Diploma Students' Reasoning About Variation with TinkerPlots™

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Abstract. The purpose of this study is to investigate the reasoning about variation with Tinkerplots on diploma students. The participants of this study consist of four diploma students from a private university in Cyberjaya, Selangor. Data for this study was collected using interview technique and observations. During the interview, the participants were given structured activities related to variation to be solved separately with the aid of TinkerPlots. There were three structured activities given to the participants to be carried out using TinkerPlots within four sessions. While the participants completed their activities, they were observed and interviewed to investigate their reasoning about variation using TinkerPlots. The findings showed that all four participants in this study managed to complete the activities on the reasoning with variation from the structured activities. However, the result for each structured activity varies. Overall study shows that on average, the participants achieved level four of the statistical reasoning framework. The TinkerPlots software used in this study helps the participants in reasoning on their prediction about variation through the activities.

Keywords: Tinkerplots · Variation · Statistics · Reasoning

1 Introduction

The demand and need of the statistical expertise have spike exponentially with the overwhelming data in this age. Moreover, the study of statistics should provide useful information for people to make decisions and act intelligently and judiciously. However, many research found that most adult in the typical society cannot relate statistically on the significant issues that affect their lives [1]. Likewise, narrowing down to the Malaysian context, under the educational perspective, the command and ability to reason among students is below average of satisfactory, according to Chan [2] in their research at the level of secondary school students in Malaysia. The poor grasp of the statistical reasoning ability is then being carried along to the next phase. These students are then continuing their study in tertiary education with same ability of reasoning, or worst due to the time transition gap.

According to the Malaysian Education Blueprint (2015–2025) [3], students learning experience integrated with the technology enabled learning models in engaging learning experience and enhancing their potential. With the variety of technology available for the

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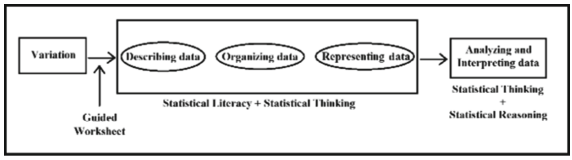

Fig. 1. Research Framework.

users, carefully selected useful tools and properly design teaching plan could reform the learning process and augment it to a higher level of understanding knowledge. Henceforth, this research is designed to tackle the students' statistical reasoning ability with the aid of technology. There are various technology platforms available for teaching and learning especially in statistics. In this research, TinkerPlots has been chosen as a main tool to aid learning process on developing statistical thinking and reasoning.

1.1 Problem Statement

The traditional way on delivering the knowledge of statistics is believed to be focused on skills, procedure and computation instead of understanding the concept as a whole and being able to reason it in a statistics manner. Understanding figures by reasoning it statistically is one of the important aspects that this research is looking into. There are ample of lists of statistical concepts that are available in the syllabus, however many students experience great difficulty in reasoning statistically about variation.

Chan [4] emphasize that the research conducted for statistical reasoning should integrate information technology. While planning on creating and designing educational experience with technology, it is important to analyze the appropriate software that will prepare the utmost essential learning environment and develop the proper understanding and reasoning of a concept.

According to Sue Allmond [5], students perceive that TinkerPlots helps them in the investigative process of statistical reasoning on variability in data effectively. In addition, TinkerPlots is one of the software that assist in the improvement of statistical thinking and reasoning by offering connection within data, between data, context and the analysis of statistical investigation.

1.1.1 Framework

The conceptual research framework is based on four key constructs of describing data, organizing and reducing data, representing data as well as analyzing and interpreting data [4] These four key constructs comprise of five thinking levels as proposed by Garfield [6] and have been refined by a recent research on the framework on assessing statistical reasoning by Chan et al. [4]. The thinking level starts from idiosyncratic to verbal and transitional. The next level is the procedural and the highest level of thinking is the integrated process. The statistical reasoning is observed at the analyzing and interpreting data which can be filtered and labeled according to the thinking level (Fig. 1).

1.1.1.1. Objectives

The purpose of this study is to investigate whether the intervention of program software could boost students' understanding and ability to reason about variation.

This research is intended to discover different approach in inculcating the students' statistical reasoning. With the available technology that has been reducing human function in computation, it is extremely important for the students to possess the skill of statistical reasoning. Students' first-hand exploration on the data may trigger the excitement on exploring the concept of variation and will eventually develop the statistical reasoning about variation compared to traditional method of "show and tell".

This research will not only impact the students' core understanding, it will give the opportunity for the educators to explore other investigative method in order to nurture the skills of statistical reasoning among students. Moreover, with the result, educators could consider to design their own teaching technique in order to balance between the traditional method and the intervention of technology in their classroom.

Other than that, the design of the syllabus of statistics subject could be revised accordingly to develop the meaningful understanding of statistics. The statistics itself may be used indirectly in other subjects and unconsciously used in daily life. Hence, the arrangement and emphasizing on the importance of statistical reasoning especially about variation could become the important criteria to make the subject as one of the core courses in the structure.

2 Literature Review

The learning goal of statistics is generally divided into three; literacy, thinking and reasoning [1]. In this research, the focus of the study is on the statistical reasoning. According to Garfield, delMas, & Chance [7], they define statistical reasoning as the way people reason and make sense with statistical ideas and information.

The general model of statistical reasoning was introduced by Garfield [6]. It consists of five hierarchical levels which are idiosyncratic, verbal, transitional, procedural and integrated process reasoning. On the other hand, Jones et al. [8] developed four main constructs in characterizing statistical thinking which was adopted from the earlier work of Shaughnessy, Garfield and Greer in 1996. The four constructs comprise of four thinking levels that represent from idiosyncratic to analytic reasoning. Likewise, Structure of Observed Learning Outcome (SOLO) model was developed by Biggs and Collis [9] as a theoretical cognitive model of statistical reasoning. The model encompasses of five levels of understanding; which are prestructural, unistructural, multistructural, relational and extended abstract.

In this research, the framework for assessing statistical reasoning proposed by Chan [4] is applied. In their research on the framework for assessing statistical reasoning summarize the model structure of statistical reasoning merging the general model of statistical reasoning introduced by Garfield [6] blended with the SOLO model by Biggs and Collis [9] together with the four main construct of Jones [8].

The research by Chan [4] found the stability, validated and consistent in the students' statistical reasoning across the four constructs as 80% of the students found proficiency for at least three out of four constructs. Although from previous studies found that no

students are able to achieve level 5 reasoning, the research successfully attain the result and only 40% of all students obtained the same level in all four constructs.

In understanding education from a mathematical and statistical education outlook, the integration of technology with the delivery of mathematical and statistical understanding in inculcating literacy, developing thinking and nurturing reasoning with mathematics specifically statistics is not a new norm for at least in Malaysian education. As stated in the Malaysian Education Blueprint (2013–2025) [3], in accordance to the previous syllabus of Kurikulum Bersepadu Sekolah Menengah (KBSM) and the new syllabus of Kurikulum Standard Sekolah Menengah (KSSM), there are several indicators at the subtopic that were already emphasizing the integration of technology in delivering a specific learning outcome intended to the students.

The correct use of tools and resources nevertheless does have the potential to change mathematics education. As mathematics especially, statistics is known as an eerie subject fear by many of human beings, the integration of technology may give ways to reduce the negative vibes and the mindset towards the subject.

Timur [10] in his research suggests that computer-support statistics software should be used in teaching statistics since it is more efficient on achievement and attitudes. TinkerPlots dynamic software is one of the powerful software developed for the usage of data visualization and modeling effective for students as early as primary schools' students. This software primarily useful for the teachers to teach statistics-based subjects and is recommended to use by the National Council of Teachers of Mathematics (NCTM) in the United States and the Australian Curriculum Mathematics in Australia. The TinkerPlots platform supports the education system by providing the data in advance as well as the tutorials for the educators.

The features in the TinkerPlots software is easy to operate, colour coded data and interactive to students. Many research were conducted on the effectiveness of the TinkerPlots software and the result shows that it helps students with memorable visual as medium to support the development of statistical thinking and reasoning [11]. Frischemeier [12] in his recent research on the activities and teaching units designed for the primary school students using TinkerPlots, found that the positive attitude towards learning statistics could be developed with the assistance of TinkerPlots software. Moreover, Fitzallen [13] from her research indicates that Tinkerplots provide interactive and cohesive learning experience especially in evaluating data analysis. Furthermore, Allmond [5] pointed out that, from her research on the variability in data using TinkerPlots, students are able to develop statistical thinking and reasoning by using Tinkerplots. From the above researchers' positive result, TinkerPlots is one of the dynamic software that could help in statistical subject in teaching and learning session.

3 Methodology

According to Garfield and Chance [14], there are several classroom assessment and techniques available to evaluate statistical reasoning. The assessments and techniques include the case studies, concept maps or the Statistical Reasoning Assessment (SRA) as to name a few. Although the SRA developed by Garfield in 1998 is widely used, this research aim is to get a thorough feedback on the statistical reasoning on variation specifically with the aid of TinkerPlots software.

This case study involves four diploma students from a private institution in Cyberjaya, Selangor as the research participants. Due to some restriction during the process of data collection of the research, the participants are selected randomly among existing students. The detailed information from the four participants is collected separately through online interview and observations while the research participants attempting the items in three structured activities using TinkerPlots.

Based on the statistical reasoning assessment discussed in the earlier part of this paper, this research instruments are being adapted from several resources in order to match with the research objectives. With the integration of technology as part of the learning process in developing statistical thinking and reasoning, the statistical reasoning assessment tool from Chan [15] is being referred as main backbone on designing the structured activities in this research. As stated by Chan [15], the content of the technology-based assessment tools was validated by Associate Professor Edward Mooney, Associate Professor Robert C. delMas, and Dr. Chris.

4 Findings and Summary

This research has successfully investigated the ability to explain their understanding of variation, to analyze variation and make connection of descriptive statistics with the reasoning of variation interactively using TinkerPlots. All the research questions presented in this research were being answered from the result of the interview transcription and recorded video observation.

From the overall result of the research, on average, the participants achieved level four of the statistical reasoning framework where they developed meaningful understanding of variation and were able to do statistical reasoning about variation by visualizing and exploring with TinkerPlots to answer the questions, making prediction and conjecture in the structured activities. The first structured activity took some time as participants are very new in handling the TinkerPlots software and the researcher needs to guide them in using the TinkerPlots software. After the first attempt of handling the software in question one and two of the first structured activity, participants start to work independently in answering questions using the software. Minor help needed while creating boxplot and histogram.

Comparing the result in this research with the earlier result by Chan [15], this research may show an overachievement in the result with an average of level four of the statistical reasoning assessment for the whole four constructs. However, the structured activities done in the first two parts of the sessions may help the participants in guiding their understanding in developing the proper statistical thinking and reasoning.

In between the activities, participants were asked on their satisfaction of using the software. All participants were enjoying the dynamic software of TinkerPlots upon answering the question and they mention that it helps them in reducing time on calculation and drawing graphical representation and as a tool to check their calculation. TinkerPlots has an interactive animated feature with color coded data and it helps them in observation while they manipulating the data in order to develop understanding, making comparison and prediction.

Overall, based on the observation and the interviews, in term of interpretation and explanation, the participants were not able to express their thoughts and understanding

in written form properly. They seem to be lacking of terms, words and proper phrase to use in explaining statistical observation, prediction, comparison and conclusion which sometimes lead to the different meaning of their understanding as compared to their verbal explanation.

From the feedback of the research participants, none of them have experience using TinkerPlots. Only one participant mentioned that he had one-time experience using software in high school. Teachers should take this opportunity to explore the usage of technology integrated activities in their statistical classroom. TinkerPlots is not the only available dynamic software that can be used in the classroom. There is other free software that can be used such as Geogebra software and CODAP. The Malaysian government has invested a sum of money specifically on the usage of mathematical software in the teaching and learning session which is the Geometer's Sketchpad. All of the above-mentioned software has its own specific features that could cater not only mathematics subjects but also statistics subject.

In future studies, researcher may consider on increasing the number of samples as this will provide more precise result. Moreover, researcher could do specific research on the diploma students' understanding and achievement on the variation and further the research by conducting pre-test and post-test to measure the students' understanding on variation using TinkerPlots. Although the suggestion might seem to be a lengthy research, the combination of qualitative and quantitative research may produce more accurate result on the students' understanding and reasoning.

Limitations

Due to the restriction of movement control order during the data collection timeframe, all interviews were conducted online whereby the meetings are through the application of Google Meet. The participants need to share their screen while answering the questions of all the structured activities with the researcher and the communication are through the application using microphone and camera. Researcher was able to capture the participants' reaction as well as monitor the progress smoothly. During the session, there was no internet connection problem between the researcher and the participants. All sessions are being conducted in a formal manner and recorded successfully.

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