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Integrating traditional food and technology in statistical learning: A learning trajectory

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Abstract

In the 21st century, understanding variability and developing statistical investigation skills are crucial for enhancing students' data literacy. However, these essential skills are often overlooked, limiting students' growth in numeracy whereby statistical problems are frequently disconnected from real-world or cultural contexts, reducing student engagement. To address this issue, this study integrates the culturally relevant context of *Lemang Batok*, which enhances students' ability to understand, apply, and analyze data through appropriate statistical concepts. The research uses an ethno-flipped classroom model that promotes flexible, collaborative learning, aiming to design a learning trajectory for teaching descriptive statistics in this context to improve numeracy skills. Utilizing design research methodology, specifically a validation study, the research followed three phases: preliminary design, experimental design, and retrospective analysis. The subjects were junior high school students from Medan and Binjai Cities, North Sumatera-Indonesia. The results indicated that the learning trajectory developed through tiered discussions significantly improved students' numeracy skills in descriptive statistics, as evidenced by increased critical thinking and enhanced abilities to analyze variability.

Keywords: Descriptive Statistics Learning, Design Research, Ethno-Flipped Classroom Model, Learning Trajectory, *Lemang Batok* Context

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The development of students' numeracy competence refers to the 21st Century numeracy model, which focuses on the application of several contexts that are close to the students' world, social, cultural, environmental, science, and mathematics science, namely personal, sociocultural, and scientific (Goos et al., 2012). Numeracy skills are also closely related to cognitive levels that refer to the International Association for the Evaluation of Educational Achievement (IEA), namely knowing (level 1), applying (level 2), and reasoning (level 3). These three levels are related to three numeracy-related problem-solving processes: formulating, using, and interpreting (Mullis & Martin, 2017). Numeracy covers several domains, including data exploration and analysis, making its development essential in school mathematics curricula (OECD, 2012). Skills in data analysis are related to scientific trends and phenomena presented in the form of statistics. Although proficiency in data analysis and statistics is often associated with secondary school, instruction on these concepts should begin in the primary grades to build a strong foundation for students to access complex ideas later.

The two major ideas or basic concepts in strengthening data analysis and statistical proficiency are variability and statistical investigation (Bargagliotti et al., 2020). Variability refers to the range of possible answers that may emerge during the data analysis process conducted by students. The variability that arises will invite students to conduct statistical investigations that direct them to carry out various statistical activities related to data collection activities, data presentation, data analysis processes, and interpretation and justification of the claims obtained. The processes of reasoning, decision-making, problem solving, data management, and interpretation of analysis results are built on quantitative and mathematical acumen (Marshman & Dunn, 2024). Therefore, the need for data analysis and statistical skills is a concern in school mathematics teaching to support numeracy.

Numeracy is used in Australia (Education Council, 2014) and Ireland (Department of Education and Skills, 2011) in the national education curriculum. In Australia and Ireland, numeracy is recognized as an essential general competency to be fostered across all subjects within the school curriculum. This recognition has prompted the development of curriculum frameworks aimed at integrating cross-cutting competencies with the content of individual subjects (Goos & O'Sullivan, 2018). While the term mathematical literacy is used by South Africa (Department of Basic Education, 2011) and Japan (Namikawa, 2018). In South Africa, the emphasis on "mathematics for all' and "mathematics by all' supports a differentiated curriculum that includes a separate subject called Mathematical Literacy. While this approach ensures that all secondary students engage with mathematics in some form, it risks relegating mathematical literacy to a lower status than traditional mathematics. In Japan, concerns about student performance on international assessments have prompted the integration of elements of mathematical literacy, as outlined in the PISA framework, into the standard mathematics curriculum (Goos & O'Sullivan, 2023).

Moreover, the need for numeracy skills requires teachers to facilitate student learning. The facilitation that teachers do by designing lessons that give students the freedom (Sjöblom et al., 2023) to explore numeracy-related problems, especially in the context of data and statistics, creates a variety of variability in the critical thinking process of students (Tiruneh et al., 2018), providing flexibility for students to conduct joint investigations, and collaboration (Reinius et al., 2021). It also provides teachers with insights or guidelines for anticipating students' evolving thoughts throughout the learning process, supporting a "teacher as designer" approach to preparing instructional experiences (Hendroanto et al., 2018; Zalavra et al., 2023). As a result, learning design is a critical factor in providing instruction that meets the diverse learning needs of students.

In student learning activity in classroom context, lesson designs can be presented through a hypothetical learning trajectory to enhance students' numeracy skills, thereby positively impacting their critical thinking and problem-solving abilities. Developing the hypothetical learning trajectories enables teachers to address the diverse learning needs of each student through effective instructional practices (Tomlinson, 2017). The Hypothetical Learning Trajectory (HLT) consists of three important components: meaningful learning objectives, a set of tasks designed to achieve those objectives (learning activities), and predictions about students' thinking and learning processes (hypothetical learning outcomes). The expected learning objectives are pursued through structured activities that guide students in engaging with real-world mathematical tasks to achieve these goals (Gravemeijer, 2020; Simon et al., 2018). The HLT approach is not outcome-focused; rather, it emphasizes the process by which students rediscover mathematical concepts, progressing through different levels of the model (Fauzan et al., 2018). These levels—situational, referential (or model-of), general (model-for), and formal knowledge—represent observable student actions during the learning process. The situational level fosters basic understanding, while the referential or model-of level employs models and strategies to illustrate the context of the task (Siemon, 2021).

The implementation of HLT is expected to provide flexibility supported by technology integration (Miller, 2018), and meaningfulness in learning (Prahmana, 2022; Prahmana & Istiandaru, 2021). The application of the ethno-flipped classroom model presents all three components simultaneously in one learning cycle (Ramadhani et al., 2021; Ramadhani, Syahputra, & Simamora, 2023b). The ethno-flipped classroom model integrates the ethnomathematics approach presented in the flipped classroom model. The flipped classroom is a learning model that emphasizes active student engagement (Shraddha et al., 2020), and incorporates a combination of FLIPP components (Flexible Environment, Learning Culture, Intentional Content, and Professional Educator) and PED components (Progressive Activities, Engaging Experiences, and Diversified Platforms) (Chao et al., 2015). This model offers learning flexibility through two phases: the out-of-class phase and the in-class phase (Cevikbas & Kaiser, 2020; Latorre-Cosculluela et al., 2021). Ethnomathematics itself is known as a learning approach that makes it easy for students to investigate data derived from phenomena that occur in their lives and helps them develop their mathematical reasoning skills and creativity (D'Ambrosio, 2017; Rosa, 2017; Hidayati & Prahmana, 2022; Rosa & Orey, 2022). The application of the ethno-flipped classroom model, in addition to using cultural context (i.e., *Lemang Batok*, a traditional food from North Sumatra, Indonesia, made from glutinous rice mixed with coconut milk with cylindrical shape), also incorporates technology to support both out-of-class and in-class learning phases (Prahmana et al., 2021; Baig & Yadegaridehkordi, 2023).

The integration of local culture into learning is in accordance with Law No. 5/2017 (Law of the Republic of Indonesia, 2017). Referring to this, the problem-solving approach used was the design of a numeracy learning trajectory focused on learning data in descriptive statistics with a local cultural context through the ethno-flipped classroom model. Learning that applies the context of ethnomathematics as a concrete medium for presenting data and statistical concepts provides an opportunity for variability to emerge during the learning process. Statistical investigation activities can also be conducted flexibly through the tiered collaboration offered in the ethno-flipped classroom model. The triggering question given by the teacher through the application of the ethnomathematics context such as "How long is the bamboo used in making *Lemang Batok*?", then the variability of the responses given by students will appear, thus allowing the presence of additional questions given by students, such as "What is the average length of bamboo in making *Lemang Batok*?" or "What is the average length of bamboo *Lemang Batok* if the amount of bamboo used when cooking is reduced or increased?". Further reactions are likely to be present in students' responses after collecting data, such as "Does the data on the length of bamboo obtained match the information presented? Or should the size of the banana leaves poking out of the top of the bamboo be added?" or critical questions such as "Is the average value of bamboo length obtained from the number of bamboos that have the same length?". The variability that is present shows the students' critical and analytical thinking processes obtained from giving numerical and statistical problems that are close to the students' social life. In this case, contextual situations play an important role in determining mathematical procedures, where they can be indicated through aspects of personal life, the workplace, carrying out civic responsibilities, and even scientific issues (Kohar et al., 2022).

Over the past five years, several researchers have documented studies on integrating socio-cultural contexts-especially traditional food into mathematics learning, one of them is *Burongko Bugis* cakes for teaching quadrilaterals (Aras et al., 2022). However, despite these advances, research on socio-cultural contexts in descriptive statistics has not yet emphasized the *Lemang Batok* context. In other hand, Ramadhani et al. (2022) previously designed a descriptive statistics learning trajectory using the *Lemang Batok* context but did not focus on numeracy skills, cognitive levels, or implementing the ethno-flipped classroom model. This study redeveloped the learning trajectory by concentrating on students' numeracy skills in the data and uncertainty domain, adjusting to their cognitive levels, and incorporating the ethno-flipped classroom model. Developed by Ramadhani et al. (2023a), this model integrates the ethnomathematics approach with flipped classroom techniques. Other studies, such as those by Sholihah and Isnarto (2023) on mathematical representation, and Meyllinda et al. (2023) on creative thinking, have also applied the ethno-flipped classroom model, demonstrating its effectiveness in enhancing mathematical skills. For numeracy, various studies have used ethnomathematics, such as Tampubolon et al. (2023) who used the *Congklak* game for the number domain, and Mukwambo et al. (2023) who applied the *Silozi* language to the geometry domain. The results of these studies indicate that the ethnomathematics approach, the ethno-flipped classroom model, and socio-cultural context can positively impact mathematics learning, numeracy skills, and student engagement. Nonetheless, no research to date has integrated the ethnomathematics approach (using traditional food), the ethno-flipped classroom model, technology, and statistics learning in the development of an HLT.

This study identifies significant potential in developing a data and statistics learning trajectory, incorporating an ethno-flipped classroom model within the context of *Lemang Batok*, grounded in the analysis of various theoretical frameworks. The learning design emphasizes flexibility, meaningful engagement, and collaboration to introduce innovative approaches to teaching variability and statistical investigation. By contextualizing *Lemang Batok* within data and statistical measures, the study further enhances the creation of relevant and effective learning models. This article outlines the process of designing a learning trajectory for data and statistics using the *Lemang Batok* context, applying the ethno-flipped classroom model to support students in understanding, applying, and reasoning through numeracy challenges.

METHODS

Design research is the research method used in this study because it is in line with the research objectives of developing a sequence of activities and understanding an empirical understanding of how learning works. The research subjects were junior high school students with age ranging from 12–15-year-old from Binjai and Medan Cities. Participants were selected based on their cultural backgrounds and experiences relevant to the context of *Lemang Batok*, a cultural element familiar to Malay communities residing in these cities. For the pilot experiment, 15 students were divided into three groups based on initial math ability (high, medium, and low), with each group containing 5 students and gender variation. The teaching experiment included 153 students, also with gender diversity. The type of design research used in this research is a validation study that produces a learning trajectory (Gravemeijer & Cobb, 2006). The development of a learning design with validation study type is conducted in three stages: preliminary design, experimental design, and retrospective analysis (Bakker, 2019; Plomp, 2013).

Preliminary Design

At this stage, the formulation of the hypothetical learning trajectory was refined and enhanced during the experiment. Key activities included analyzing the objectives, specifically fostering students' understanding of numeracy within the data domain of descriptive statistics by integrating the *Lemang Batok* context through the ethno-flipped classroom model; assessing the initial conditions of the study, namely students' numeracy skills; discussing conjectures related to the Local Instructional Theory (LIT) developed; defining class characteristics and the teacher's role in numeracy learning with the *Lemang Batok* context via the ethno-flipped classroom model; and establishing the theoretical objectives to be achieved through this research. The HLT research ultimately produces the LIT that can be adapted to fit the characteristics of students.

The results of the preliminary design stage are the design of learning activities to achieve the learning objectives arranged at each stage of learning and the conjecture (conjecture) of the trajectory of student activities in achieving learning objectives. The preliminary design of HLT and numeracy worksheets with *Lemang Batok* context were then validated content-wise and construct-wise using expert judgment techniques and analyzed using the Many-Facet Rasch Model analysis. Validation activities were conducted by ten experts in the field of Mathematics Education, selected based on their educational backgrounds, professional experience, and research expertise. The criteria for validity using MFRM analysis are based on mean-square infit values (Infit MNSQ), mean-square outfit statistics (Outfit MNSQ), standardized infit statistics (Infit ZSTD), and standardized outfit statistics (Outfit ZSTD). The expected range for the mean-square infit and outfit statistics (Infit and Outfit MNSQ) is from 0.5 to 1.5. The infit and outfit ZSTD values for a facet element are considered acceptable if they fall between -2 and +2. A significantly negative ZSTD value (ZSTD ≤ -2.0) indicates data overfit, while a significantly positive ZSTD value (ZSTD ≥ 2.0) indicates data misfit (Arnold et al., 2018; Boone et al., 2014) Reliability values above 0.67 are regarded as acceptable (Fisher, 2007).

The initial design products of the HLT and numeracy worksheets with the *Lemang Batok* context that had been valid and reliable based on expert judgment were then refined in the design experiment stage. The data learning conjecture in descriptive statistics on average value material using the *Lemang Batok* context is presented in Table 1.

Table 1. Conjecture of descriptive statistics learning using *Lemang Batok* context

Stage	Activity Description	Conjectures
Activity based on experience (Informal)	Activity 1a: Collecting *Lemang Batok* Bamboo (Level 1-Understanding) Collect data information obtained from the video of *Lemang Batok* making process (https://www.youtube.com/watch?v=be4I5gT-iq0)	1. Students are able to understand the size of bamboo in *Lemang Batok* and can describe it well and clearly. 2. Students have not been able to understand the size of bamboo in *Lemang Batok* and have not been able to describe it well and clearly. 3. Students have realized that by understanding the size of the bamboo in *Lemang Batok*, students have used the concept of statistical data size on random data.
Linking Activities (Model of)	Activity 1b: Collecting *Lemang Batok* Bamboo (Level 1: Understanding) Sort the length of bamboo used in making *Lemang Batok* using a statistically randomized data collection context.	1. Students can collect data on the length of bamboo used in making *Lemang Batok* and sort them from the shortest to the longest correctly and precisely. 2. Students are able to collect data on the length of bamboo used in making *Lemang Batok* but are not yet able to sort it from the shortest to the longest correctly and appropriately.

Stage	Activity Description	Conjectures
		3. Students have not been able to collect data on the length of bamboo used in making *Lemang Batok* and have not sorted it from shortest to longest correctly.
Linking Activities (Model for)	Activity 2: Arranging *Lemang Batok* Bamboo (Level 2: Applying) Use data sorted from shortest to longest to determine the average length of bamboo in the context of descriptive statistics.	1. Students can determine the number of sorted bamboo length data from the *Lemang Batok* making process correctly and precisely. 2. Students are able to determine the amount of bamboo length data that has been sorted from the *Lemang Batok* manufacturing process but have not been able to apply the concept of average value to descriptive statistics correctly and appropriately. 3. Students do not determine the amount of bamboo length data that has been sorted from the *Lemang Batok* manufacturing process and have not been able to apply the concept of average value to descriptive statistics correctly and appropriately.
Formal Knowledge	Activity 3: Cooking *Lemang Batok* (Level 3: Reasoning) Estimate and compare the average length of bamboo in *Lemang Batok* with the increase in the number of bamboos.	1. Students can estimate and approximate the average length of bamboo in *Lemang Batok* by increasing the number of bamboo properly. 2. Students can estimate and approximate the average length of bamboo in *Lemang Batok* with the addition of the number of bamboo well, but not correct. 3. Students cannot estimate the average length of bamboo in *Lemang Batok* with the addition of the number of bamboo well and correctly.

Table 1 presents students' conjectures that were organized according to the designed learning activities. The *Lemang Batok* context was used in each numeracy-data problem in the designed descriptive statistics. The learning activities have also been adjusted to the three levels of numeracy skills, namely level 1 (understanding), level 2 (application), and level 3 (reasoning), and adjusted to the learning objectives to be achieved. The conjectures in Table 1 pertain to the mathematization process grounded in Freudenthal's Realistic Mathematics Education (RME) approach (Freudenthal, 2002). This approach is applied in formulating these conjectures as the basis for designing the HLT, where the learning trajectory comprises a series of activities (contextual problem-solving tasks) that support students in rediscovering formal mathematical concepts by leveraging their informal knowledge. Learning activities incorporate both horizontal and vertical mathematization processes. In designing the HLT, it is essential to consider the core principles of Realistic Mathematics Education (RME), which include applying context, using models to support progressive mathematization, utilizing students' constructions, fostering interactivity, and building connections (Swidan, 2020).

Design Experiment

The HLT and numeracy worksheets designed during the preliminary design stage were tested. This trial aimed to explore and hypothesize students' strategies and thinking in relation to numeracy problems related to the data domain in learning descriptive statistics in the context of *Lemang Batok* by applying the ethno-flipped classroom model. The stages of the design experiment were divided into two cycles: the pilot experiment (first cycle) and the teaching experiment (second cycle) (Bakker, 2019). The first cycle, namely the pilot experiment, was conducted on small groups of students, namely, five students in each Initial Mathematics Ability (IMA) group (five students in the high IMA group, five students in the medium IMA group, and five students in the low IMA group). At this stage, a series of learning activities designed in the HLT were applied to the learning process. In addition, the researchers observed and analyzed the learning activities that occurred during the learning process according to the HLT design and syntax of the ethno-flipped classroom model. The syntax of the ethno-flipped classroom model is illustrated in Figure 1.

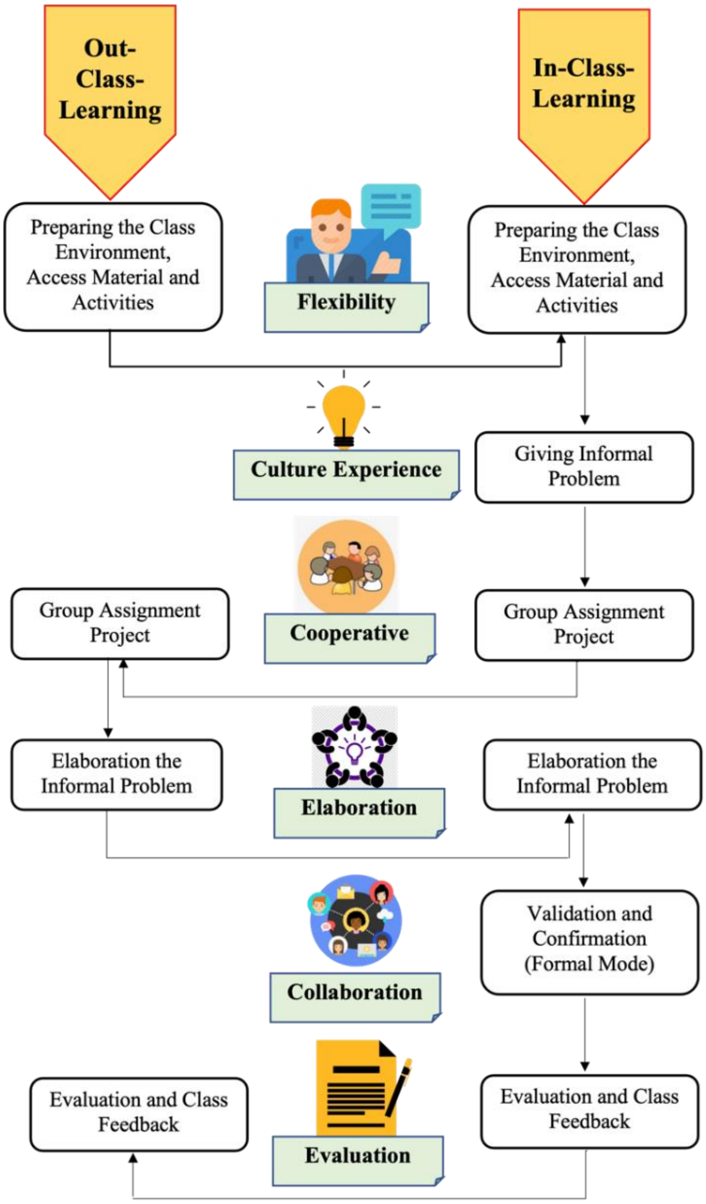


Figure 1. Syntax of the Ethno-Flipped Classroom model (Ramadhani et al., 2023a)

The results of the pilot experiment were used to evaluate and improve the learning trajectory. The evaluation results were then applied in the second cycle of the teaching experiment. The second cycle was conducted on a wider group of students with the aim of implementing the learning trajectory that had been evaluated and revised, as well as obtaining data on the numeracy skills of students who were taught using the HLT design developed in accordance with the learning objectives to be achieved. The implementation of learning activities used numeracy problems with data domains in descriptive statistics based on the *Lemang Batok* context and applied the syntax of the ethno-flipped classroom model.

Retrospective Analysis

After the teaching experiment, learning activity data were obtained and analyzed retrospectively. All data collected at the design experiment stage were analyzed by comparing the conjecture and HLT with the results of the application of the learning trajectory that had been carried out at the design experiment stage. The results obtained from the retrospective analysis process provided a description of the learning trajectory and students' numeracy skills in the data domain in descriptive statistics using the context of *Lemang Batok*.

RESULTS AND DISCUSSION

This study produced a descriptive statistics learning trajectory design using the context of *Lemang Batok*. Data learning is a part of the domain of students' numeracy skills. The data learning applied in the learning trajectory design in this study is the average value of the data centering measure material. Activities in the design of data learning trajectories in descriptive statistics are divided into three activities that are differentiated based on the level of numeracy skills: level 1 (understanding), level 2 (application), and level 3 (reasoning). The learning activities designed not only use the context of *Lemang Batok* but also the syntax flow of the ethno-flipped classroom model. The first data-learning activity in descriptive statistics was the *Lemang Batok* Bamboo Gathering Activity. Learning continues by doing the second activity, namely, arranging *Lemang Batok* bamboo. Learning ends with the third activity, namely the *Lemang Batok* Cooking Activity. Details of the results of the development of learning trajectory design through the design research method-type validation study are explained in stages as follows.

Preliminary Design (Preparation and Design Phase)

Before the learning trajectory design was developed, the researcher conducted an observation and literature study to determine the learning objectives to be achieved and the ethnomathematics context to be used. The observation process and literature study were conducted together with the teacher to obtain the initial condition of students' numeracy skills. The results of the observation activities found that students had not reached the application and reasoning levels in the learning data in descriptive statistics. The results of the data learning test in descriptive statistics showed that as many as 48% of the students were unable to apply the concept of average value, and as many as 52% of the students had difficulty analyzing, integrating information, concluding, and providing justification to support the results of the reasoning process. The observation findings are also in line with the results of the analysis conducted by researchers and teachers based on the results of the 2024 Education Report Card. The results of the analysis of the Education Report Card show that students' numeracy skills in the data domain in descriptive statistics decreased by 1.78%, and only 43.59% of students reached moderate ability (Ministry of Education, 2023). The observation process also shows findings from the teacher's perspective, where the teacher has not applied the ethnomathematics context as part of the contextualization process of the average value concept. However, the teacher already has good instructional skills by implementing collaborative activities between students and using learning media to support active and student-centered learning. Figure 2 presents the data-learning process using descriptive statistics conducted by the teacher.

Figure 2. Learning observation activities data in descriptive statistics at the preliminary design stage

The teacher facilitates data learning in descriptive statistics through collaborative activities between students and applies flat building media as contextual media to obtain a variety of data sizes as shown in Figure 2. The observation results show that students are enthusiastic about learning, but the teacher still provides assistance to students because they have difficulty using the concept of average value and providing justification for the results of measurements and calculations made. After the observation process was carried out, researchers and teachers jointly conducted a literature study to determine the ethnomathematics context used. The results of the literature study showed that the characteristics of the students and the surrounding environment of Binjai and Medan Cities were close to the context of *Lemang Batok*. *Lemang Batok* is also a dish that is routinely served at traditional activities of the Malay Tribe, as well as celebrations of religious holidays. Therefore, researchers and teachers agreed to use the context of *Lemang Batok* in the design of the data-learning trajectory in descriptive statistics.

Based on the results of observations and literature studies, researchers and teachers agreed to focus on the data domain in descriptive statistics to improve students' numeracy skills and use *Lemang Batok* as a medium for student contextualization. Therefore, the learning objectives to be achieved are also adjusted to the level of numeracy skills, such as students can collect data to answer questions through numeracy problems in the context of *Lemang Batok* (level 1-understanding), students can determine and interpret the mean of numeracy problems in the context of *Lemang Batok* (level 2-application), and students can analyze and investigate possible changes in the central measurement (mean) due to changes in data.

The preliminary design stage is closed by conducting discussions with teachers related to the conjecture that becomes the basis of the design of the learning trajectory of data in descriptive statistics using the context of *Lemang Batok* and determining the learning model to be used. Data from the initial observation activities were used as the basis for determining the conjecture and learning model to be used. The observation results show that the learning process requires additional time so that all activities can be run effectively and smoothly. Furthermore, flexibility in learning is also needed so that students can determine the cognitive load of each student, so that they can prepare themselves for participating in learning activities prepared by the teacher. Therefore, the ethno-flipped classroom model was chosen for application as part of the data-learning process in descriptive statistics. The implementation of the ethno-flipped classroom model is also supported by technological integration to facilitate learning flexibility. The technology integration used is the Padi Kapas application that has been developed previously (https://apkcombo.com/id/padi-kapas/padikapas.smp14/).

The Padi Kapas platform is an Android-based educational tool designed to support flexible and meaningful learning. It offers several features, including a student attendance tracker, learning modules, assignment submission, and a literacy section. This platform enables students to access instructional materials in advance, aligning with the ethno-flipped classroom model, which emphasizes preparing the learning environment, accessing resources, and participating in activities. Accessing materials before class helps students manage cognitive load, identify individual learning needs, and effectively plan their learning progress (Skulmowski & Xu, 2022). As described at the beginning of the section, several activities were designed based on the hypothesized learning trajectory and students' thought processes. This series of learning activities was divided into three activities that were completed in three meetings. Figure 3 presents the flow of the learning trajectories developed for data learning in terms of descriptive statistics, specifically the mean.

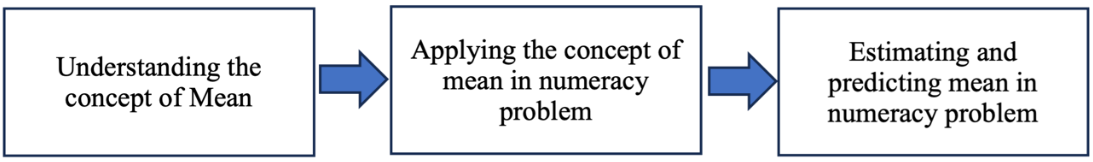


Figure 3. Learning trajectory descriptive statistical learning

Furthermore, the next stage is to compile data learning procedures in descriptive statistics in the context of *Lemang Batok* using the syntax of the ethno-flipped classroom model. The learning procedure designed is adjusted to the syntax of the ethno-flipped classroom model, which is presented in two learning stages, namely the out-class learning stage cycle and the in-class learning stage. The entire syntax of the ethno-flipped classroom model was included in the two learning stages. This shows that flexibility of learning facilitates students' learning needs according to their learning abilities. Table 2 presents the data-learning procedure in terms of descriptive statistics using the ethno-flipped classroom model.

Table 2. Data learning procedures in descriptive statistics using the Ethno-Flipped Classroom model

Syntax of Ethno-Flipped Classroom Model	Learning Stage	
	Out-Class Learning	**In-Class Learning**
Preparing the Class Environment, Access Material, and Activities	Teacher Activities: The teacher prepares a video of the process of making *Lemang Batok* which is used as a triggering question and initial apperception related to the learning that will be carried out. The video is uploaded to the Padi Kapas application and provides an explanation of the learning objectives to be achieved	Teacher Activities: The teacher again invites the students to watch the video of *Lemang Batok* making process and invites the students to convey the information obtained from the video of *Lemang Batok* making process. The teacher asks student

Syntax of Ethno-Flipped Classroom Model	Learning Stage	
	Out-Class Learning	In-Class Learning
	(https://www.youtube.com/watch?v=be4I5gT-iq0) Student Activities: Students join the Padi Kapas application and watch a video related to the process of making *Lemang Batok*. Students are also directed to gather information contained in the video. Students also learn the learning objectives to be achieved (Activity 1a-Level 1: Understanding).	representatives to explain the process of making *Lemang Batok*. Student Activities: Students watch the video of *Lemang Batok* making process together and convey the information obtained from the video of *Lemang Batok* making process. Student representatives also explain the process of making *Lemang Batok* (Activity 1a-Level 1: Understanding).
Giving Informal Problem		Teacher Activities: The teacher gives one informal problem using the context of *Lemang Batok* through the data learning worksheet in descriptive statistics. Student Activities: Students pay attention to the *Lemang Batok* context information problem presented by the teacher on the data learning worksheet in descriptive statistics (Activity 1b-Level 1: Understanding).
Group Assignment Project	Teacher Activities: The teacher again provides directions through the Padi Kapas application for students to conduct further discussions related to informal data problem solving in descriptive statistics with the context of *Lemang Batok*. The teacher directs the students to write down the things that are not understood to be discussed later in the in-class learning session. Student Activities: Students continue the discussion and collaboration in their respective study groups by utilizing the Padi Kapas	Teacher Activities: The teacher forms students' study groups according to their ability levels (based on the initial observation test scores of numeracy skills). The teacher directs students to collaborate with each other in solving informal problems related to data in descriptive statistics with the context of *Lemang Batok*. Student Activities: Students collaborate in learning groups according to their ability level. All group members

Syntax of Ethno-Flipped Classroom Model	Learning Stage	
	Out-Class Learning	**In-Class Learning**
	application. Students also write down things that are not understood from informal data problems in descriptive statistics with the context of *Lemang Batok* obtained during the discussion session (Activity 2-Level 2: Applying).	participate in solving informal problems related to data in descriptive statistics with the context of *Lemang Batok* (Activity 2-Level 2: Applying).
		Teacher Activities: The teacher invites students to continue the discussion through a tiered discussion activity. Tiered discussion is done by sending students from low ability study groups to discuss with medium ability student groups. The same thing is also done by low and medium ability student groups conducting further discussions with high ability student groups. The teacher's role is to facilitate students in the tiered discussion process and bridge students from low and medium ability groups to discuss with high ability student groups. Student Activities: Students conduct further discussion through a tiered discussion activity (Activity 3-Level 3: Reasoning).
Elaboration the Informal Problem	Teacher Activities: The teacher facilitates students with learning videos that have been uploaded on the Padi Kapas application. The teacher invites students to elaborate the results of the discussion by paying attention to the learning video provided on the Padi Kapas application.	Teacher Activities: The teacher directs the students to present the results of the elaboration process on the informal problems solved. The presentation is done by students from the high ability group. The presentation is the result of elaboration that occurs from tiered discussion activities. The teacher facilitates to control the course of the presentation. The teacher then introduces the concept of average value used in

Syntax of Ethno-Flipped Classroom Model	Learning Stage	
	Out-Class Learning	**In-Class Learning**
		solving informal data problems in descriptive statistics using the context of *Lemang Batok*.
	Student Activities: Students elaborate the results of the discussion by watching the learning videos provided in the Padi Kapas application (Activity 1b, Activity 2, Activity 3).	Student Activities: Students present the results of tiered discussion activities represented by students from high ability groups (Activity 1b, Activity 2, Activity 3).
Validation and Confirmation (Formal Mode)		Teacher Activities: The teacher directs the students to conclude the final result of the discussion process. The teacher also invites students to validate the results of the discussion and confirm whether the results of the discussion are in accordance with the concept of average value on data in descriptive statistics. The teacher also provides reinforcement to students to justify the problems that have been solved and find formal mathematical concepts. Student Activities: Students validate and confirm the discussion results that have been obtained with the concept of average value on data in descriptive statistics (Activity 2-Level 2: Applying). Students also justify and find formal mathematical concepts and can provide conclusions from the problem solving results obtained (Activity 3-Level 3: Reasoning).
Evaluation and Class Feedback	Teacher Activities: The teacher invites students to provide self-assessment and reflection of learning through a questionnaire presented on the Padi Kapas application.	Teacher Activities: The teacher invites students to do self-reflection and gives the final evaluation (numeracy test of data domain in descriptive statistics).

Syntax of Ethno-Flipped Classroom Model	Learning Stage	
	Out-Class Learning	In-Class Learning
		The teacher also gives rewards to students after successfully solving the informal problems given.
	Student Activities: Students engage in self-assessment tasks and reflection on learning by filling in the questionnaire presented on the Padi Kapas app.	Student Activities: Students engage in an evaluation of data domain numeracy skills in descriptive statistics.

After determining the conjecture as the basis for designing learning trajectories and determining learning procedures using the ethno-flipped classroom model, the design of student learning activities packaged in the form of numeracy worksheets and lesson plans is validated by experts using validation sheets that have been designed and validated in advance. The validation results were then analyzed using the Many-Facet Rasch Model (MFRM) technique. MFRM is one part of Rasch Model measurement, which is conducted for the purpose of multi-rater analysis (Ramadhani, Syahputra, Simamora, et al., 2023). MRFM analysis allows raters to provide different assessments. MFRM analysis has been used in many studies to handle rater-related variability and inconsistency in many fields (Parra-López & Oreja-Rodríguez, 2014; Wang & Stahl, 2012). The results of the assessment of 10 experts based on the MFRM analysis show that all learning activities in the numeracy worksheet are valid and reliable with a value of 0.83 and 0.86, respectively, in the Very Good category based on Cronbach's alpha value (Bond et al., 2020), and can be used in the next stage of testing, namely the design experiment stage.

Design Experiment

The results of the initial design of data learning trajectories in descriptive statistics that were valid and reliable based on the results of the assessment of 10 experts were then applied to design experiment activities. The design experiment activities were carried out in two cycles, namely a pilot experiment and a teaching experiment.

In the pilot experiment, the results of the data learning trajectory design in descriptive statistics using the context of *Lemang Batok* were then implemented in small groups of students. The 15 students involved in the pilot experiment were divided into three groups based on their numeracy ability (the grouping of students in the pilot experiment was based on their formative test scores from previous learning activities). Each group consisted of five students. All students involved in the pilot experiment activities followed the implementation of the data learning trajectory design in descriptive statistics for three meetings with each meeting consisting of two learning stages (out-class learning and in-class learning), so there was a total of six meetings. Students in each group collaborated in working on the activities presented in the data-learning worksheet in descriptive statistics. Students worked on activities that were differentiated into three different levels according to the level of numeracy skills. The implementation of the pilot experiment activities also included two observers whose role was to observe the implementation of the data-learning trajectory design in descriptive statistics using the *Lemang Batok* context, which had been designed previously.

Based on the observation results, both observers found that it was necessary to optimize learning time at each stage of learning activities, both in the out-class learning session and in the in-class learning session. This can be seen from the difficulty of students to maximize discussion time in the mode of and mode for stages, until it impacts the formal mode stage. The results of the observation findings obtained were then analyzed and discussed with the teacher to make improvements to the design of the data-learning trajectory in descriptive statistics using the context of *Lemang Batok*. Furthermore, after the revision process, the second cycle of design experiment activities was conducted, namely, teaching experiment activities with the subject of a wider group of students.

Furthermore, in the teaching experiment phase, the results of the improved design of the data-learning trajectory in descriptive statistics using the context of *Lemang Batok* were then implemented in the second cycle of activities, namely teaching experiments. The teaching experiment activities were carried out for eight meetings, each consisting of three on-class learning meetings, three in-class learning meetings, and two meeting used for taking the pre-test and post-test in numeracy test. The teaching experiment was conducted with 153 junior high school students from Binjai and Medan Cities in North Sumatera-Indonesia. In the first meeting of the teaching experiment stage, students took a pre-test on numeracy. Prior to administration, the numeracy test was validated by expert judgment and met the criteria for validity and reliability. The test consists of three essay questions covering the domain of data and uncertainty within a socio-cultural context, with cognitive levels ranging from understanding (level 1), applying (level 2), to reasoning (level 3).

Teaching experiment activities were also carried out by integrating technology using the Padi Kapas application to optimize the implementation of out-class learning. During the process of implementing the teaching experiment activities, the observer will also observe the course of the activities and readjust to the revised learning trajectory design. Details of the activities carried out by students based on the design of the data-learning trajectory in descriptive statistics using the context of the *Lemang Batok* and the ethno-flipped classroom model are described as follows.

Activity 1a: Watching the Lemang Batok Making Process

This activity was conducted during an out-of-class learning session. The first out-class learning activity session was conducted before the learning class began. This aims to provide opportunities for students to prepare themselves and understand their learning needs before participating in the learning process that will be followed (preparing the class environment). The out-of-class learning phase demonstrates the flexibility offered by the ethno-flipped classroom model. This flexibility provides opportunities for interaction not only between students but also between students and teachers, as well as between students and the learning material (Attard & Holmes, 2020; Fernández-Gutiérrez et al., 2020). This activity was also continued in the in-class learning session. Students were also asked to write down any information obtained from watching the process of making *Lemang Batok* and present it in front of the class (https://www.youtube.com/watch?v=be4I5gT-iq0).

In this activity, students use critical thinking skills to obtain any information contained in the video of the *Lemang Batok* -making process (see Figure 4). Students are also invited to analyze the context they want to raise from the video of the *Lemang Batok* making process and its relationship to the material to be learned. Through this activity, students are expected to understand that the variation in the size of bamboo used in the process of making *Lemang Batok* is related to the concept of data size. The results of observations made by observers show that 45% of students realized that the bamboo used in making *Lemang Batok* has a varied size, and this shows that the size variation in bamboo is related to data size. The observations from activity 1a align with constructivist learning theory, which emphasizes that knowledge is not passively absorbed or directly transferred to students but is actively constructed through interpretation. Students build their understanding through interactions with objects, experiences, and their environment. In this case, students construct knowledge through their socio-cultural experiences, specifically the activity of making *Lemang Batok*. The integration of the *Lemang Batok* context, as part of ethnomathematics in the design of learning trajectories for descriptive statistics, has been shown to meet students' learning needs. This is evident in students' responses to activities that guide them in understanding mathematical concepts and connecting them with prior knowledge, supported by a student-centered learning environment (Bergmann & Sams, 2022). Students also explore researchable questions, collect and analyze data, and develop and present evidence-based claims (Prain et al., 2023).

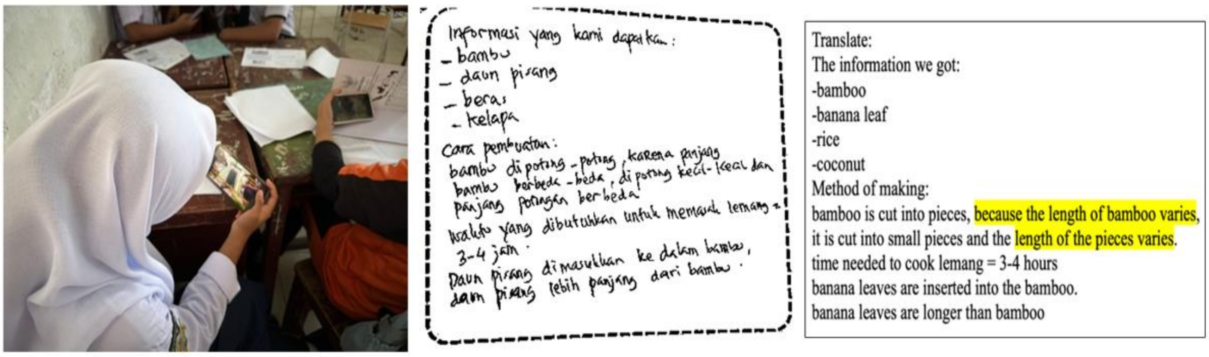


Figure 4. Students watched a video of the process of making a *Lemang Batok* and the answers to Activity 1a

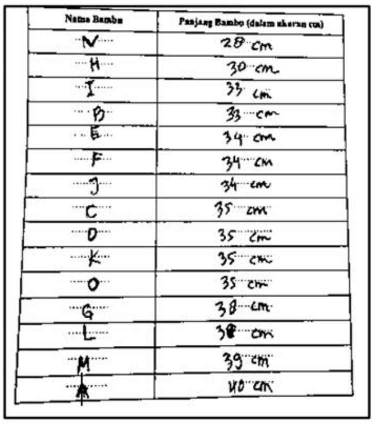
Activity 1b: Collecting Bamboo Lemang Batok

This activity takes place during a classroom learning session, where the teacher introduces an informal problem related to descriptive statistics using the context of *Lemang Batok*. By engaging with such informal problems, students can better understand the concept of data measurement. The activity also involves students in sorting *Lemang Batok* from shortest to longest. Before exploring the problem, the teacher groups students based on their ability levels to encourage collaboration among peers with similar skills.

This group assignment aims to help students better understand their learning needs and manage cognitive load during the learning process. Grouping students by ability level is part of the interaction pattern within the ethno-flipped classroom model. The interactions within these groups facilitate students' ability to manage cognitive load by addressing their individual learning needs. This process is supported by a learning environment that promotes meaningful situations, collaboration, discussion, and knowledge construction (Paas & van Merriënboer, 2020).

In this activity, students use their ability to understand the concept of size and adjust the variation in bamboo length with the concepts of shortest and longest size. Students are also expected to show critical thinking based on the results of their understanding. This is because the size of the bamboo is the length of the bamboo, while in the picture presented on the worksheet, there are remaining banana leaves protruding from the top of the bamboo. Students with critical thinking will ask questions, does the length listed include the remaining banana leaves protruding from the top of the bamboo, or is the length listed only the length of the bamboo from the bottom of the bamboo to the top of the bamboo? Through this activity, students are expected to understand the concept of data size and use this understanding to sort bamboo sizes in the order requested on the worksheet.

The findings from the observation of activity 1b (see Figure 5) indicate that homogeneous grouping (based on students' ability levels to initially address learning needs) promotes greater co-construction of elaborations (i.e., elaborations made collaboratively by several students). Group composition not only affects students' academic achievement but also influences their social interactions. These social interactions can serve as important mediators of the effects of group composition on small group learning (Murphy et al., 2017). The initial homogeneous grouping in the learning trajectory design, facilitated by the ethno-flipped classroom model, meets students' learning needs according to their ability levels. This foundational stage helps students identify areas for further development and exploration, which will be addressed in the next phase of the ethno-flipped classroom model: the tiered discussion stage.



Nama Bambu	Panjang Bambo (dalam ukuran cm)
N	28 cm
H	30 cm
I	33 cm
B	33 cm
E	34 cm
F	34 cm
J	34 cm
C	35 cm
D	35 cm
K	35 cm
O	35 cm
G	38 cm
L	38 cm
M	39 cm
A	40 cm

Translate:
Bamboo name
Bamboo lengt (in centimeters)

Figure 5. Students are collecting data on the length of the Bamboo *Lemang Batok* and the answers to Activity 1b

Activity 2: Assembling Bamboo Lemang Batok

This activity is carried out in the out-of-class learning session, where the group discussion session continues from what was previously done in the in-class learning session. This activity is carried out with the help of technology, namely the Padi Kapas application. Students discuss the forum menu provided. Through this activity, students are invited to understand the concept of measuring the average value of a collection of bamboo *Lemang Batok* that has been arranged in the order requested. This activity also invites students to think about how the average value measure can be obtained and used from a collection of varied data sizes. This activity was repeated in the in-class learning session. Students again conduct discussions with study groups to ensure that the results of the discussions have been obtained during the implementation in the out-class learning session (see Figure 6).

In this activity, students are expected to have understood the concept of the average value measure and be able to use it to solve informal problems. Students are also invited to be able to think critically and understand that the order of data size has an influence in determining the average value of a varied dataset. Students are also invited to think creatively about how to determine the average value of a dataset of varying *Lemang Batok* bamboo sizes. Study group discussion sessions not only invite students to collaborate and work together but also increase self-confidence. Furthermore, collaborating with peers of similar competence levels enhances students' learning independence and encourages more active interaction. As the academic performance gap between peers decreases, communication becomes more balanced, enabling lower-performing students to participate more actively in problem-solving and gradually take greater initiative in tasks (Zhang, 2024).

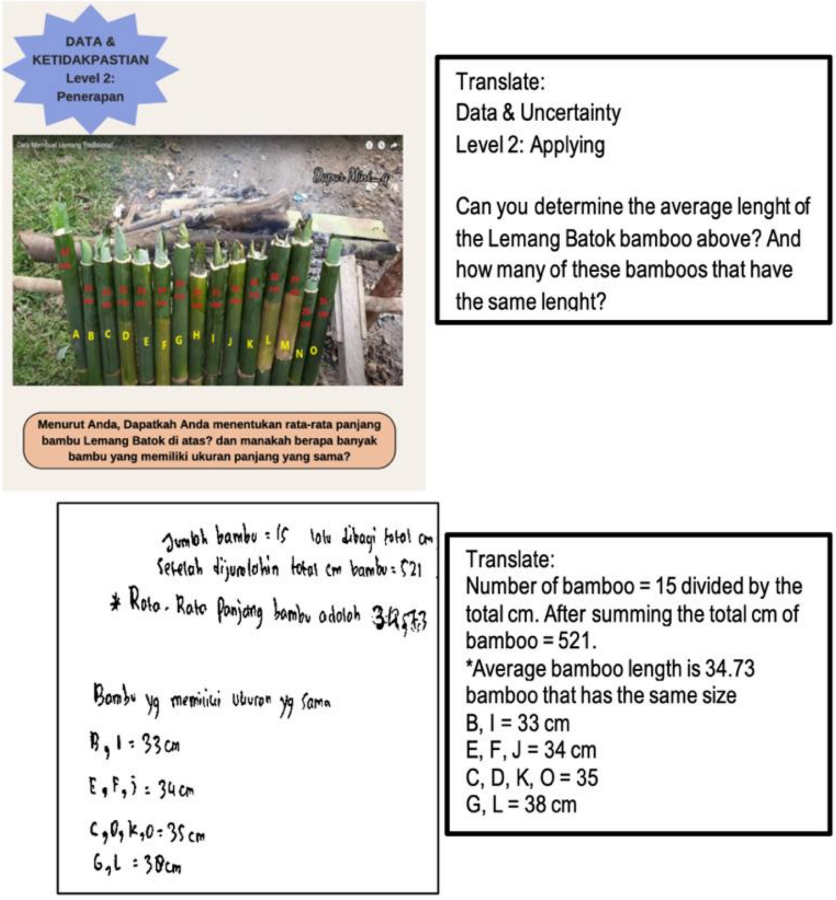


Figure 6. Students are continuing the discussion session in the study group and the results of the answers in Activity 2

Activity 3: Cooking Lemang Batok

This activity is carried out in the in-class learning session, where students continue the discussion session to solve informal problems related to data in descriptive statistics using the *Lemang Batok* context. In this activity, students are invited to analyze and re-use the concept of average value on data size. Students are also invited to combine the concept of calculating the average value in the existing dataset and analyze the concept of calculating the combined average value if there are additional data on the size of *Lemang Batok* bamboo (see Figure 7).

Through this activity, students are expected to use critical and analytical thinking skills to determine whether the average length of *Lemang Batok* bamboo will be different if there is an addition of bamboo or a change in bamboo size data. Students are also expected to express critical thinking where, if there is an addition of bamboo size or a change in bamboo size data, does it need to be reordered? Students were also invited to find the concept of combined average value through these activities. This activity was then carried out again in the out-class learning session to evaluate the results of the discussion obtained in the in-class learning session.

In the out-of-class learning session, students are invited to evaluate the results of the discussion obtained and ask other critical questions to ascertain whether the combined mean value convention can solve the informal problem given. Students are also invited to compare the findings obtained, whether the average value in the previous dataset of *Lemang Batok* length is greater than the average value in the dataset that has received the addition of new data. The discussion session continued as an in-class learning activity, where students conducted further collaboration through tiered discussion activities. Tiered discussions were conducted to confirm the answers that had been obtained in all the activities that had been conducted previously. Tiered discussions were conducted between student learning groups with different competency levels. Representatives of each study group with low ability will bring critical questions that have not been answered or the findings obtained for the group of students with medium ability. Representatives of low-ability students are expected to take advantage of the opportunity to confirm their answers or ask questions that are needed according to their learning needs. The confirmation results obtained by the low group student representatives were then brought back and discussed together with other students in the same group.

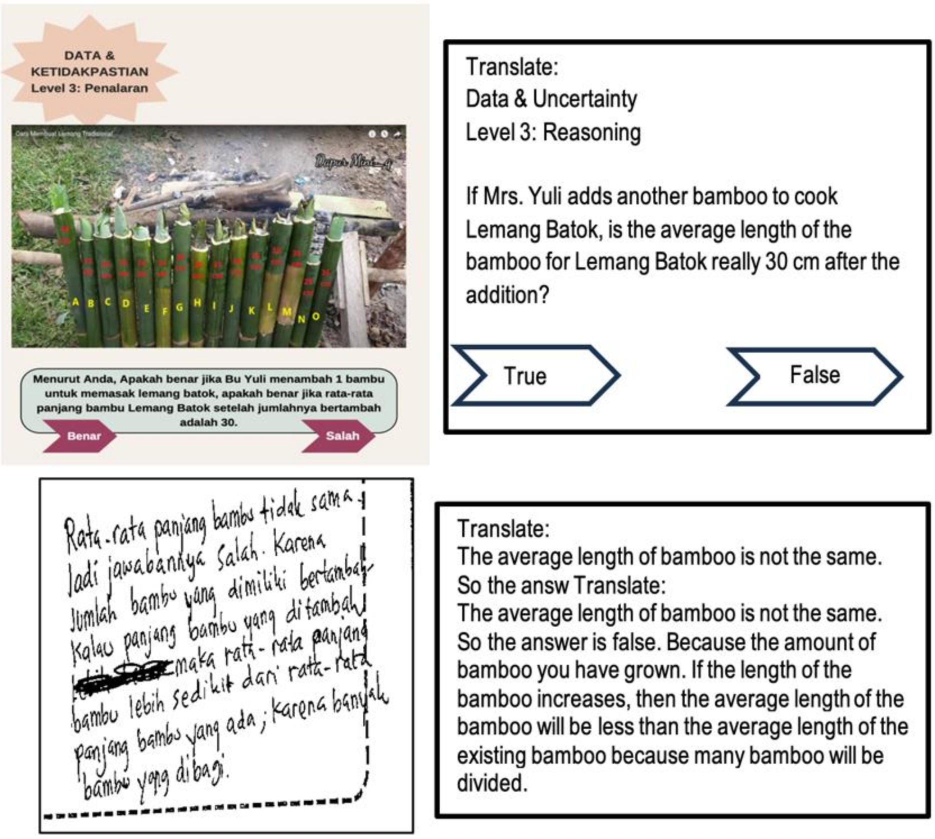


Figure 7. Students are analyzing the calculation of the average value if there is a change and addition of data on the length of bamboo *Lemang Batok*, and the answer results in activity 3

The tiered discussion was continued again with each student representative from the low- and medium-ability groups together discussing with students from the high-ability group (see Figure 8). This stage is the final confirmation stage, to confirm whether the results of the discussion of students from low- and medium-ability groups are in accordance with the findings obtained by students in high-ability groups.

The tiered discussion process enables students to play the role of peer tutors for their peers. The interaction resulting from the tiered discussion process will optimize the process of abstraction and formalization of mathematical concepts obtained based on the findings from informal problem-solving. The final stage of the tiered discussion process will help students carry out the process of summarizing the findings and justifying the results, to be able to determine whether the addition of data size to the *Lemang Batok* length data set has an effect on the size of the overall average value of the data. Students are also invited to carry out a formalization process in which the use of the combined average value concept is related to the previous average value concept.

The observation results from activity 3 show that tiered discussions help students engage more actively and optimize reasoning abilities, which have been stimulated from the initial same-level group discussions. This finding is supported by Zambrano et al. (2019), who state that tiered discussion activities are proven to enhance students' learning and interaction skills. Tiered discussions foster student diversity and allow it to flourish. They also promote critical thinking and effectively support statistical investigation activities. Additionally, students can explore the material presented by the teacher while collaborating with peers, boosting their confidence, interest, motivation, and adaptation in using technology for learning (Abeysekera & Dawson, 2015). Improved student learning abilities typically occur after a series of learning processes over time (Darling-Hammond et al., 2020).

Figure 8. Representatives of the low- and medium-ability group students confirm the findings of the discussion with high-ability group students

After the process of inference and justification is carried out by students together through tiered discussions, the activity continues by inviting students to elaborate on the findings (elaboration of the informal problem). Students return to their respective study groups and elaborate on the findings by utilizing learning resources facilitated by the teacher, both through textbooks and learning videos provided on the Padi Kapas application. In this elaboration activity, students are invited to utilize their cultural experiences related to the context of the *Lemang Batok* and the use of technology-integrated resources to maximize the findings that have been obtained previously.

The results of the elaboration process were validated and confirmed. Validation and confirmation activities were carried out by student representatives from high-ability groups through the presentation of findings. The presentation of the findings is the result of the agreement between the discussion findings obtained during the tiered discussion session and the elaboration process. The presentation of findings was done by students to make a final confirmation to the teacher whether the findings obtained by all students were in accordance with the concepts they had obtained. This presentation activity also facilitates students to increase their sense of responsibility for the results of the discussion obtained and maximizes student confidence not only for students with high ability groups but also for students with medium and low ability groups.

Learning activities using the data learning trajectory design in descriptive statistics using the context of the *Lemang Batok* through the application of the ethno-flipped classroom model ended by conducting reflection and evaluation with students. This activity was carried out by conducting a final conclusion of the entire series of activities that students had completed collaboratively. Furthermore, reflection and evaluation were also carried out by administering self-reflection questionnaires to students, as well as numeracy tests for data learning in descriptive statistics to measure students' numeracy skills after participating in a series of learning activities.

The numeracy test administered at the end of the teaching experiment stage was the same test given at the beginning. This test was used to evaluate students' numeracy skills, particularly in descriptive statistics within the domain of data and uncertainty, incorporating a socio-cultural context, after following the developed learning trajectory. The students' numeracy test results in general from the teaching experiment stage are presented in Figure 9.

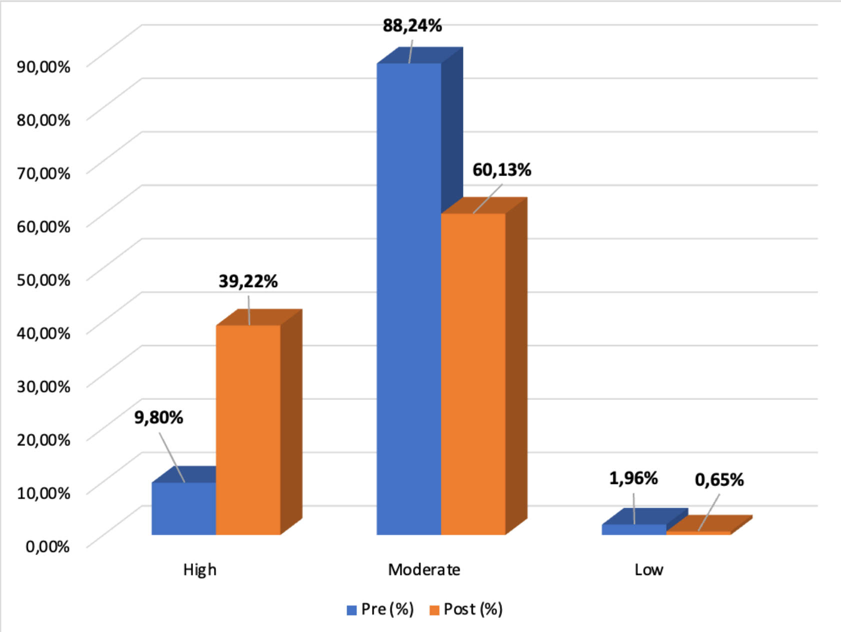


Figure 9. Percentage of students' numeracy levels in the data and uncertainty domain (descriptive statistics learning) across cognitive levels

Figure 9 presents that the overall level of students' numeracy skills, particularly in the domain of data and uncertainty—descriptive statistics learning—is predominantly at a moderate level in both the pre-test and post-test conditions. In percentage terms, there is an increase in the proportion of students achieving moderate and high numeracy levels. After participating in learning through the descriptive statistics learning trajectory with a socio-cultural context using the ethno-flipped classroom model, 60.13% of students reached the moderate level, and 39.22% achieved a high level in numeracy skills. The test results of students' numeracy skills, categorized by cognitive level in descriptive statistics (data and uncertainty domain) from the teaching experiment stage, are presented in Figure 10.

The results of the analysis of students' numeracy skills by cognitive level are shown in Figure 10. In the pre-test, students' numeracy skills were categorized as competent at the understanding level (level 1), progressing at the applying level (level 2), and also progressing at the reasoning level (level 3). These categories changed in the post-test. At the understanding level (level 1), although students remained in the competent category, the percentage of students at this level increased from 52.94% (pre-test) to

58.17% (post-test). At the applying level (level 2), students' numeracy skills improved from the progressing category, where 52.94% of students were initially, to the competent category with the same percentage. At the reasoning level (level 3), students remained in the progressing category, but the percentage of students in this category increased from 46.41% (pre-test) to 54.25% (post-test).

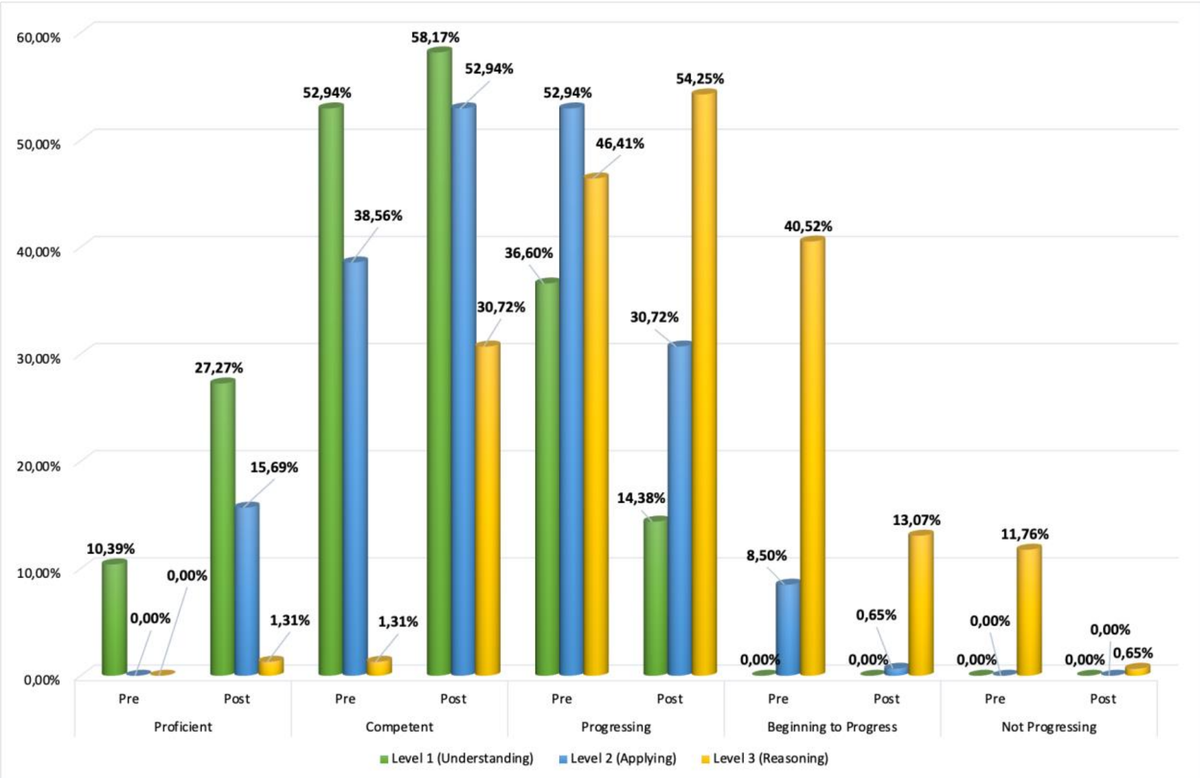


Figure 10. Percentage of students' numeracy skills in the domain of data and uncertainty (descriptive statistics learning) by cognitive level

Based on the analysis results, it is concluded that students' numeracy skills at each cognitive level have not yet reached the proficient category, with the highest level achieved in the post-test being the competent category at the understanding level (level 1). This indicates that students have competently demonstrated skills such as remembering, identifying, classifying, calculating, retrieving, and measuring in the numeracy context within the data & uncertainty domain—particularly in descriptive statistics—at the understanding level (level 1). However, students still need to improve in choosing strategies, modelling, applying, and interpreting numeracy contexts in the data & uncertainty domain—especially in descriptive statistics—to surpass the progressing category at the applying level (level 2). Similarly, to reach the proficient category at the reasoning level (level 3), students must develop skills in analysing, integrating, evaluating, concluding, and justifying. Nevertheless, as shown in Figure 9, the overall level of students' numeracy skills in descriptive statistics learning (data & uncertainty domain) has reached a moderate level (60.13%). These results demonstrate that the application of the learning trajectory for descriptive statistics in a socio-cultural context, developed using the ethno-flipped classroom model, effectively supports and facilitates the improvement of students' numeracy skills at each cognitive level.

The improvement in students' numeracy skills across the different cognitive levels is a result of the application of the developed learning trajectory, which integrates flexibility into meaningful, student-centered learning. Flexibility in learning offers students new learning experiences, starting with initial collaboration based on their ability levels and continuing with a tiered collaboration design. This gradual, tiered collaboration helps students better understand their individual learning needs, which in turn leads to increased student engagement in the learning process (Le et al., 2018; Zhu & Kaiser, 2022). Sulistyowati et al. (2023) also agreed that the implementation of the learning trajectory using an ethnomathematics approach within a socio-cultural context aids students in developing their numeracy skills. The learning trajectory, designed according to students' cognitive numeracy levels, also helps teachers better assess students' numeracy skills while incorporating non-routine problems grounded in socio-cultural contexts relevant to students' daily lives.

The entire series of student learning activities was observed by the observer according to the observation sheet provided. Observers observed whether the design of the data learning trajectory in descriptive statistics using the context of the *Lemang Batok* designed and revised was in accordance with the implementation carried out in the teaching experiment activities. Furthermore, the observer also made observations by seeing whether the syntax of the ethno-flipped classroom model had run optimally in the teaching experiment activities. Observations were also made from the student side, where observers collected data related to student responses in participating in learning activities as well as the interaction process that occurred during the collaboration process and tiered discussions. In addition to observational data, observers also conducted interviews with student and teacher representatives and documented all activity sessions carried out.

Retrospective Analysis

All learning activity data obtained from observations during the teaching experiment were analyzed to match the conjecture and learning trajectory that had been developed. The results of the analysis showed that the responses and learning outcomes obtained by the students were in accordance with the conjecture and learning trajectory developed. The observation results showed that students with low ability responded in accordance with this conjecture. However, unique findings were obtained, where students in low-ability groups were able to achieve higher conjectures than expected by researchers and teachers. This finding was seen during the tiered discussion process, where low-ability students were able to provide critical questions that referred to the length of the bamboo in learning activity 1b. Low-ability students confirmed that the length of the bamboo listed on the numeracy worksheet did not include the length of the banana leaf poked out of the top of the bamboo. The low-ability student representative confirmed with the medium-ability student group and brought the question back when continuing the tiered discussion session with the high-ability student group. The following are transcripts from interviews between Researcher (R) and students of low-ability (student code: AJ).

R : What makes you think that the measurement on the worksheet is not the actual length of bamboo?

AJ : I think that the measurements of 30 cm, 38 cm, and other measurements are not the actual length of the bamboo, so they include the length of the banana leaf that comes from the top of the bamboo.

R : What do you think is the actual length of bamboo?

AJ : So, if we want to know the actual length of bamboo, we must first subtract the length of the banana leaf. When I watched the video of the process of making a Lemang Batok, I heard that the length of the banana leaves used to insert into the bamboo was 10-15 cm longer than the size of the bamboo used. Therefore, my friends and I thought that the actual size of the bamboo was not the one shown in the picture.

R : What do you think the actual length of the bamboo is?
AJ : (silent while looking at the picture of the bamboo arrangement on the worksheet) Yes, it must be reduced by the length of the banana leaf inserted into the bamboo. The banana leaves come out, so what is the length of the remaining banana leaves that come out minus the length in the picture? But we weren't sure. That is why we wanted to confirm with the other groups whether it was the same as what we thought or not.

Based on the results of the interviews conducted, it appears that student AJ has good critical thinking skills. This can be seen from the argumentation given, where students point out that there is inconsistent information in the picture with the appearance of the picture given. This response exceeded the response expectations that arise in students with low groups, and this response did not appear when the pilot experiment activities were carried out. However, the response given by AJ was in accordance with the response that the teacher expected to appear during the learning process.

In addition, the observation results also obtained findings where the medium-ability student group gave conclusions that were beyond the conjecture that had been designed. Student SY stated that when sorting bamboo from the shortest size to the longest size, the average value of bamboo size can be obtained by determining how many bamboo sizes have the same length. These findings indicate the existence of a creative thinking process carried out by students. The following are transcripts from interviews between Researcher (R) and students of moderate-ability (student code: SY).

R : Why is the average size of the bamboo Lemang Batok 35 cm? How did you perform the calculation?
SY : The bamboo length data were sorted in a table (showing the results of learning activity 1b) to determine how many bamboos have the same length.
R : Can you explain this in more detail?
SY : Yes, for example, the length of bamboo 34 is in bamboo whose code is E, F, and J. Well, so there are three bamboos whose length is 34 cm. And so on. Therefore, we found that bamboo with a length of 35 cm is in 4 bamboos, bamboo C, D, K, O. Well, because there are the most bamboos with a length of 35 cm, so the average value of bamboo length is 35 cm. That is what we think mom.
R : Why do you think that?
SY : Yes, because the average is usually taken from most data, ma'am.

Based on the interview results, it appears that students had misconceptions related to the size of the average value. The student's argument could be correct because the average value and mode value often have the same value. However, this concept cannot be used to conclude that the average value of a dataset can be determined by determining the data that appears the most. SY already understood the concept of data ownership, which refers to the frequency of data. However, SY had difficulty using the concept of data ownership, so misconceptions related to the size of the average value emerged. Although misconceptions occurred and SY's responses were outside the designed conjecture, creative and analytical thinking processes were already evident.

Another finding was also captured by the observer during the observation process, where representatives of students with high-ability groups provided justifications that were beyond conjecture. Student representatives of the high-ability group (coded MR) conveyed justifications related to the discussion of Learning Activity 3 during the tiered discussion session. The MR said that the average value will decrease as new bamboo data are added. The following are transcripts from interviews between Researcher (R) and with students of high-ability (student code: MR).

R : Do you agree that the average value in the bamboo length data will be different if there are additional bamboo length data?
MR : Yes, ma'am, it must be different, the data increases.
R : Will the average value be smaller or larger than the average value before the data is added?
MR : It must be smaller than mom.
R : Why can you explain this in more detail?
MR : Yes, the average value must be smaller than ma'am. No matter how much bamboo length data are added, for example, adding one size that is 40 cm long, the average value must be smaller than the previous one.
R : Why is it that? The added size contains a large amount of data.
MR : Yes ma'am; it does not matter if the data size is big or small ma'am.
R : Why does this not matter?
MR : Yes, because later all the bamboo length data are summed up and then divided by the number of bamboos. Thus, because there is an increase in bamboo, what is divided increases. Therefore, the more that is divided, the smaller the quotient will be. Therefore, the addition of bamboo with a large length does not make the average value bigger, ma'am.
R : What if there is a reduction in data? Suppose we remove bamboo O. What about the average value after bamboo O was removed?
MR : Yes, the average value was larger. There are no longer 15 bamboos being divided, so there are only 14 bamboos because bamboo O is not counted.

Referring to the confirmation results on MR, it appears that MR has understood the concept of data frequency. MR can justify that adding or subtracting the amount of data in the dataset will affect the average value in the dataset. The average value will be greater if the amount of data is reduced, and the average value will be smaller if the amount of data is increased, even though the size of the added or reduced data has the largest size. MR has conducted an analytical thinking process and has good reasoning power. MR is not only able to analyze and evaluate, but also justifies using a good mathematical approach. This can be seen from the responses of MR students using the concept of data frequency comparison in providing mathematical arguments to support their claims. This reasoning process shows that MR has exceeded the level of reasoning in numeracy skills.

The findings obtained from the teaching experiment activities show that the conjecture and learning trajectory of data in descriptive statistics using the context of the *Lemang Batok* are in accordance with the implementation in the field. The conjecture expected to arise from student activities is achieved, as is the conjecture expected to arise from teacher activities. Based on these findings, it is concluded that all designed activities facilitate students' learning needs related to numeracy skills in the learning data in descriptive statistics. All activities designed also prove that mathematics plays a role in solving problems that occur in everyday life and becomes part of the culture of society. This study specifically contributes to developing a descriptive statistics learning trajectory (data and uncertainty domain) grounded in the *Lemang Batok* context and the ethno-flipped classroom model (Ramadhani, Saragih et al., 2023) Retrospective analysis supports the notion that this approach effectively improves students' understanding, application, and reasoning in descriptive statistics, while expanding the range of cultural contexts that can be utilized in mathematics instruction (Sharma, 2024).

Furthermore, the learning trajectory produced in this research also provides a unique study where the application of learning trajectories using cultural contexts can be applied in a flexible and meaningful learning model, namely, the ethno-flipped classroom model. The learning trajectory developed is not only able to help students understand the concept of data in descriptive statistics but also teaches students to preserve the values contained in it through mathematics learning. Therefore, the integration of cultural values in mathematics learning not only helps students in numeracy skills but also develops their character in existing cultural values. Learning trajectories with contexts that are close to students' social lives meet the needs of students in improving data thinking, analysis, and reasoning power, focused, meaningful, fun, and developing good character (Muslimin et al., 2020).

Overall, the study's results contribute significantly to mathematics education, especially for learning trajectories tailored for teaching descriptive statistics within a socio-cultural context using the ethno-flipped classroom model. The support from previous studies on the ethno-flipped classroom model, learning trajectory design, and the application of socio-cultural contexts in numeracy problems establishes a foundation for extending these learning trajectories to broader research contexts (D'Ambrosio, 2017; Fauzan et al., 2018; Gravemeijer, 2020; Muslimin et al., 2020; Prahmana & Istiandaru, 2021; Ramadhani et al., 2021; Aras et al., 2022; Hidayati & Prahmana, 2022; Bergmann & Sams, 2022; Prahmana, 2022; Ramadhani et al., 2022; Meyllinda et al., 2023; Mukwambo at al., 2023; Ramadhani, Syahputra, & Simamora, 2023a, 2023b). Additionally, the findings reinforce the value of the ethno-flipped classroom model in creating learning trajectories aligned with students' cognitive numeracy levels. The study also introduces novel insights, demonstrating that integrating the ethno-flipped classroom model into learning design positively impacts students' numeracy skills, particularly in the domain of data and uncertainty, such as descriptive statistics.

CONCLUSION

The concept of data in descriptive statistics can be understood, applied, and reasoned by students through the integration of local contexts such as socio-culture. This study successfully developed and implemented a learning trajectory of data in descriptive statistics in the context of a *Lemang Batok* using the ethno-flipped classroom model. The learning trajectory developed and implemented consists of several activities carried out through the application of the syntax of the ethno-flipped classroom model, namely watching the process of making *Lemang Batok*, then collecting bamboo *Lemang Batok*, sorting bamboo *Lemang Batok* which begins with the process of understanding the concept of data size and frequency represented in the form of bamboo *Lemang Batok* length. The activity continues by applying the concept of the average value of a collection of bamboo *Lemang Batok* that have varying lengths, and students can reason about the problem of changing the average value of bamboo *Lemang Batok* length data if there is a change in data, until they can estimate and justify, and are able to communicate concept findings found from problem activities that students have done collaboratively. Through this learning trajectory, the variability and statistical investigation activities of students were well facilitated. Students can preserve the values contained in the cultural context to help them improve numeracy skills, especially in the data domain in descriptive statistics, and develop characters obtained from cultural values contained in the activities undertaken. Suggestions for further research include implementing the learning trajectory in a wider group that aims to obtain data on changes and improvements in numeracy skills in a more complex manner.

Finally, this research is limited to designing learning trajectories for descriptive statistics, a subset of the data and uncertainty domain, and focuses solely on one numeracy context: the socio-cultural context of

Lemang Batok. Future research could expand by developing learning trajectories in other numeracy domains, such as numbers, algebra, geometry and measurement, or different aspects of the data and uncertainty domain. Additionally, exploring other numeracy contexts, including personal and scientific ones, could be valuable. The findings from this study provide a foundation for assessing students' numeracy skills in terms of cognitive levels and can serve as a basis for broader research. Furthermore, this research opens opportunities for further analysis of numeracy skills based on cognitive levels, potentially incorporating demographic factors such as gender, initial ability levels, and family social background.

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Declarations

Author Contribution	:	RR: Conceptualization, Data Curation, Formal Analysis, Investigation, Methodology, Project Administration, Visualization, Writing - original draft, and Writing - review & editing. RCIP: Formal Analysis, Supervision, Validation, Methodology, Visualization, and Writing - review & editing. S: Supervision, Validation, Software, Methodology, and Writing - review & editing. AS: Data curation, Resources, Software, and Visualization.
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