demonstrate Statistical Literacy Skills: A Case Study of Japanese High School Students on Reading Statistical Reports. *Journal of Statistics and Data Science Education*, *33*(1), 77–89. https://doi.org/10.1080/26939169.2024.2334903

Malalina, Putri, R. I. I., Zulkardi, & Hartono, Y. (2023). Developing mathematics teaching materials using maritime context for higher-order thinking in junior high school. *Journal on Mathematics Education*, *15*(1), 173–190. https://doi.org/10.22342/jme.v15i1.pp173-190

Mazouchová, A., Jedličková, T., & Hlaváčová, L. (2021). Statistics Teaching Practice at Czech Universities with Emphasis on Statistical Software. *Journal on Efficiency and Responsibility in Education and Science*, *14*(4), 258–269. https://doi.org/10.7160/eriesj.2021.140405

Meeran, S., Kodisang, S. M., Moila, M. M., Davids, M. N., & Makokotlela, M. V. (2024). Ethnomathematics in Intermediate Phase: Reflections on the Morabaraba Game as Indigenous Mathematical knowledge. *African Journal of Research in Mathematics, Science and Technology Education*, *28*(2), 171–184. https://doi.org/10.1080/18117295.2024.2340095

Meryansumayeka, Zulkardi, Putri, R. I. I., & Hiltrimartin, C. (2022). Designing geometrical learning activities assisted with ICT media for supporting students' higher order thinking skills. *Journal on Mathematics Education*, *13*(1), 135–148. https://doi.org/10.22342/jme.v13i1.pp135-148

Mesghina, A., Hong, G., & Durrell, A. (2024). Cooperative Learning in Introductory Statistics: Assessing Students' Perceptions, Performance, and Learning in Heterogeneous and Homogeneous Groups. *Journal of Statistics and Data Science Education*, *32*(4), 444–456. https://doi.org/10.1080/26939169.2024.2302175

Nursyahidah, F. (2021). Learning Design on Surface Area and Volume of Cylinder Using Indonesian Ethno-mathematics of Traditional Cookie maker Assisted by GeoGebra. In *Mathematics Teaching-Research Journal* (Vol. 13, Issue 4, pp. 79–98).

Nursyahidah, F., Albab, I. U., & Mulyaningrum, E. R. (2023). Learning design of quadrilateral STEM-based through lesson study. *Eurasia Journal of Mathematics, Science and Technology Education*, *19*(11), em2352. https://doi.org/10.29333/ejmste/13747

Nursyahidah, F., Albab, I. U., & Rubowo, M. R. (2023). Learning Design of Sphere using Realistic Mathematics Education Assisted by Interactive Video. *Jurnal Pendidikan Matematika*, *17*(3). 297-312. https://doi.org/10.22342/jpm.17.3.20040.297-312

Nursyahidah, F., Albab, I. U., & Rubowo, M. R. (2024). Development Hypothetical Learning Trajectory on Statistics Material in Grade VIII Using Realistic Mathematics Education at the Preliminary Stage with Pranata Mangsa Context. *Jurnal Pendidikan Matematika*, *7*(2).

Nursyahidah, F., Anindya, F. M., Yulianti, M. A., Prisanto, Z. I., & Rosario, M. A. R. (2025). Integrating Local Wisdom with Technology: Designing Learning Trajectory of Cylinder through Realistic Mathematics Education Approach. *Jurnal Pendidikan Matematika*, *19*(1). pp 81-98. https://doi.org/10.22342/jpm.v19i1.pp81-98

Plomp, T., & Nieveen, N. (Eds.). (2013). *Educational Design Research: Part A: An introduction*. Enschede, The Netherlands: SLO – Netherlands Institute for Curriculum Development.

Prahmana, R. C. I., Yunianto, W., Rosa, M., & Orey, D. C. (2021). Ethnomathematics: Pranatamangsa system and the birth-death ceremonial in Yogyakarta. *Journal on Mathematics Education*, *12*(1), 93–112. https://doi.org/10.22342/JME.12.1.11745.93-112

Prahmana, R. C. I., & D'Ambrosio, U. (2020). Learning Geometry and Values from Patterns: Ethnomathematics on the Batik Patterns of Yogyakarta, Indonesia. *Journal on Mathematics Education*, *11*(3), 439–456. https://doi.org/10.22342/jme.11.3.12949.439-456

Pratiwi, M. D., Putri, R. I. I., & Zulkardi, Z. (2022). Mathematics Critical Thinking Ability Material Social Arithmethic class VII Assisted Video Animation in the Era of Covid-19. *Infinity Journal*, *11*(2), 297. https://doi.org/10.22460/infinity.v11i2.p297-310

Putri, R. I. I., Zulkardi, & Riskanita, A. D. (2022). Students' problem-solving ability in solving algebra tasks using the context of Palembang. *Journal on Mathematics Education*, *13*(3), 549–564. https://doi.org/10.22342/jme.v13i3.pp549-564

Putri, R. I. I., Zulkardi, Sari, N., Sagita, L., Siligar, E. I. P., & Sukma, Y. (2025). Learning numeracy using new Pempek mathematics. *Journal on Mathematics Education*, *16*(1), 1–22. https://doi.org/10.22342/jme.v16i1.pp1-22

Putri, R. I. I., Zulkardi, Z., Setyorini, N. P., Meitrilova, A., Permatasari, R., Saskiyah, S. A., & Nusantara, D. S. (2021). Designing a healthy menu project for Indonesian junior high school students. *Journal on Mathematics Education*, *12*(1), 133–146. https://doi.org/10.22342/jme.12.1.13239.133-146

Ramadhani, R., Saragih, S., & Napitupulu, E. E. (2022). Exploration of Students' Statistical Reasoning Ability in the Context of Ethnomathematics: A Study of the Rasch Model. *Mathematics Teaching-Research Journal*, *14*(1), 138–168.

Ramadhani, R., Prahmana, R. C. I., Soeharto, & Saleh, A. (2024). Integrating traditional food and technology in statistical learning: A learning trajectory. *Journal on Mathematics Education*, *15*(4), 1277–1310. https://doi.org/10.22342/jme.v15i4.pp1277-1310

Ridha, S. K., Bostanci, H. B., & Kurt, M. (2022). Using Animated Videos to Enhance Vocabulary Learning at the Noble Private Technical Institute (NPTI) in Northern Iraq/Erbil. *Sustainability*, *14*(12), 7002. https://doi.org/10.3390/su14127002

Rubel, L. H., Nicol, C., & Chronaki, A. (2021). A critical mathematics perspective on reading data visualizations: Reimagining through reformatting, reframing, and renarrating. *Educational Studies in Mathematics*, *108*(1–2), 249–268. https://doi.org/10.1007/s10649-021-10087-4

Silva, A. C., Viseu, F., Aires, A. P., & Neto, T. B. (2022). Investigative Activities for Statistics Learning with 1st Grade Portuguese Students. *Education Sciences*, *12*(10), 665. https://doi.org/10.3390/educsci12100665

Songkhro, J., Dequiña, Jr., L. S., Dominguez, R. R., & Phanlapa Khathayut, P. (2022). Effectiveness of Using Animated Videos via Google Sites in Enhancing Socio-culture of Native English-Speaking Countries. *Education Quarterly Reviews*, *5*(2). https://doi.org/10.31014/aior.1993.05.02.497

Steinberger, P. (2020). Assessing the Statistical Anxiety Rating Scale as applied to prospective teachers in an Israeli Teacher-Training College. *Studies in Educational Evaluation*, *64*, 100829. https://doi.org/10.1016/j.stueduc.2019.100829

Suarez-Rivera, C., & Langan, D. (2022, December 1). Teaching Statistics in Context: Effects of Statistics History on Student Learning. *Bridging the Gap: Empowering and Educating Today's Learners in Statistics. Proceedings of the Eleventh International Conference on Teaching Statistics*. Bridging the Gap: Empowering and Educating Today's Learners in Statistics. https://doi.org/10.52041/iase.icots11.T8F2

Timotheou, S., Miliou, O., Dimitriadis, Y., Sobrino, S. V., Giannoutsou, N., Cachia, R., Monés, A. M., & Ioannou, A. (2023). Impacts of digital technologies on education and factors influencing schools' digital capacity and transformation: A literature review. *Education and Information Technologies*, *28*(6), 6695–6726. https://doi.org/10.1007/s10639-022-11431-8

Treffers, A. (1987). *Three Dimensions*. Springer Netherlands. https://doi.org/10.1007/978-94-009-3707-9

Uyen, B. P. (2021). The effectiveness of applying realistic mathematics education approach in teaching statistics in grade 7 to students' mathematical skills. *Journal of Education and E-Learning Research*, *8*(2), 185–197. https://doi.org/10.20448/JOURNAL.509.2021.82.185.197

Wahba, F., Ajlouni, A. O., & Abumosa, M. A. (2024). The impact of ChatGPT-based learning statistics on undergraduates' statistical reasoning and attitudes toward statistics. *Eurasia Journal of Mathematics, Science and Technology Education*, *20*(7), em2468. https://doi.org/10.29333/ejmste/14726

Weiland, T., & Sundrani, A. (2022). Opportunities for K-8 Students to Learn Statistics Created by States' Standards in the United States. *Journal of Statistics and Data Science Education*, *30*(2), 165–178. https://doi.org/10.1080/26939169.2022.2075814

Weiland, T., & Williams, I. (2024). Culturally Relevant Data in Teaching Statistics and Data Science Courses. *Journal of Statistics and Data Science Education*, *32*(3), 256–271. https://doi.org/10.1080/26939169.2023.2249969

Wirth, L., & Greefrath, G. (2024). Working with an instructional video on mathematical modeling: Upper-secondary students' perceived advantages and challenges. *ZDM – Mathematics Education*. https://doi.org/10.1007/s11858-024-01546-2

Zapata-Cardona, L., & Martínez-Castro, C. A. (2023). Statistical modeling in teacher education. *Mathematical Thinking and Learning*, *25*(1), 64–78. https://doi.org/10.1080/10986065.2021.1922859

Zheng, M., Cuenin, K., Lyon, C., & Bender, D. (2023). An Exploratory Study of Dental Students' Use of Whiteboard Animated Videos as Supplementary Learning Resources in Basic Sciences. *TechTrends*. https://doi.org/10.1007/s11528-023-00875-5

Zulkardi, & Setiawan, M. B. T. (2020). Javanese calendar as context to learn number pattern and least common multiple. *Journal of Physics: Conference Series*, *1470*(1), 012094. https://doi.org/10.1088/1742-6596/1470/1/012094

Zulkardi, Z., & Putri, R. I. I. (2020). Supporting Mathematics Teachers to Develop Jumping Task Using PISA Framework (JUMPISA). *Jurnal Pendidikan Matematika*, *14*(2), 199–210. https://doi.org/10.22342/jpm.14.2.12115.199-210