Impact of Using Tinkerplots on Statistical Reasoning

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Abstract

In this 21st century of learning, students are not only required to know how to do the calculation procedures but more importantly they must be able to justify their solutions by reasoning. This is particularly important in the teaching and learning of statistics in schools. This study aims at investigating the impact of using TinkerPlots in statistical reasoning among Year Five pupils. The research was conducted in an international school. The research utilized the quasi experimental research design. Two intact classrooms were selected with one classroom as the control group while the other was the experimental group. The experimental group went through intervention using TinkerPlots whereas the control group went through the traditional method. The research conducted pre- test and post-test for both the groups. The findings show that a significant difference existed between pre-test and post-test for the experimental group. In conclusion, the students' statistical reasoning results improved using TinkerPlots. The study implies that using TinkerPlots enhances students' reasoning skills. Implementing teaching and learning statistics using TinkerPlots would help students explore data, concepts and test their conjectures. This would support the student-centered learning where teachers facilitate the students to develop their ideas and knowledge.

1. Introduction

Statistics education plays an important role in mathematics because the students are exposed to real world situations and have to make decisions wisely based on the interpretation made and be able to give reason for their choice. Moreover, statistics education is also an emerging field that grew out of different disciplines and is currently establishing itself as a unique field of study. The two main disciplines from which statistics education grew are statistics and mathematics education [1]. It is followed by the point that statistics education has been the focus for researchers in many disciplines, perhaps because statistical reasoning is used in many disciplines and provides so many interesting issues and challenges [2].

2. Teaching and Learning Statistics

In the past three decades, statisticians in business, industry, and academia have promoted statistical thinking as an important outcome for students learning statistics. The importance of statistics was underscored in what has since become one of the most influential documents in statistics education [3]. [4] recommended that students gain multiple experiences with the messy process of data collection and exploration, discussions of how existing data are produced, experiences which ask them to select appropriate statistical summaries and draw evidence-based conclusions. According to [5], if students equate statistics with mathematics, they may expect the focus to be on a single correct outcome. However, statistics offers distinctive and powerful ways of reasoning that are distinctly different from mathematical reasoning.

3. Teaching and Learning Statistics with Technology

[6] stated in parallel to these developments, statistical “packages” such as SPSS (http://www.spss.com) and BMDP (http://www.statistical-solutions-software.com) were developed for supporting the statistical practitioner. For many decades these two tools were characterized as a “black box” with a collection of statistical methods, where the user analyzed the statistical problem, selected the appropriate method (predominantly numerical), and obtained the corresponding results. However, neither interactive working styles nor statistical graphs were very much supported with these packages at that time. [7] explained that technologies for learning statistics should mirror the theory and practice of professional statistics packages to keep the gap between learning statistics and using statistical methods professionally as small as possible. Another perspective is to use technology to improve statistics learning. The focus in this perspective is on other affordances of technology, such as making statistics visual, interactive and dynamic, focusing on concepts rather than computations, and offering the opportunity to experiment with data to make it engaging for students.

[8] discussed many technological tools available for statistics instruction. Choosing technology or a combination of technologies most appropriate for the student learning goals could involve a complex set of considerations and decisions about how to best choose and use these tools, how often to use them, and for what purposes and activities. Many types of technological tools and resources support statistics teaching and learning. These include: (a) statistical software packages, (b) spreadsheets, (c) applets/stand-alone applications, (d) graphing calculators, (e) multimedia materials, (f) data repositories, and (f) educational software. The goal of this section is to provide an overview of these types of tools and common examples of each, and to highlight the software requirements from an educational perspective [6].

[9] implemented a recent study using the TinkerPlots software to enhance statistical reasoning of primary five and six graders. They were able to construct plots and utilize plots to support their thinking on the given data. From these three studies, they noticed that the TinkerPlots software is a dynamic graphing software package that is usually used in primary schools and middle schools. Moreover, [10] stated by using the dynamic software in statistics such as TinkerPlots the students are able to develop their understanding in statistics including grasping of basic concepts before they study advanced topics in normal distribution. TinkerPlots empower students to use their ability to create graphical representation, which will enable them to develop their visualization skills, thinking skills, concepts and understanding.

4. Statistical Reasoning Studies with Technology

According to [11], in a series of studies on children’s understanding about chance and distribution, these researchers examined students’ emergent understanding of randomness while engaging with software especially designed to support their probabilistic reasoning. The students’ understandings were then analyzed by comparing them to experts’ meanings for randomness. Unlike the experts, the children shifted rapidly between four meanings for randomness. Moreover, their choices for these meanings seemed to be triggered by seemingly superficial (from the statistical viewpoint) aspects of the data. These findings helped the researchers re-design the software to better steer the micro-evolution of students’ knowledge toward the focus of the expert’s aspirations. Progress in the understandings of teaching and learning of statistical reasoning and the availability of high quality technological tools for learning statistics have enabled the relatively young field of statistics education to integrate and readily capitalize on these advances [1].

5. Purpose and Research Questions

The research objective is to find out the impact of *TinkerPlots* in statistical reasoning among Year Five pupils. Overall, the research gives importance to the following two research questions:

1. Is there any significant difference in the mean score of the post test between the control and experimental group?
2. Is there any significant difference between the mean score of the pre test and post test of the experimental group?

6. Methodology

The research utilized the quasi experimental design. The research targeted students in an international school. The research population comprised all students who are studying in Year Five in international schools. Random sampling design was used in this research by selecting two classes of students from the particular school. A total of 46 students were selected as the research sample. Their age group is 9-11 years old; they consisted of different ethnicity from Malaysia and internationally such as: America, New Zealand, UK, Korea, Pakistan and India. A class of 23 students was selected as the experimental group while the other class consisting of 23 students was chosen as the control group.

All the students were given a pre-test before they were introduced to *TinkerPlots Software*. Then, the experimental group underwent intervention for a month using *TinkerPlots Software*. The students had to spend two days in a week with an hour for each slot. They were introduced to the software for the first intervention, and students started to familiarize with the software. The students were given a project to conduct later. They had to collect the data, analyze and interpret the data using the *TinkerPlots* software. Meanwhile, the control group was taught using the traditional method. The intervention for experiment group planned for 10 lessons as shown in Table 1.

Table 1
Lesson Planning for Interventions

LESSON/ LEARNING OBJECTIVE	TEACHER ACTIVITIES	STUDENT ACTIVITIES
Lesson 1 & 2 **Learning Objective:** I can create the cards (data) in *TinkerPlots*	Teacher to introduce the *TinkerPlots* Software and the main functions of the software: Cards, Table, Plot, Slider, Text. Teacher to ask students to insert the cards and add the values or insert table as shown in the slides prepared to continue the values of the attributes.	1. Students to add the attributes and values in *TinkerPlots* which are given in the PowerPoint slide as Figure 1. 2. Students to answer the questions on the paper (Intervention 1) attached in appendix.
Lesson 3 **Learning Objective**: I can draw the bar chart/ line graph	Teacher to give input on what types of graphs can be chosen for data representation. Teacher to remind students on how to draw bar chart and line graphs by showing examples on Smart board.	1. Students will be given graph paper to plot the graphs (bar chart/ line graph). 2. Students to refer to their data analysis on *TinkerPlots* as Figure 2 and draw the graphs. 3. Students answer the worksheet after drawing the graph.

Lesson 4&5 **Learning Objective**: I can analyze bar /line graph using data	Teacher to facilitate the children to insert the data in *TinkerPlots*. Teacher shows a few ways of exploring the data.	1. Students collect the data within class about favorite subject and least favorite subject. 2. Students will start inserting the data they have collected in *TinkerPlot Software*. 3. Students to try out as teacher and explore new ways of analyzing the data like Figure 3. 4. Students compare with the Talk Partner and discuss the inference. 5. Students will do the worksheet based on the analysis.
Lesson 6&7 **Learning Objective:** I can collect data	Teacher to prepare questionnaire and remind students what types of data will be collected.	1. Students will be given a questionnaire about can drinks (Intervention 4) attached in appendix. 2. Students will survey students from other classes. They do the survey in the cafeteria by randomly choosing the participants. 3. Students insert the data collected in the *TinkerPlots Software*.
Lesson 8 **Learning Objective:** I can analyse and interpret data	Teacher gives a few examples of interpreting data from the analysis.	1. Students to analyze the data using the software as Figure 4. 2. Students interpret the data. 3. Students to answer the questions on the worksheet given.
Lesson 9 **Learning Objective:** I can create my own survey	Teacher encourage students to propose a few ideas to survey at home or school. Teacher gets feedback from the students.	1. Students choose the area they would like to conduct research. 2. Students design their survey form. 3. Students make conjectures.
Lesson 10 **Learning Objective:** I can collect, analyse and interpret data	Teacher to remind students to check whether the conjectures made are the same or not. Teacher to have a whole class discussion about the survey conducted by each student.	1. Students collect data for their topic of interest. 2. Students to key in the data collected in *TinkerPlots.* 3. Students analyze the data as Figure 5. 4. Students to create questions based on the analysis and Talk Partner to answer the questions. Students need to evaluate the answers given by the Talk Partner. 5. Students to answer the question given by the teacher.

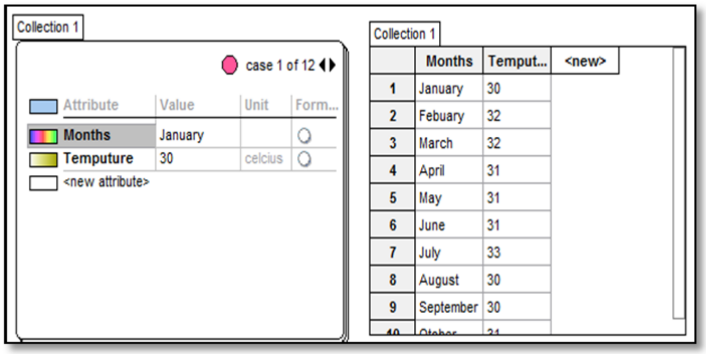

Figure 1

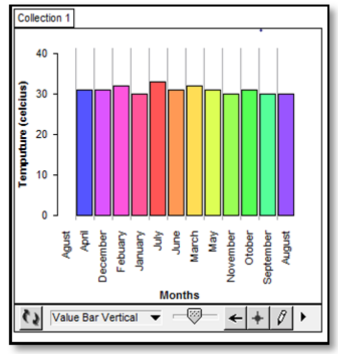

Figure 2

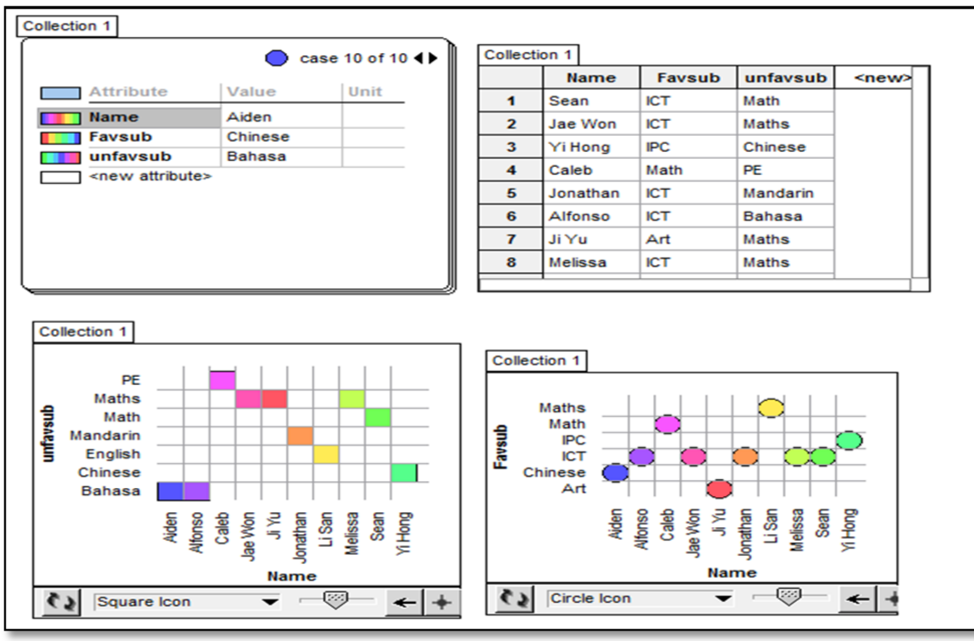

Figure 3

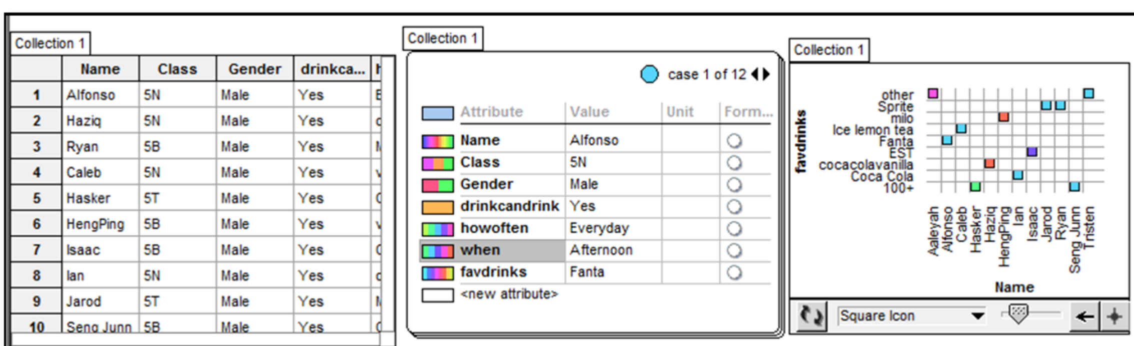

Figure 4

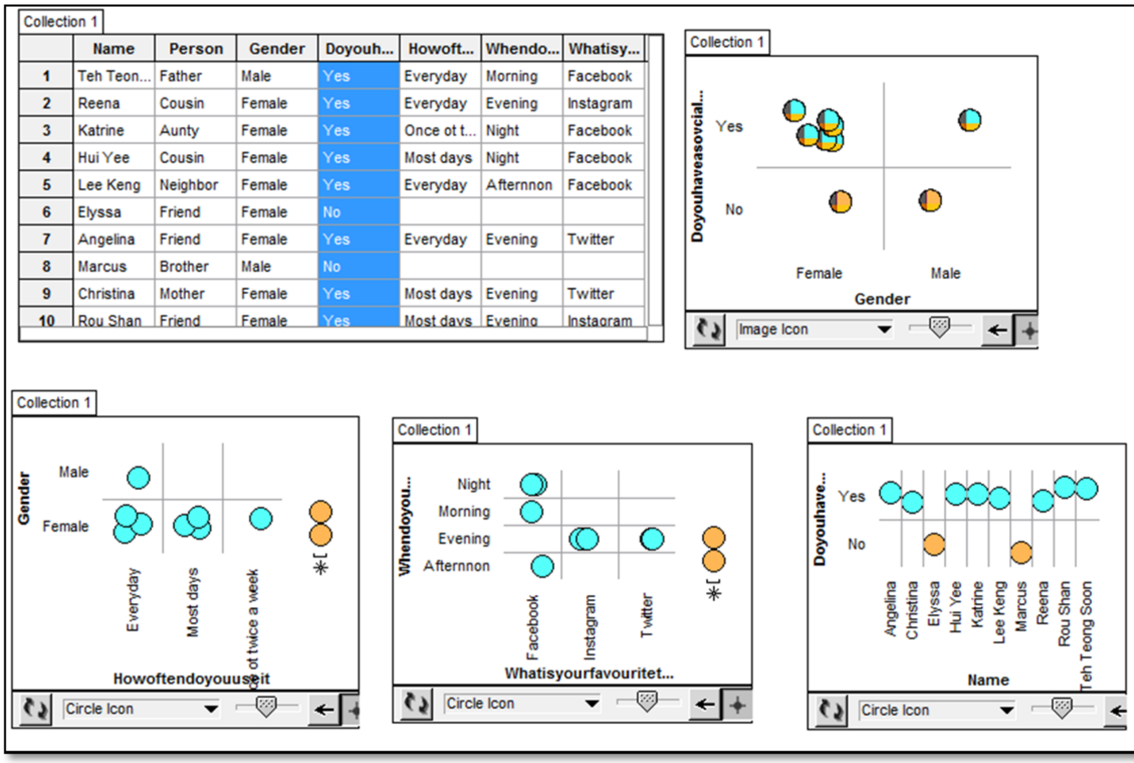

Figure 5

After the end of the interventions, both the experimental and control groups were given post-test. The results for pre-test and post-test were entered into a computer, in SPSS for analysis. Paired sample *t*-test and independent *t*-test were used for analysis and interpretation of the results.

7. Results

To answer "Is there any significant difference in the mean score of the post test between the control and experimental group?"

Table 2

Descriptives

	Group		Statistic	Std. Error
PostTest	Experiment	Mean	15.0870	.56901
		Median	15.0000	
		Variance	7.447	
		Std. Deviation	2.72885	
		Minimum	9.00	
		Maximum	20.00	
	Control	Mean	11.0000	.70008
		Median	11.0000	
		Variance	11.273	
		Std. Deviation	3.35749	
		Minimum	6.00	
		Maximum	17.00	

Table 3

Independent Samples t-test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	*t*	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Post-Test	Equal variances assumed	1.001	.323	4.530	44	.000	4.08696	.90216	2.26878	5.90513
	Equal variances not assumed			4.530	42.236	.000	4.08696	.90216	2.26663	5.90728

An independent samples *t*-test was conducted to determine the significant difference between post-test in the experimental group using *TinkerPlots* and control group on students' statistical reasoning skills. According to the descriptive statistics in Table 2, the post test mean score of the experimental group is higher (*M* = 15.087, *SD* = 2.729) than the control group (*M* = 11, *SD* = 3.357). Table 3 showed the results of the Levene's Test for Equality of Variances is to determine if the equal variances assumptions has been met. According to Levene's Test, the homogeneity of variance assumption was satisfied (*F*= 1.001, *p*= .323). There was a significant difference in the scores for the experimental group, *t* (44) = 4.530, *p* <.05. The effect size was = 1.33 and interpreted using Cohen's guide (1988) there as very large effect difference between the sample and hypothesized proportions. These results indicate that the students in the experimental group using *TinkerPlots* performed better in post-test than the students in the control group.

To answer "Is there any significant difference between the mean score of the pre-test and post-test of the experimental group?"

Table 4

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Before Intervention	23	6.00	16.00	9.5652	2.51949
After Intervention	23	9.00	20.00	15.0870	2.72885
Valid N (listwise)	23				

Table 5
Paired Samples t-Test

		Paired Differences					*t*	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Before Intervention - After Intervention	-5.52174	2.23341	.46570	-6.48754	-4.55594	-11.857	22	.000

Table 4 shows the mean score of pre-test and post-test in experiment group using TinkerPlots. It shows the magnitude of the difference between the tests and can be seen which test has a higher mean. The post-test has higher mean (M = 15.087, SD = 2.729) than the pre-test (M = 9.565, SD = 2.519). A paired samples t-test was conducted to determine the significant difference between pre-test and post-test in using *TinkerPlots* on students' statistical reasoning skills. Based on Table 3, there was a significant difference in the scores for the experimental group (M = -5.522, SD = 2.233), t (22) =-11.857, p<.05. The effect size was = 2.53. According to Cohen's (1988) interpretation, this is interpreted as a very large effect. There is nearly two standard deviation units of difference between the means of the pre-test and post-test scores. These results proves that the students in experimental group using *TinkerPlots* performed better in post-test after using *TinkerPlots* for data handling.

8. Discussion and Conclusion

The findings of the study indicate that using technology has the most effect on statistical reasoning compared to the traditional method of teaching. There is a significant difference in post-test scores between the control group and experiment group. The study supported the conclusion by [7] stated that technologies for learning statistics should mirror the theory and practice of professional statistics packages to keep the gap between learning statistics and using statistical methods professionally as small as possible. [12] discussed the many technological tools available for statistics instruction. Choosing technology or a combination of technologies most appropriate for the student learning goals could involve a complex set of considerations and decisions about how to best choose and use these tools, how often to use them, and for what purposes and activities.

Furthermore, the study also showed that integrating *TinkerPlots* in learning data handling enhanced students' reasoning skills. The students performed better after using *TinkerPlots*. As supported by [1], progress in the understandings of teaching and learning of statistical reasoning and the availability of high quality technological tools for learning statistics have enabled the relatively young field of statistics education to integrate and readily capitalize on these advances.

[13] suggested statistical reasoning refers to the ability to understand and integrate statistical concepts and ideas in order to interpret data and make decisions based on a given context. In addition, positive stimulation of students' self and value beliefs about statistics has beneficial effects. These motivational factors influence the development of adequate statistical thinking during the teaching and learning process, the structural application of the knowledge obtained in real life situations, and future interest in statistics.

In conclusion, the students can develop their statistical reasoning skill by using *TinkerPlots* software in learning. Research suggests that teachers should use the software in teaching and learning for data handling since it is user friendly for primary students.

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