Designing Hypothetical Learning Trajectory of Descriptive Statistics Through Ethnomathematics Problem Assisted TinkerPlots

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Abstract.
Integration of Technology, Information, and Communication (ICT) in learning mathematics are one of the focuses developed in implementing "Kurikulum Merdeka." One of the ICT integrations is TinkerPlots. TinkerPlots is ICT-based mathematics learning media that allows students to explore learning flexibly and according to student needs. TinkerPlots can assist teachers in implementing mathematics learning that focuses on the discovery process through ethnomathematics-based informal problems. The discovery process made by students through TinkerPlots then bridges students to understand formulas in formal mathematics. The purpose of this study is to create a Hypothetical Learning Trajectory (HLT), specifically for descriptive statistics learning, using TinkerPlots. This HLT will then be tested on students in additional research to see whether it should be classified as Local Instructional Theory (LIT) in descriptive statistics. Students can learn descriptive statistical material based on ethnomathematics problems through the help of TinkerPlots. This research employs the preliminary research stage of the design research process. The participants in the study were 15 students in one of the senior high schools in Nias Island, North Sumatera. Videos were used to observe the learning process and how students worked on the supplied question. The study results were descriptive statistical HLT, which contained learning objectives, learning activities, and the assumptions of each activity. This HLT may be a potential option for overcoming students' issues with descriptive statistical ideas by using TinkerPlots media to solve ethnomathematics-based informal problems.
Keywords: Design Research, Ethnomathematics, Hypothetical Learning Trajectory, Statistical Descriptive, TinkerPlots

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1. INTRODUCTION

Descriptive statistics is one of the materials taught to high school students in learning mathematics. Mathematics education incorporates elements that are established on the basis of human life principles in order to adapt to their immediate surroundings, such as seeking explanations, understanding, experiences, and solutions to phenomena or actual events [1], [2]. Mathematics cannot construct itself but is very dependent on aspects inherent in the culture in which humans develop and manage their lives [3], [4]. The integration of cultural aspects in learning mathematics helps students construct the knowledge gained through life experience and use it to construct new knowledge gained through the learning process. Cultural aspects are part of mathematics itself [5]. Thus, mathematics, which is both related to and distinct from culture and daily human existence, finally takes on a new shape within the context of formal schooling. Ethnomathematics is another term for culture in mathematics. The term ethnomathematics refers to the process by which a particular culture (ethno) actualizes the steps necessary to calculate, conclude, compare, and classify a technique or idea that enables people in a particular culture to model the environment and natural and social contexts, as well as to explain and comprehend mathematical phenomena [6], [7].

One of the materials in mathematics learning that can be integrated into the cultural aspect is descriptive statistics learning. Descriptive statistics obtained by high school students start from collecting data, distributing or grouping data, analyzing data, presenting data, concluding the results of data analysis, and presentation that has been carried out. Students are only given a standard formula for calculating descriptive statistics without understanding what the formula means in descriptive statistics learning. Students cannot carry out in-depth activities and explorations from the data collection stage to data analysis and presentation. We can see this in the field findings, where students are directly confronted with a collection of facts and are forced to understand and address the challenges. In the process of learning statistics with such a model, students do not understand the data that will be used in solving problems. Students do not go through collecting information until an investigation of the information contained in the problem is given.

Furthermore, the context of statistical problems that students solve is far from students' everyday experiences and the culture and traditions that students have. This finding makes students find it challenging to solve school statistical problems and use the solutions of these problems to solve other statistical problems. English and Watson [8] stated that current school statistics learning does not focus on informal understanding of statistical data. That is, finding affects pupils' capacity to analyze and respond to inquiries about data presentation. Students also have difficulty connecting the information or data obtained with analytical techniques and conclusions that provide solutions to the problems given.

Previous research results showed that high school students had difficulty reading the statistical data presented [9]. Another result shows that students have difficulty understanding statistical problems and solving problems related to the size of the concentration of data [10]. Students also have difficulties understanding problems related to standard deviation and variance in grouped data [11], they have difficulty processing data and drawing conclusions from the results of data analysis and data presentation that has been done previously [9]. The difficulties experienced by students are caused by students still having a tendency to memorize formal formulas in descriptive statistics. It has a real impact on students' statistical understanding and reasoning processes [12]. Students also have difficulty understanding statistical problems that are not close to problems related to culture and traditions around student life. That is the problem that causes students to find it challenging to use the cultural knowledge they have so far to construct new knowledge encountered from the problems presented [13]. Based on the results of previous studies that have been described, it can be concluded that descriptive statistics learning needs to be redesigned by emphasizing the presentation of everyday problems close to students' culture and traditions. Descriptive statistics learning also needs to be supported by the application of ICT-based media that helps students explore the statistical data presented to perform analysis and draw appropriate conclusions, and understand the meaning of the statistical calculation process that has been carried out.

TinkerPlots is an application used to analyze exploratory data related to descriptive statistics that project-based students will carry out. TinkerPlots has a dynamic visualization aspect that supports and structures the way students visualize statistical models. Konold and Lehrer [14] argues that the objects students construct through these applications and the inscriptions they create to organize and explore the outputs are forms of dynamic mathematical expression that elicit and facilitate their thinking. This application is also beneficial for students to develop and strengthen their ability to translate statistical problems into the TinkerPlots model, generate data using the model, and answer statistical issues based on the data generated from the TinkerPlots model [15], [16].

The purpose of this study is to develop a Hypothetical Learning Trajectory for descriptive statistics learning using the ethnomathematics context and TinkerPlots. The ethnomathematics setting is drawn from Nias Pesisir cultural artifacts. The context of the Nias Pesisir cultural artifacts in descriptive statistical learning is used, such as the context of the traditional food, the context of the Nias Pesisir community's traditional clothing of the Nias Pesisir community, and so on. The context of the Nias Pesisir

cultural artifacts is the starting point for understanding descriptive statistics problems. The integration of cultural artifacts into their context also provides students with important learning opportunities, as the integrated culture encompasses moral principles and a philosophy of life. The integration of ethnomathematics into mathematics education benefits pupils by inspiring them to emulate good character [17].

According to the description above, statistics education should be reformed through the creation of learning routes based on the ethnomathematics context in order to facilitate students' comprehension of descriptive statistics. Students will study mathematics in order to answer problems found in daily life, particularly those that are closely related to those that may be solved using descriptive statistics. The learning trajectory has been constructed in the form of learning phases that begin with the introduction of the context. Additionally, students will rediscover descriptive statistical principles through the use of real-world scenarios and the TinkerPlots tool. The processes of learning will culminate in students' comprehension of descriptive statistical ideas and the meaning of the analytical process in descriptive statistics, until students can articulate the concepts and meanings of the process in a formal manner (according to the existing formula). Additionally, these findings will aid students in comprehending the relationship between mathematics, culture, and their daily lives. On the other hand, it will familiarize students with ICT-based mathematics applications and promote critical, creative, and meaningful thinking. This learning path may be a viable choice for improving students' comprehension and reasoning about descriptive statistics, for developing students' skills in using ICT-based mathematics applications, and for conserving Indonesian culture through cultural integration in the classroom.

2. MATERIALS AND METHODS

The research method used is the preliminary research step of design research. The design research approach is an approach that develops interventions in teaching and learning activities as a solution to solving educational problems [18]–[20]. Research using a design research approach can answer the problem formulation and achieve research objectives [21]. The design research approach allows researchers to study student learning processes. In addition, the design research approach can also find out to what extent the activities that have been designed can support students' understanding of the material to be developed (in this case descriptive statistics material).

There are three activities in the preliminary research step of design research such as observations and interviews, obtaining information, and prepare learning activities through library research. In this study, design research helps develop a Hypothetical Learning Trajectory (HLT) to support students' understanding of the descriptive statistics with informal problem based on ethnomathematics context assisted TinkerPlots. This research took place in one of the public Senior High School in Nias Island, North Sumatera, Indonesia. The participants were twelve graders consisting of 5 male and 10 female students.

3. RESULTS AND DISCUSSIONS

The preliminary design phase is to formulate a learning trajectory outline and refined in the experimental design phase [20]. There were three activities conducted at this stage. The first was to conduct observations and interviews with the teachers. The second was obtaining information about students' difficulties in descriptive statistics using informal problem based on ethnomathematics context. The third was to prepare learning activities through library research on the descriptive statistics concept using ethnomathematics context and assisted TinkerPlots and the IRME approach. This information was used to design the Hypothetical Learning Trajectory (HLT), consisting of three components, such as: learning objectives, learning activities, and the hypothesized learning process [22]. The hypothesized learning process or the conjecture become a guideline that will develop in every learning activity. It should also be flexible and subject to revision during the design trial phase.

The researcher began this study by implementing the initial concept of using cultural objects from the Nias Pesisir tribe as a framework for everyday concerns provided through descriptive statistics acquired through literature review. Following that, the researcher made observations about the context at one of the Senior High Schools in Nias Island, North Sumatera and concluded by designing a Hypothetical Learning Trajectory (HLT). The incorporation of HLT into all learning activities is a critical component of instructional design. The design of learning activities is inextricably linked to the development of the learning trajectory, which includes a hypothetical strategy for instructional materials. A learning trajectory is a concept that students will encounter during the course of their education. In the specified learning process, the context employed in descriptive statistics learning will become Learning Instructional Theory. The Hypothetical Learning Trajectory (HLT) that was designed for descriptive statistics learning is depicted in Fig 1.

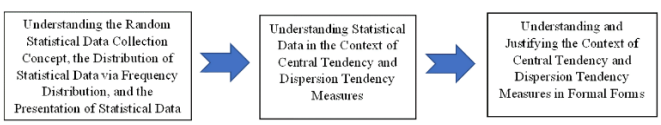

FIGURE 1. Hypothetical learning trajectory for statistical descriptive learning

Numerous activities have been developed in response to potential learning paths and students' thought processes. Before developed the potential learning paths, teacher started lesson by asking the students about “Gowi Nifufu” (one of the traditional meals in Nias Island, North Sumatera). The teacher asked questions to clarify students’ knowledge of “Gowi Nifufu” as the context used in the learning process. Students could mention the how the making “Gowi Nifufu”, as shown in Dialog 1 below.

Dialog 1

Teacher **:** Have you ever watched the making process of “Gowi Nifufu”?

Student : Yes, I have

Teacher : What are the ingredients used in the process of making “Gowi Nifufu”?

Student : Selected tubers (sweet potato, cassava, or taro) that are boiled and coconut

Teacher : Is “Gowi Nifufu” a snack or a main meal?

Student : A main meal, rice substitute

FIGURE 2. The traditional meals in Nias Island “Gowi Nifufu”

Dialog 1 indicates that students know about “Gowi Nifufu”, so teacher introduced “Gowi Nifufu” as a context and starting point in the learning process. Next, the teacher showed the video of making process of “Gowi Nifufu”. The teacher hoped that students had the same perception about “Gowi Nifufu”.

This series of learning activities is organized into three sections, each of which is finished in five sections. The purpose of this research is to demonstrate an understanding of one or more fundamental concepts of descriptive statistics in everyday life activities while remaining sensitive to the students' culture and traditions. Table 1 below illustrates the relationship between student learning paths, learning activities, and basic descriptive statistics concepts

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TABLE 1. The relationship between student learning paths, learning activities, and the basic concepts

	Students Learning Paths	Learning Activities	Descriptive Statistics Basic Concepts
Activity based on Experience (Mode of)	**Activity 1** Watching a video of Nia's "Gowi Nifufu" being prepared.	Watching a video of the process of making Nia's food "Gowi Nifufu."	Data Collection Concept
		Identifying the components necessary to make the traditional Nias dish "Gowi Nifufu."	
		Collecting random data on the amount of "Gowi Nifufu" produced in accordance with the month of production specified in the Student Worksheets	
Lesson Activities (Mode for)	**Activity 2** Contribute to the understanding the form of data on the amount of "Gowi Nifufu" produced and to the collection of data by month of production.	Understanding the form of data on the amount of "Gowi Nifufu" production that is presented (whether there is the least amount of production, the highest number of productions, and the same amount of production in different production months)	Distribution Statistical Data via Frequency Distribution and Presentation of Statistical Data
		Inputting data on the amount of production that has been collected according to the month of production in the TinkerPlots application	
	Activity 3	Presenting production amount data by month of production using the TinkerPlots application	

	Helping to present production quantity data using the TinkerPlots app	Presenting production data in the form of frequency distribution using the TinkerPlots application	
	Activity 4 Doing data exploration on TinkerPlots	Exploring data through TinkerPlots to discover the concept of the Central Tendency Measure	Context of Central Tendency and Dispersion Tendency Measures
		Exploring data through TinkerPlots to find the concept of the Dispersion Tendency Measure	
Formal Knowledge	**Activity 5** Write down the concept of the central tendency measure and the dispersion value measure in the formal form	Defining the Concept of a Central Tendency Measure	Context of Central Tendency and Dispersion Tendency Measures in Formal Forms
		Defining the Concept of Dispersion Tendency Measure	
		Writing about learning experiences using ethnomathematics contexts and the TinkerPlots app.	

Five learning activities were built based on Table 1 above for presentation in Hypothetical Learning Trajectory in descriptive statistics learning utilizing an ethnomathematics context (in this example, the context of the Nias food-culture artifact "Gowi Nifufu") and the TinkerPlots program. Table 2 below illustrates one of the conjectures regarding descriptive statistics learning in the context of ethnomathematics and the application of TinkerPlots

TABLE 2. The conjecture of descriptive statistical learning activities using ethnomathematics context assisted TinkerPlots in Activity 3

Students Learning Paths	Learning Activities	Predictions of Student Reactions	Teacher's Reactions
Activity 3 Helping to present production quantity data using the TinkerPlots app	Presenting production amount data by month of production using the TinkerPlots application Presenting production data in the form of frequency distribution using the TinkerPlots application	Students can present production amount data by month of production using the TinkerPlots application.	The teacher gives verbal appreciation to students using Amaedola (advice) in Nias culture.
		Students have not been able to present data on the amount of production by month of production using the TinkerPlots application.	The teacher helps students to be able to present data on the amount of production based on the month of production using the TinkerPlots application.
	Presenting production amount data by month of production using the TinkerPlots application	Students can present production data in the form of frequency distribution using the TinkerPlots application.	The teacher gives verbal appreciation to students using Amaedola (advice) in Nias culture.
		Students have not presented production data in the form of frequency distribution using the TinkerPlots application.	The teacher helps students to be able to present data on the amount of production in the form of frequency distribution using the TinkerPlots application.

An example of the presenting production amount data using the TinkerPlots application can be view in the Fig. 2 below.

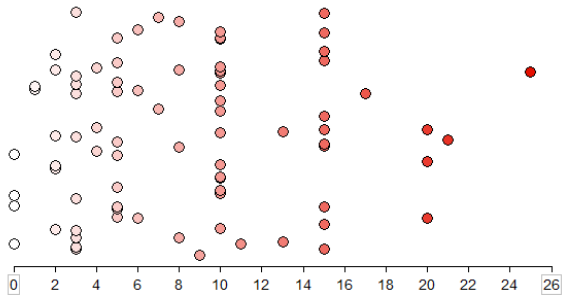

FIGURE 2. An example of one of the views on TinkerPlots

According to Table 2, a hypothetical learning trajectory was built based on conjectures about student and teacher reactions. The conjectures presented to assist the teacher in directing optimal descriptive statistics learning to achieve the learning objectives that have been previously planned following the literature study at the beginning of the research. The conjecture that underlies the design of the hypothetical learning trajectory also shows that descriptive statistics learning directs students not only to understand the concepts of descriptive statistics but also to analyze, explore, and do creativity to find formal concepts from descriptive statistics. The use of the TinkerPlots application also plays a significant role in providing flexibility to students in exploring the statistical data presented to conclude from the results of the analysis of the explored statistical data. According to Fitzallen [23] children can use the TinkerPlots program to explore the statistical data offered by utilizing the tool's many tactics. Students who employ the Explore and Complete technique develop strong associations between pictorial representations and their encapsulating meanings. When this occurs, the teacher can concentrate on the meaning of the data and the inferences drawn from it. When students employ the Proceed and Falter technique, the teacher's involvement may focus on how the graphical representation answers the exploratory question before moving on to additional data analysis. When students employ the Snatch and Grab method, teacher interventions may need to focus on graphical representations and question exploration to ensure students comprehend the essential alignment between produced graphical representations and how they assist in answering questions. Seloraji and Leong [24], Aridor and Ben-Zvi [25], and Biehler et al. [26] all agreed that using TinkerPlots assists students in not just comprehending statistical topics but also in enhancing their statistical reasoning abilities. Thus, the TinkerPlots application and the display of informal problem-based statistical data in an ethnomathematics setting aid students in developing their mathematical abilities and can be used to create hypothetical learning paths. The findings from this study are then analyzed in the subsequent stage of the research design process.

4. CONCLUSION

The ethnomathematics context can be used as the context of informal mathematics problems, especially in descriptive statistics learning. This study was successful in developing a hypothetical learning trajectory by utilizing the ethnomathematics context of Nias cultural objects, specifically the context of the indigenous Nias dish "Gowi Nifufu," and the use of TinkerPlots for descriptive statistics learning. The learning trajectory used in descriptive statistics learning consists of five learning activities, including watching a video of the process of making Nias food "Gowi Nifufu,"; helping understand the form of data on the production amount of "Gowi Nifufu" and Helping collect data according to the month of production; helping to present production quantity data using the TinkerPlots application; perform data exploration on TinkerPlots, and write down the concepts of central value measures and dispersion value measures in the formal form. The design of a hypothetical learning trajectory is designed to help students explore understanding and reasoning related to descriptive statistical material through presenting everyday problems based on ethnomathematics and applying the TinkerPlots application. The design also helps students understand the meaning of the statistical data analyzed, both in the central tendency measure and the dispersion tendency measure. The design developed also provides descriptive statistics learning that focuses all learning activities on student learning activities. The design developed is consistent with the objectives of the shift to a new paradigm of learning, which is the stated goal of the "Kurikulum Merdeka" or “Independent Curriculum.” The results of this study were then continued in the next stage of research, namely retrospective analysis to construct Local Instructional Theory related to descriptive statistics

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