

From *Furusato* to *Pendidikan Khas Kejogjaan* teaching concept: Teachers' point of view in design math lesson

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Abstract

Ethnomathematics offers a means of connecting formal mathematics with students' lived experiences; however, cultural integration in mathematics education often remains at the level of contextual examples rather than informing the systematic design of Teaching-Learning Materials (TLM). How teachers transform local cultural knowledge into coherent mathematical inquiry, particularly through theoretically grounded place-based approaches, remains insufficiently understood. This study addresses this gap by synthesising the Japanese concept of *Furusato Kyoiku* (Hometown Education) and Indonesia's *Pendidikan Khas Kejogjaan* (PKJ) within the Problem, Plan, Data, Analysis, Conclusion (PPDAC) framework. Using an ethnographic qualitative approach, it investigates how three mathematics teachers in Yogyakarta, Indonesia, conceptualised, explored, and structured local cultural resources into statistics TLM across elementary, junior high, and senior high school levels. Data from interviews, classroom observations, and curriculum analysis were examined through four guiding questions concerning cultural exploration, discovery, significance, and interpretation. Despite differences in grade level, statistical content, and cultural artefacts, all teachers followed a common design sequence: identifying culturally proximate contexts, investigating them through direct engagement, evaluating their mathematical and curricular relevance, and aligning selected content with PPDAC. Examples included traditional Yogyakarta snacks, *Kawung* batik, and plant cultivation to support statistical inquiry, including scatter plots and linear regression. These findings suggest that integrating *Furusato Kyoiku*, PKJ, and PPDAC can provide a structured pathway from superficial cultural references to place-based mathematical modelling, while supporting local heritage preservation. Further research across diverse contexts is needed to establish the framework's broader applicability.



Keywords: Ethnomathematics; *Furusato Kyoiku*; *Pendidikan Khas Kejogjaan*; Teaching Learning Material

Introduction

Mathematics is frequently perceived by students as an abstract, rigid, and decontextualized discipline, leading to low engagement and a lack of perceived relevance in their daily lives. Internationally, educational frameworks increasingly emphasize culturally responsive pedagogy and place-based education to bridge the gap between formal school curricula and students' socio-cultural backgrounds (UNESCO, 2021). Despite global endorsement of ethnomathematics, the study of the relationship between mathematics and culture, teachers worldwide struggle to move beyond superficial cultural references, often reducing local heritage to trivial decorative illustrations rather than meaningful mathematical context (Rosa & Orey, 2011; Pais, 2011). Nationally, in Indonesia, the implementation of *Kurikulum Merdeka* explicitly encourages contextual learning and regional identity preservation through initiatives such as the Project for Strengthening the Pancasila Student Profile (P5) and local content mandates. However, at the classroom level, Indonesian mathematics teachers consistently report challenges in operationalizing cultural heritage into structured Teaching-Learning Materials (TLM), particularly in complex domains like statistics, where abstract data handling dominates instructional time (Lidinillah et al., 2022; Utami et al., 2020).

In response to this persistent instructional dilemma, we argue that successfully embedding local culture into mathematics requires equipping teachers with an explicit conceptual framework for place-based design rather than providing pre-packaged, static cultural worksheets. More recent scholars extend this argument pedagogically: appreciating mathematics as cultural wisdom rooted in students lived experience is positioned as central to building a more just and inclusive mathematics education, and to helping students see themselves as mathematicians. In the Indonesian context, this argument has gained particular traction. Prahmana and D'Ambrosio (2020) found that ethnomathematics in Indonesia extends beyond merely exploring and experimenting with cultural elements in school mathematics, showing that it can be meaningfully integrated into the formal curriculum. Taken together, these expert positions substantiate the researcher's premise that treating culture as a substantive design resource rather than a superficial wrapper for pre-existing content is both theoretically justified and pedagogically necessary.

Extensive prior research has documented the positive impact of ethnomathematics on student motivation and conceptual understanding across various mathematical topics (Sunzuma & Arigbabu, 2019; Muhtadi et al., 2017; Hariastuti et al., 2020). Previous studies have successfully identified ethnomathematical elements in traditional crafts, architectural monuments, and indigenous games (Alangui, 2010; Zhang & Zhang, 2021). However, a critical empirical gap remains: most of these studies, including Alangui's (2010) analysis of stone walls and water flows and Zhang and Zhang's (2021) study of the Temple of Heaven, document cultural mathematical practices as content, identifying the mathematics embedded in an artefact

or tradition, but stop short of examining how classroom teachers themselves discover, interpret, and structure such content into coherent, pedagogically sound TLM. In particular, these studies leave unanswered how teachers decide which of the many mathematical properties latent in a cultural artefact are pedagogically viable for a given grade level, how teachers sequence an open-ended cultural exploration into a bounded, teachable unit, and what criteria teachers use to judge whether a cultural observation is mathematically substantive enough to retain. Few studies investigate how practicing teachers across different grade levels actually navigate the cognitive, pedagogical, and cultural transitions required to translate authentic local heritage into rigorous TLM (Gravemeijer et al., 2017). Furthermore, while the Problem, Plan, Data, Analysis, and Conclusion (PPDAC) framework established by Wild and Pfannkuch (1999) is widely recognized as a premier pedagogical tool for statistical thinking, its application as an analytical framework for teachers designing culture-based statistics TLM across primary and secondary levels remains largely unexplored. The teacher, as the agent who must translate ethnomathematical potential into an actual classroom sequence with clear learning objectives, remains comparatively under-examined.

This study addresses that gap by drawing on a theoretical model external to the Indonesian mathematics education literature: the Japanese concept of *Furusato Kyoiku*, or hometown-based education (Mizobuchi, 2021, Baba et. al., 2025). *Kyōdo kyoiku*, or local education closely tied to the notion of *furusato gakushu*, or hometown learning has historically been used in Japan to root formal schooling in the topography, history, and identity of a community. This study proposes that this concept offers a transferable theoretical lens for the Indonesian Nusantara context, where regional cultural identity is likewise treated as a legitimate foundation for character and content-based education. This proposition is timely and locally grounded: the Special Region of Yogyakarta has formally institutionalized a structurally similar policy, *Pendidikan Khas Kejojjaan* (PKJ), introduced through the Governor of Special Region of Yogyakarta Regulation Number 40 of 2022 as a strategy to strengthen character through local cultural values, and designed not as a standalone subject but as content integrated across all existing school subjects to cultivate a distinctly Yogyakarta-rooted student character (Dwijonagoro, et.al., 2023).

The novelty of the present study lies in this dual theoretical synthesis pairing *Furusato Kyoiku*'s place-based pedagogical philosophy with PKJ's local policy infrastructure and in operationalizing it methodologically through PPDAC, thereby offering teachers a concrete pedagogical structure through which culturally exploratory insight can be converted into standards-aligned statistics TLM, rather than remaining an abstract curricular aspiration. Combining these three elements is necessary because each addresses a gap the others do not: *Furusato Kyoiku* supplies the pedagogical rationale for treating local identity as legitimate mathematical content, PKJ supplies the institutional legitimacy specific to the Yogyakarta context that makes such content permissible within the formal curriculum, and PPDAC supplies the concrete procedural structure that neither of the other two provides on its own; the resulting contribution is therefore not a new philosophy of cultural integration but an operational design framework that teachers can actually follow when building culture-based statistics TLM.

Furthermore, the novelty of this research also lies in its dual-layered conceptualization, which addresses this literature gap by merging place-based educational philosophies, namely *Furusato Kyoiku* and PKJ, with the PPDAC investigative cycle as a design guide for teachers. Rooted in social constructivism and situated cognition, this study posits that teachers construct pedagogical content knowledge most effectively when engaged as active ethnographic co-designers of their local curriculum. Rather than treating cultural integration as a one-size-fits-all activity, this research introduces an exploratory four-question framework, such as Where do I begin exploring?, How can I discover it?, How will I know if I discovered something important?, and (4) How can I make sense of it?, derived from qualitative ethnographic traditions (Spradley, 1979; Clifford & Marcus, 1986). This framework serves as a generative heuristic, guiding teachers through the nuanced cognitive steps of identifying cultural phenomena, extracting mathematical properties, evaluating pedagogical viability, and synthesizing the findings into structured TLM.

Finally, the primary objective of this study is to examine descriptively how mathematics teachers across elementary, junior high, and senior high school levels in conceptualize, explore, and integrate local cultural elements into structured statistical TLM through the synthesized lens of *Furusato Kyoiku* and PKJ. By analyzing teachers' reflections, design practices, and the resulting PPDAC-aligned materials, this study illuminates how empowering educators as cultural explorers fosters both deep mathematical reasoning and the authentic preservation of local heritage.

Methods

Research Design

This study employed an ethnographic qualitative research design focused on teachers' curriculum design practices (Spradley, 1979; Creswell, 2007). An ethnographic approach was selected because it allowed researchers to observe, document, and interpret how practicing teachers immersed themselves in local cultural contexts, synthesized socio-cultural artifacts, and translated informal ethnomathematical knowledge into structured TLM (Rosa & Orey, 2011). To systematically evaluate the resulting TLM, the study embedded the PPDAC framework proposed by Wild and Pfannkuch (1999) as a pedagogical analysis tool. Specifically, the ethnographic character of the design is most evident in Phase 2 (Ethnographic Cultural Exploration), during which researchers accompanied each teacher into the field visiting market stalls, batik workshops, and school gardens to observe first-hand how teachers immersed themselves in, and made sense of, the cultural setting, rather than relying solely on retrospective interview accounts; the interview guide, observation protocol, and document analysis checklist described in the Research Instruments section were the specific instruments used to document that immersion.

Research Participants

Participants were three in-service mathematics teachers in Yogyakarta, Indonesia, representing elementary (Grade 6), junior high (Grade 8), and senior high (Grade 11) levels. Participants were selected using purposive sampling based on four specific criteria, such as active mathematics teaching status in Yogyakarta; demonstrated interest or experience in incorporating local cultural or place-based content into their mathematics instruction; representation across primary, lower-secondary, and upper-secondary school levels; and willingness to participate in a multi-stage design workshop and focus group discussions (FGD). This sampling strategy was chosen because the study's aim was not to generalize across the general population of mathematics teachers, but to obtain information-rich cases capable of illuminating the design process in depth, a rationale consistent with the purposive, criterion-based sampling logic typically applied in exploratory qualitative and ethnographic research as summarized in [Table 1](#).

Table 1. Profiles of Research Participants and Design Scope

Participant	Grade Level	Cultural Artifact Selected	Mathematical Topic
Teacher 1	Grade 6 Elementary School	Traditional Yogyakarta Snacks (<i>Jajanan Pasar</i>)	Statistics (Pictograms, bar charts, frequency tables, data comparison)
Teacher 2	Grade 8 Junior High School	Batik Kawung Geometric Patterns	Circle Geometry
Teacher 3	Grade 11 Senior High School	Local Agricultural Plant Cultivation	Scatter Plot and Linear Regression

Research Procedure

The research unfolded in four main chronological phases spanning over eight months. The complete procedure followed a systematic design to ensure reproducibility, as illustrated in [Figure 1](#).

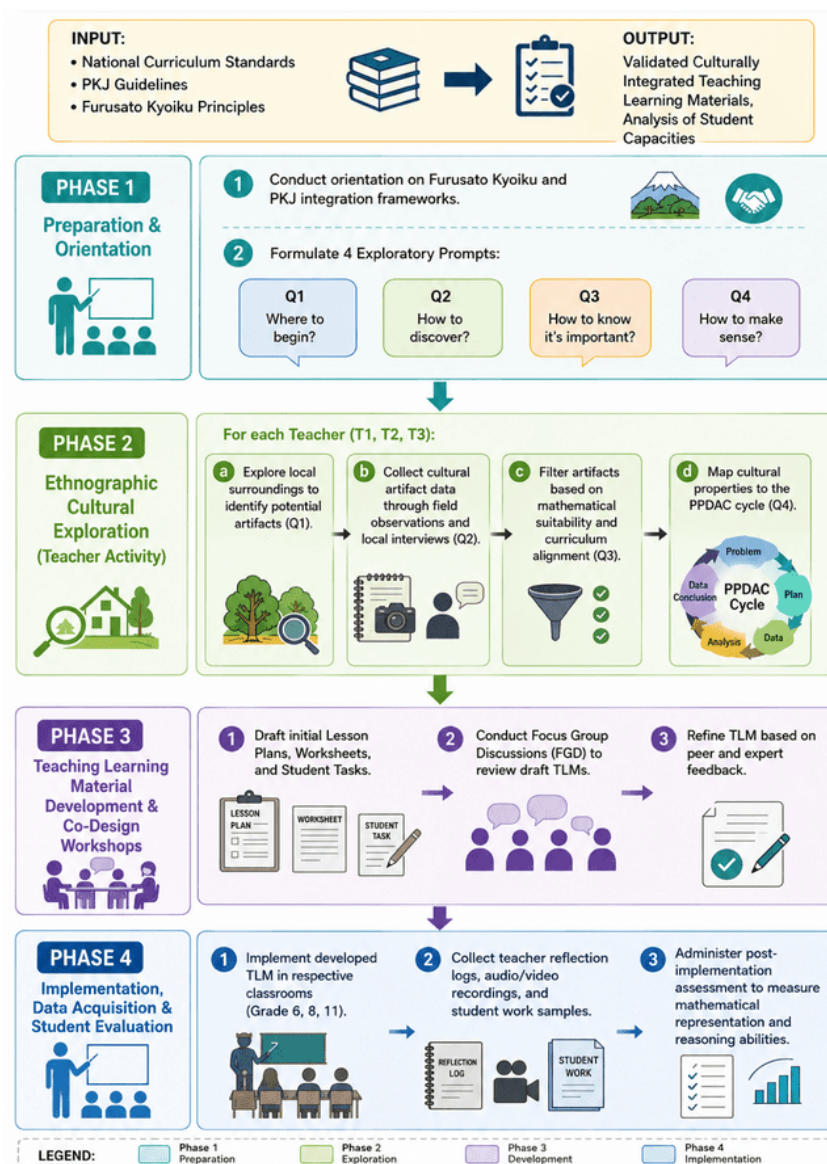


Figure 1. Research Procedure

Research Instruments

Three instruments were used to gather data: (1) a semi-structured interview guide, organized around the four exploration questions (see Figure 1), used to elicit teachers' reasoning during each phase of TLM design; (2) a classroom and design-session observation protocol, used to document teachers' actual behavior, materials-in-progress, and classroom implementation; and (3) a document analysis checklist, used to evaluate curriculum documents and draft TLM against the five PPDAC stages. All instruments were developed by the researcher and reviewed for content adequacy prior to use.

Data Collection

Data collection occurred through triangulated qualitative: (1) Ethnographic Fieldwork and Documentation: Researchers observed teachers exploring local cultural materials (e.g.,

traditional snacks, batik pattern, and school gardens) and documented field notes, photographs, and artifact samples; (2) In-Depth Interviews: Individual interviews lasting 45 to 60 minutes were conducted with each teacher prior to, during, and after TLM development; (3) FGD: Three times of 60-minute FGDs were audio- and video-recorded to analyze how teachers collectively negotiated cultural and mathematical concepts (January-March 2026); (4) Classroom Implementation Artifacts: Worksheets and students' project products.

Data Analysis

Thematic findings were then compared across the three teacher cases using cross-case analysis. Subsequently, the developed TLM were analyzed using the PPDAC framework to identify how local culture supported mathematical inquiry. The final interpretation synthesized the perspectives of ethnomathematics, *Furusato Kyoiku*, and PKJ to explain teachers' design practices. To improve trustworthiness, data triangulation was achieved by comparing interview data, classroom observations, curriculum documents, and the developed TLM. Member checking was also conducted by returning preliminary interpretations to the participating teachers for confirmation.

Results

The findings of this study demonstrate how mathematics teachers conceptualize, explore, and integrate local cultural heritage into structured statistical TLM. By operationalizing the four exploratory prompts within the synthesized framework of *Furusato Kyoiku* and PKJ, teachers shifted from viewing culture as static background context to utilizing it as a dynamic engine for statistical inquiry. The results are structured around the systematic research workflow spanning preparation, ethnographic exploration, TLM co-design, and classroom implementation.

Teachers' Ethnographic Exploration of Cultural Artifacts

Teachers navigated the four-question (Q1-Q4) framework during Phase 2 to identify and operationalize ethnomathematical contexts within Yogyakarta's cultural landscape.

Where do I begin exploring? (Initial identification)

Initially, all three teachers perceived culture as part of students' daily experiences rather than as explicit mathematical content. During the first exploration stage, they searched for cultural practices that were familiar, meaningful, and observable within students' local environments. Rather than beginning with curriculum objectives, teachers first examined community activities, traditional artefacts, and environmental resources promoted through PKJ.

Elementary School - Teacher 1 (T1): Identified traditional Yogyakarta markets (*pasar tradisional*) and street vendors. T1 selected traditional Javanese snacks (*jajanan pasar* such as *kipo*, *klepon*, *nagasari*, etc) due to their familiarity to students and inherent variability in color, shape, price, and consumer preference. The teacher stated that students regularly encountered

traditional snacks in local markets, and these snacks are sold daily near the school, and students already handle quantities of them informally. This made them suitable for collecting categorical data, comparing frequencies, constructing bar graphs, rather than merely decorating worksheets.

Junior High School - Teacher 2 (T2): Focused on local artisanal craft traditions in Yogyakarta. T2 selected Batik Kawung, a classical Javanese motif based on cross-sectioned sugar palm fruits (*kolang-kaling*), noting its rich geometric symmetry and spatial arrangements. T2 explored palace heritage traditional batik geometric symmetry. Instead of treating batik as decoration, T2 viewed circle diameter radius symmetry pattern repetition as mathematical properties.

Senior High School - Teacher 3 (T3): Explored local agricultural practices surrounding school gardens and suburban farming sites. T3 selected plant cultivation project alignment with an existing cross-subject science collaboration (measuring growth rates of local vegetables) to connect mathematical modelling with environmental stewardship. This eventually became authentic statistical investigation for the students.

Interview data indicated that the selection criteria at this stage prioritized experiential proximity, defined as the artefact's presence in students' daily environments, and perceived mathematical potential, rather than strict adherence to PKJ curriculum guidelines. This finding suggests that PKJ served less as a prescriptive checklist and more as a permission structure and institutional validation, enabling teachers to incorporate familiar local knowledge as legitimate instructional content. For instance, T1 noted that although PKJ does not explicitly reference traditional snacks as learning media, the policy "gave her room" to integrate them into a statistics lesson. Furthermore, the media cards created by T1 featuring traditional snacks illustrate that these items are not merely treated as mathematical objects or calculation variables. Instead, each snack is presented as a representation of the cultural values and philosophies embedded within Yogyakarta society.

How can I discover it? (How to Explore - Cultural Data Collection)

During field exploration, teachers utilized qualitative observation and community engagement to gather empirical data on the chosen artifacts. T1 conducted field visits to traditional market stalls, taking photographs, interviewing vendors regarding daily sales quantities, and documenting how traditional snacks are categorized and bundled. While T2 engaged with local batik artisans, recording measurement protocols, tracing motifs, and documenting the spatial grid patterns used to maintain motif proportion during wax application (*canting*). T3 set up longitudinal observational plots, documenting growth parameters (stem height, leaf count, sunlight exposure, and soil moisture levels) over a four-week period with students.

This phase revealed a key pattern that teachers whose artefacts were static and pre-existing (T1 and T2) engaged in observational discovery by documenting and measuring what already existed in the cultural object. In contrast, T3's artefact was generative the cultural/scientific practice of planting produced the statistical data itself, rather than the data

being extracted retrospectively from an existing object. This distinction matters pedagogically, as it shaped the type of statistical reasoning each TLM could support.

How will I know if I discovered something important? (Filtering & Pedagogical Alignment)

Teachers evaluated potential cultural artefacts against national curriculum standards and mathematical rigor to ensure the artefacts went beyond superficial illustration. T1 filtered out static cultural facts (e.g., historical origins of traditional snacks) and retained quantitative variables suitable for frequency tables, pictograms, and bar charts. T2 evaluated the geometric dimensions of Batik Kawung, recognizing that measuring motif proportions provided real spatial data necessary to transition students from pure spatial visualization to geometric statistical analysis. T3 confirmed that plant growth data provided non-linear and linear bivariate data sets ideal for generating authentic scatter plots and exploring linear regression concepts.

All three teachers reported using a combination of curriculum alignment and mathematical clarity as criteria for judging whether a cultural observation was worth retaining. This finding addresses a central concern raised in the introduction: rather than treating culture as a decorative wrapper, teachers in this study actively evaluated and pruned cultural content against mathematical criteria, indicating a genuine two-way negotiation between cultural authenticity and statistical rigor rather than a one-directional imposition of either.

How can I make sense of it? (Mapping Cultural Properties to PPDAC)

In the final exploratory step, teachers mapped their cultural findings directly onto the five stages of the PPDAC statistical cycle, establishing the structural foundation for their TLMs.

Table 2. Alignment of Cultural Artifacts and Grade-Level Mathematics with the PPDAC Framework

PPDAC Stage	Grade 6: Traditional Snacks (T1)	Grade 8: Batik Kawung Patterns (T2)	Grade 11: Plant Cultivation (T3)
Problem	Which traditional snacks are most popular among students, and how are they categorized?	How do geometric proportions in Batik Kawung remain consistent across different canvas sizes?	What is the quantitative relationship between cultivation time/light exposure and plant height?
Plan	Design a survey protocol to collect classmate preference data and sweet sales counts.	Establish measurement grids to record radii, perimeter, and area metrics of batik motifs.	Set up a 4-week experimental tracking log for agricultural variables.
Data	Collect discrete categorical and numerical frequency data from classroom trials.	Gather continuous spatial and measurement data across multiple batik samples.	Record bivariate quantitative data pairs (Time/Sunlight vs. Stem Height).

Analysis	Construct pictograms, frequency tables, and bar charts; compare mode and range.	Calculate dimensional ratios, plot scatter metrics, and evaluate spatial data variations.	Plot scatter diagrams, determine line of best fit, and calculate linear regression equations.
Conclusion	Synthesize traditional snacks preferences to reflect cultural preservation and consumer choice.	Interpret how mathematical precision preserves cultural aesthetic heritage in batik making.	Formulate data-driven agricultural decisions and predict future growth trends mathematically.

For T1 (G6), the problem stage was framed by questions given: (1) “Who has ever bought traditional market snacks?”; (2) “In your opinion, which snacks are most frequently purchased?”; (3) “How can we find out which snacks are the most popular?”. By role playing activity (plan stage) in the T1’s class, the data collected as counts and measurements of traditional snacks, and analysis conducted through pictograms, bar charts, and frequency tables, consistent with the Grade 6 competency of sorting, comparing, and presenting categorical data. Figure 2 shown students’ worksheet developed by the T1 based on the Table 2 (mapping cultural to PPDAC).

Student Worksheet

Subject : Mathematics
Topic : Data Presentation and Analysis
Grade : VI
Student Name : _____
Date : _____

Activity 1: Buying and Selling Simulation (Data Collection)
Imagine you are a seller and a buyer of traditional market snacks. Record the number of snacks that are "sold" in your group.

Snack Name	Times	Number Sold
Wajik		
Lemper		
Klepon		
Getuk		
Onde-onde		
Apem		
Nagasaki		
Serabi		

Activity 2: Presenting Data
Create a bar chart based on the data from Activity 1.

Activity 3: Data Analysis
Answer the following questions based on your bar chart.

- Which snack was sold the most?
How many were sold?
- Which snack was sold the least?
How many were sold?
- What is the difference between the highest and lowest number of snacks sold?
(Hint: subtract the smallest number from the largest number)
- Mention one other piece of information you can find from the bar chart!
(Example: snacks with the same quantity, or order from most to least)

Activity 4: Reflection on Local Wisdom
Answer the following questions based on your bar chart.

- What are the benefits of tables and bar charts in presenting data?
(Example: are they easier to read, compare, or understand?)
- How does the data in the bar chart help you understand information about snack sales?
(Example: identifying the most and least popular items)
- What do you know about traditional market snacks?
(Mention their characteristics or examples)
- Give examples of cultural values found in traditional market snacks!
(Example: togetherness, tradition, or use of natural ingredients)
- How can we preserve traditional market snacks?
(Example: buying them, introducing them to friends, or learning how to make them)

Figure 2. Students’ Worksheet Developed by T1

Students are required to systematically sort and compare their marketplace tokens, analyze emerging trends, and formally present their findings using bar charts (conclusion stage). This process facilitates a meaningful synthesis of mathematical concepts and cultural exploration. In T2 (G8), the problem stage was framed by the guiding question, “How do the geometric proportions of the Batik Kawung motif remain consistent across canvas sizes of different dimensions?”, which connected the repeating circular or oval units of the pattern to the derivation of formulas for the area and circumference of a circle as shown in Figure 3. In the plan stage, T2 established a measurement grid and asked students to select several Kawung units of different sizes and to plan how they would record each unit’s radius, perimeter, and area using rulers and string. During the data stage, students gathered continuous spatial and measurement data by tracing and measuring these units across multiple batik samples. The

analysis stage involved directly applying the circle-area and circumference formulas to the patterned units and calculating the dimensional ratios between units of different sizes, while the conclusion connected the mathematical results to the cultural significance of the Kawung motif, such as its association with self-control or purity in Javanese philosophy.

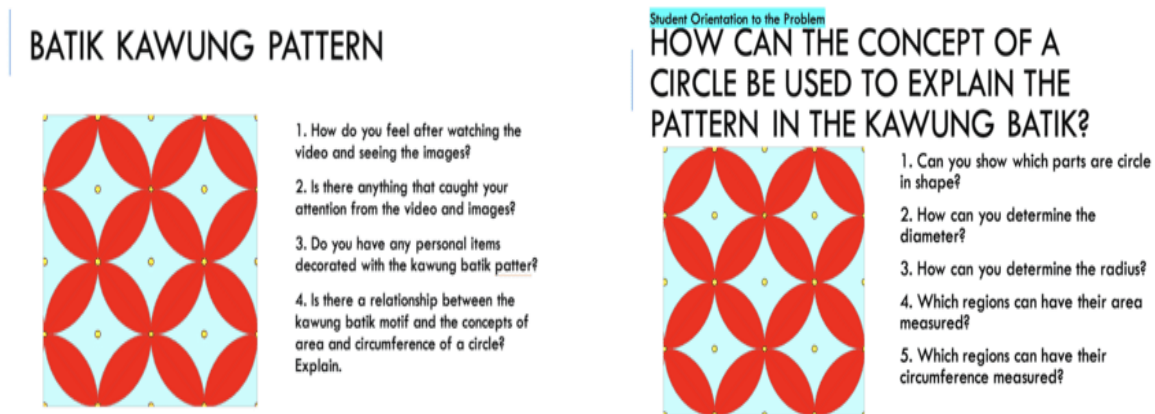


Figure 3. Learning Media Developed by T2

For T3 (G11), the entire PPDAC cycle was structured around the planting project: problem concerned the relationship between for example watering frequency, sunlight exposure and plant growth, plan specified the data-collection schedule, data consisted of longitudinal growth measurements, analysis involved constructing scatter plots and fitting linear regression models, and conclusion required students to interpret the regression coefficient in terms of the real growing conditions they had observed presented in Figure 4.

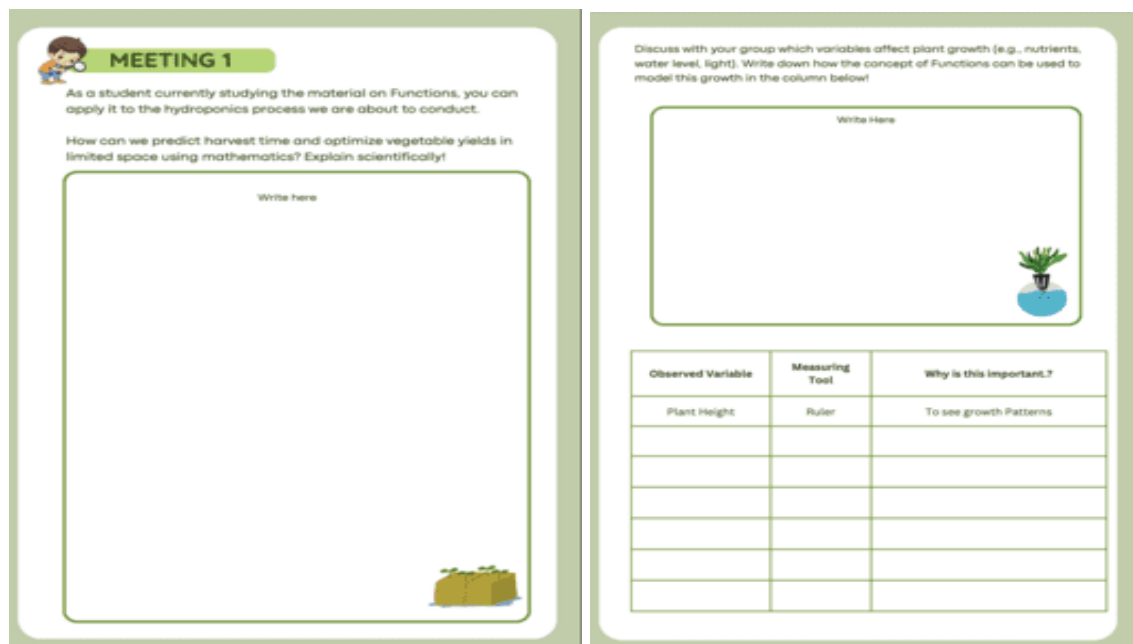


Figure 4. Students' Worksheet Developed by T3

This comparative mapping shows a developmental pattern consistent with the increasing statistical sophistication expected across grade levels: G6's PPDAC cycle center on descriptive, categorical representation; G8's PPDAC cycle bridged geometry and data through a single static structure; and G11's PPDAC cycle supported inferential, bivariate reasoning grounded in authentic, student-generated data.

TLM Development and Collaborative Co-Design

During the FGDs, draft TLM were reviewed monthly by Japanese and Indonesian lecturers' expertise. The FGDs aimed to align perspectives and enhance teachers' understanding of how local culture or contexts familiar to students can be effectively integrated into mathematics instruction. In the initial meeting, teachers were asked to prepare preliminary ideas or share experiences related to the use of local materials or contexts in teaching mathematics, particularly statistics, as well as other topics relevant to the local cultural context. The diverse backgrounds of the participating teachers were expected to provide broader perspectives on the potential for integrating local cultural contexts into mathematics education across various educational levels.

Feedback focused on the importance of the key questions posed by teachers, the clarity of statistical competencies for each grade level, the accuracy of the cultural information presented, and the feasibility of data collection within a single class period. The second meeting centered on reviewing lesson plans and instructional strategies across various mathematics topics and grade levels in different schools. Teachers presented plans for topics such as arithmetic sequences, hydroponics, and cultural studies, with particular emphasis on integrating mathematics, physics, and cultural elements into instruction. The discussion addressed practical aspects of lesson implementation, including data collection methods and challenges associated with real-world application.

The outcomes of discussions with experts, including lecturers and international partner lecturers, addressed concerns related to student engagement and emphasized the importance of clear objectives in lesson planning. The session concluded with a review of progress in developing lesson plans and highlighted the need for further refinement in the subsequent meeting, which would be the final session before implementation. These revisions demonstrate that the co-design workshops served as a dependability mechanism in the research process, providing an external check that reduced the risk of the TLM reflecting only individual teachers' interpretations of cultural-mathematical integration. This process increased the likelihood that the resulting materials were both mathematically sound and feasible for classroom implementation.

Classroom Implementation and Student Evaluation

Each TLM was implemented in the respective teacher's classroom (Grade 6, $n = 12$; Grade 8, $n = 25$; Grade 11, $n = 14$). Teacher reflection logs and classroom observations indicated that student engagement with culturally grounded tasks exceeded that observed during typical

statistics lessons, especially during the data-collection phase of the traditional snacks-sorting and planting activities. Engagement was assessed qualitatively through the observation protocol described earlier, which recorded indicators such as voluntary participation in data-collection tasks, the frequency and specificity of student questions, on-task time during small-group work, and the proportion of students completing worksheet tasks without direct teacher prompting; teachers additionally logged these same indicators in their reflection journals for the textbook-based statistics lessons they had taught in the preceding unit, and it was against this within-teacher baseline that the comparison between “typical” and culturally grounded lessons was made. We emphasize that the classroom implementation data reported in this section document teachers’ ability to design and enact culturally grounded TLM, and the resulting student engagement and task performance within a single lesson sequence; they do not constitute a systematic assessment of student mathematics learning outcomes (e.g., pre-post achievement gains), which would require a dedicated assessment design and is therefore outside the scope of the present study.

For example, in Grade 6 during the role-playing activity *Social Roles in Action*, observations indicated that the classroom environment transformed into a peer-led marketplace as shown in Figure 5. Students interacted directly while assuming specific roles such as Seller, Buyer, and Data Recorder. The teacher deliberately assigned these distinct roles to ensure that the Seller explained the background of the traditional food and to prevent any student from holding multiple responsibilities. Instead of working individually, students engaged in collaborative dialogue to complete the transaction. One student acted as the buyer and made selections, while another served as the recorder to manage the task. This collaborative approach ensured that information was systematically documented, organized, and prepared for subsequent learning activities.



Figure 5. Students in Action (Role Playing Activity)

The worksheet, provided by student A, offers empirical evidence of how an individual student interacts with the intended curriculum, assessment materials, and local cultural contexts at the immediate classroom level. G6 Student A’s work demonstrates an excellent step-by-step

conversion of a real-world experience into abstract mathematical structures through the worksheet tasks:

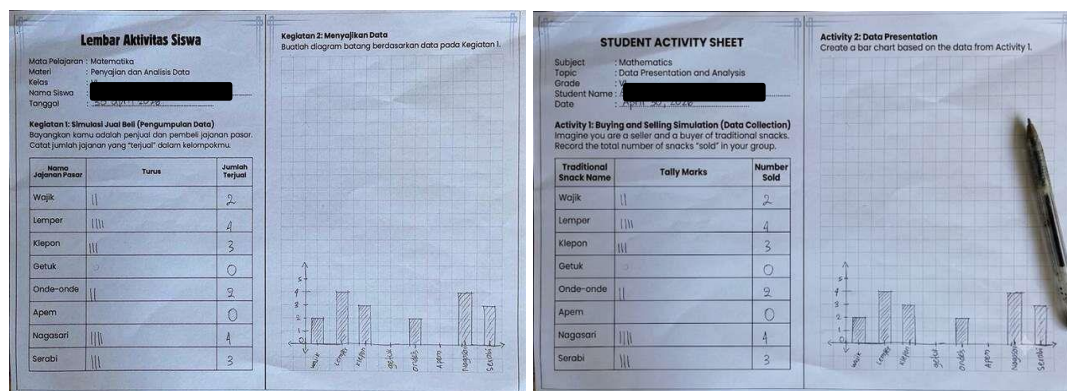


Figure 6. Student A's Work in Activity 1-2

In Activity 1 (Tallying and Frequency Data), she translates the classroom buying-and-selling simulation into raw statistical data, using a tally system (*turus*) to count totals, such as recording 4 tallies for *Lemper* and 0 for *Getuk* and *Apem*. In Activity 2 (Data Visualization Integration), she transforms her numerical table into a hand-drawn bar chart. Her chart uses appropriate vertical scaling (1 through 5) with spaces blank for snack zero spaces for *Getuk* with showcasing solid, self-directed, demonstrating data presentation principles presented in Figure 6.

In Activity 3 (Data Analysis), Student A uses the worksheet as an analytical tool to interpret her mathematical artefacts. She correctly identifies the most popular snacks (*Lemper* and *Nagasari*, each with 4 units) and the least popular snacks (*Getuk* and *Apem*, each with 0 units). Her completed worksheet responses serve as evidence of effective teacher-student engagement. In Activity 4, the classroom curriculum demonstrably encourages Student A to connect school mathematics with cultural knowledge from her home and community. She observes that using tables and bar charts makes data, such as “*Mudah dipahami dan mudah menghitung dengan cepat*” (easy to understand and easy to calculate quickly). Furthermore, she recognises mathematics as a means to analyze community purchasing patterns holistically, such as “*Saya bisa melihat jajanan antara paling banyak dan yang paling sedikit*” (I can see which snacks are the most common and which are the least common) (see Figure 7).

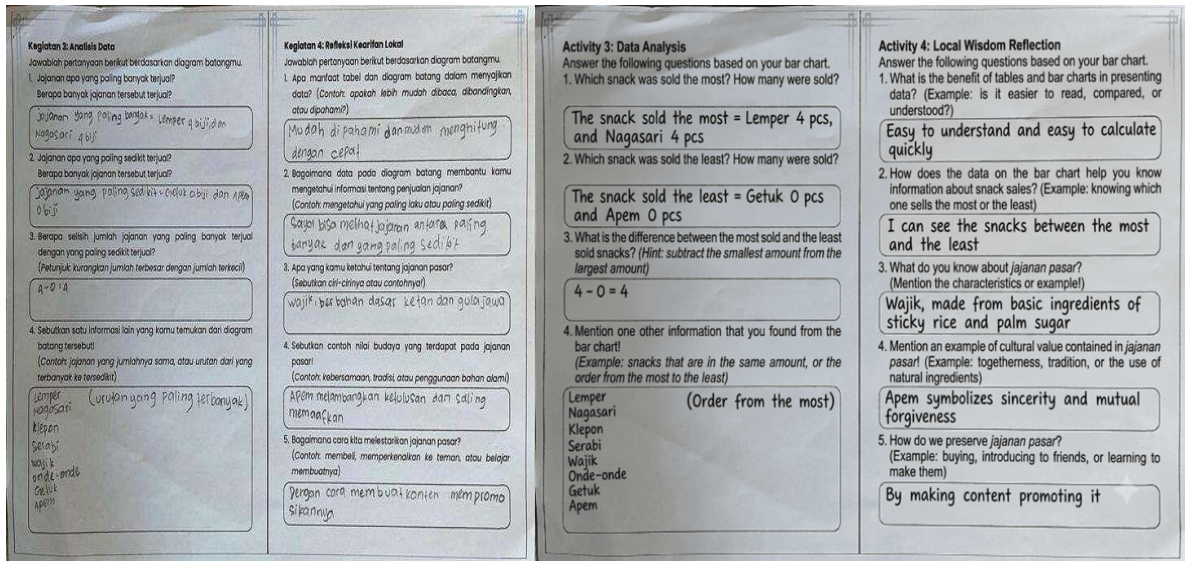


Figure 7. Student A's Work in Activity 3-4

Discussions

The findings directly address the study's objective of describing how mathematics teachers at three educational levels conceptualized, explored, and integrated local cultural elements into statistics' TLM. The four-question exploratory framework was analytically valuable because it decomposed what might otherwise appear as a single, intuitive act of incorporating culture into a mathematics lesson into four distinct cognitive-pedagogical moves: selecting a culturally relevant entry point (Q1), investigating that entry point through direct engagement with its cultural context (Q2), evaluating its mathematical legitimacy against curricular standards (Q3), and translating the retained content into a structured pedagogical sequence using the PPDAC model (Q4). This sequence was observed consistently across all three teachers, despite substantial differences in grade level, statistical topic, and type of cultural artefact. This consistency suggests that the framework captures an underlying pattern in teacher design cognition, rather than reflecting an artefact of any single case.

The findings support the proposition advanced in the introduction that *Furusato Kyoiku*'s emphasis on place-based (Mizobuchi, 2021), identity-anchored learning and PKJ's regional character-education mandate are not only compatible but also mutually reinforcing when applied to mathematics curriculum design (Dwijanagoro, et.al., 2023; Niswatun et.al., 2024; Istiharoh & Nurizka, 2025). *Furusato Kyoiku* accounts for teachers' motivation to begin with personally and locally meaningful entry points (Q1), while PKJ serves as the institutional legitimation that renders such choices pedagogically permissible within the formal curriculum. This was evident even in cases such as T2's batik-based lesson, where the connection to statistics or geometry was not explicitly prescribed by policy documents. The distinction between motivational and institutional roles has not, to the authors' knowledge, been clearly articulated in prior ethnomathematics literature reviewed in the introduction (Prahmana & D'Ambrosio, 2020), which typically document the mathematical content of cultural artefacts

without examining the institutional or motivational conditions influencing teachers' adoption of these artefacts.

This distinction constitutes a distinct contribution of the present study whereas prior ethnomathematics scholarship (e.g., Rosa & Orey, 2011; Alangui, 2010; Prahmana & D'Ambrosio, 2020) has primarily catalogued the mathematics embedded within cultural artefacts, the present study contributes an operational account of how teachers themselves move from cultural noticing to classroom-ready statistics TLM, formalized as the four-question exploratory sequence mapped onto PPDAC. This contribution is methodological rather than purely descriptive, and it is transferable beyond the Yogyakarta setting: any context in which a place-based educational philosophy (of which *Furusato Kyoiku* is one example) coexists with a formal, locally mandated character- or content-education policy (of which PKJ is one example) could, in principle, adopt the same motivational-institutional-procedural structure identified here to support teachers in designing culturally grounded mathematics instruction. This transferability claim is, at this stage, a theoretical hypothesis generated by a single-site, three-teacher study rather than a demonstrated finding; it would need to be tested empirically in other contexts pairing a place-based educational philosophy with a local, formal education policy before it can be treated as established.

The comparative PPDAC mapping presented in Table 2 illustrates that PPDAC functioned not merely as an analytical lens for the researcher but as a genuine design scaffold that teachers implicitly or explicitly used to convert open-ended cultural exploration into a bounded, teachable sequence. This is consistent with Wild and Pfannkuch's (1999) original conception of PPDAC as a model of the statistical investigation cycle, extended here to a new application: structuring culturally sourced problems rather than pre-given datasets. The developmental progression observed across grade levels (categorical $\rightarrow$ geometric-static $\rightarrow$ bivariate-inferential) suggests PPDAC's flexibility as a scaffold that can accommodate increasing statistical complexity while preserving a consistent underlying design logic a useful property for schools seeking to implement culturally responsive statistics instruction coherently across grade bands rather than as isolated, grade-specific interventions. It is important to be precise about what this evidence does and does not show.

The primary evidence for PPDAC functioning as a design scaffold is the consistency with which all three teachers' materials could be mapped onto its five stages despite differing grade levels, cultural artefacts, and statistical topics (see Table 2); this structural consistency is suggestive of PPDAC's organizing influence, but on its own it demonstrates a good classificatory fit rather than directly proving that teachers' in-the-moment design thinking was itself transformed by PPDAC, since this mapping was applied by the researchers to the completed materials rather than tracked as it unfolded during design. Establishing that stronger, causal claim would require process-tracing evidence, for example comparing early and late drafts of each TLM or documenting teachers' explicit use of PPDAC terminology during the FGDs and is a natural extension for future research building on the descriptive account offered here. Relatedly, we frame PPDAC's apparent usefulness for coherent, cross-grade implementation as a promising possibility rather than a settled conclusion, since it rests on a

cross-sectional comparison of three single cases rather than a systematic evaluation of coherence across grade bands within one school or district.

The Q3 filtering process, in which teachers actively discarded culturally rich but mathematically ambiguous content, addresses a tension frequently noted in the ethnomathematics literature: the risk that cultural integration, if applied uncritically, either dilutes mathematical rigor or reduces cultural content to superficial decoration (as raised in the introduction). The evidence here suggests a middle path is achievable in practice: teachers did not treat cultural authenticity and mathematical structure as competing demands to be traded off, but as joint constraints that jointly determined which cultural observations were retained.

On the depth of cultural integration achieved, the strongest available evidence comes from the classroom implementation illustrations rather than from teachers' design intentions alone. For example, Student A's own reflection that the lesson helped her see "*jajanan antara paling banyak dan yang paling sedikit*" (snacks ranging from the most frequent to the least frequent), as shown in Classroom Implementation and Student Evaluation phase, shows a student connecting the statistical procedure directly to a culturally familiar practice of community purchasing, rather than merely manipulating a cultural object as inert data. We note, however, that this evidence remains illustrative, drawn from a small number of worksheet and interview excerpts across three classrooms, rather than a systematic analysis of the extent to which students in each class engaged with the underlying cultural meanings (such as the philosophical associations of the Kawung motif or the social role-structure of the traditional market) as opposed to their surface mathematical features; a structured comparison of student artefacts against a depth-of-cultural-engagement rubric would be needed to substantiate a stronger claim and is left for future work.

Conclusion

These findings have several practical implications. First, professional development programs for teachers that aim to support culturally responsive statistics teaching could directly train teachers to use the four-question exploratory sequence as a structured design tool, instead of relying on individual initiative for cultural integration. Second, the co-design and focus group discussion process helped identify feasibility and accuracy issues before classroom use. This suggests that developing culturally integrated teaching and learning materials should be supported by structured peer review at the institutional level, rather than leaving teachers to work alone. Third, the different but complementary roles of *Furusato Kyoiku* and PKJ seen in this study suggest that regional education policies like PKJ could offer clearer guidance on how character-education goals connect to specific subject design practices, since teachers here mostly had to make those connections themselves.

On the other hands, there are some limitations to keep in mind when considering these findings. First, the study involved only three teachers, which limits how much the results can be applied to other educators or different academic settings. Second, since the research took place at just one site in Yogyakarta, the results mainly reflect the local social and cultural

context. This means the findings may not apply directly to other cultural settings in the wider Nusantara region. Finally, the short period of classroom implementation made it hard to observe long-term changes in teaching practices or lasting effects on student learning.

Finally, to address these limitations, future research could take several steps. Researchers might include more participants and cover a wider range of Nusantara cultural settings to improve cross-cultural validity and transferability. Future studies could also use a mixed-methods approach, combining teachers' qualitative insights with student performance data. Comparing results from urban and rural, or public and private schools, could help identify strategies that work best in different contexts.

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Conflicts of Interest

The authors declare that no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely by the authors.

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