UMT PRESS

Journal of Mathematical Sciences and Informatics
Journal Homepage: https://journal.umt.edu.my/index.php/jmsi
eISSN: 2948-3697
DOI: http://doi.org/10.46754/jmsi.2025.06.002

SHORT-TERM CAMPS AS CATALYSTS FOR ENHANCING STATISTICAL SKILLS PERFORMANCE IN A MULTINATIONAL SETTING

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ARTICLE INFO

Article History:
Received 10 September 2024
Revised 5 March 2025
Accepted 10 April 2025
Published 15 June 2025

Keywords:
Short-term Camps; statistical analysis; students' performance.

ABSTRACT

Short-term educational programmes can boost academic performance. This study explored how the Awesome Math Camp 2023 impacted students' statistical skills. The camp included participants from Malaysia, Thailand, and Indonesia and consisted of 34 participants, 13 males and 21 females. Using the bar chart analysis, Kolmogorov-Smirnov test, paired t-test, and Spearman's rank correlation, the study assessed the camp's impact. The bar chart analysis was used to illustrate survey data on students' interest in statistics before and after a camp. The Kolmogorov-Smirnov test was used to check for normality in data, the paired t-test was used to compare the difference of means for two related groups and Spearman's rank correlation was used to measure the strength and direction of association between two ranked variables. The bar chart shows that the number of students who were very interested after the programme increased while the number of students in the interest and less interest categories decreased after the programme. Descriptively, it showed an improvement in the post-test compared to the pre-test, which is an 87.9% increase. The analysis of pre-test and post-test scores showed significant improvements in students' statistical skills where the *p*-value was equal to 0.00000048 which is less than 0.05. However, Spearman's rank correlation found no significant link between specific statistical items and score changes, suggesting that overall exposure to statistical concepts is more important. The study concludes that short-term camps can significantly improve statistical skills and increase interest in the subject, demonstrating the potential of targeted, short-term educational interventions to provide significant benefits in a limited timeframe.

2020 Mathematics Subject Classification:

Introduction

STEM stands for science, technology, engineering, and mathematics and refers to any subjects that fall under these four disciplines [1]. Statistics is one of the big focuses of mathematics. STEM careers are increasingly vital as technology advances with high demand projected to persist, yet there is a shortage of STEM professionals. Significant government investment underscores the importance of STEM education for maintaining competitiveness, prompting initiatives to encourage diverse participation and offering incentives like scholarships [2]. Developing students' statistical understanding is crucial in today's educational institutions to enable them to make well-informed decisions across an abundance of subjects. Short-term camps are increasing acceptance

as an opportunity to give students practical experience while improving their statistical knowledge. However, not much research has been done on how successful these camps are, particularly in nations like Malaysia, Thailand, and Indonesia. According to [3], a short-term camp is an overnight programme, whether one-time or continuing one to three nights in length. But, for the national training programme, the format or duration does not matter. This short-term camp runs for five days continuously with two days for formal classes and three days for outdoor activities.

This study aims to bridge that gap by investigating how short-term camps affect students' statistical performance. Besides, this study aims to quantify the impact of a short-term mathematics camp on statistical understanding among students from diverse backgrounds. Therefore, 34 students from three schools in these nations have been the focus of the researcher's attention. Test results from before and after the camps are being documented, together with the participants' Likert scale ratings on 11 statistical subjects. The researcher is also interested in determining if there's any correlation between how students rate their understanding and their actual scores on the tests. The researcher is also investigating whether these camps improve students' interest in statistics. Tests and surveys are used to do this. The data will be demonstrated using statistical tools such as Kolmogorov-Smirnov test, Spearman's rank correlation coefficient and t-tests. The researcher encourages us to know more about the way short-term camps may improve students' performance and interest in statistics by learning these factors. Data was analysed using Microsoft Excel and IBM SPSS.

Literature Review

Short-term Influence on Student's Performance

At a math camp in Pojoaque, New Mexico, the focus is on building students' problem-solving skills, appreciation for mathematics, and confidence in their ability to learn advanced math [4]. This academic summer camp plays a crucial role in student's development, as shown in the benefits found in [5] study on ADHD children's summer camps, which foster discipline and address behavioural issues effectively. Research, including [6] at UiTM Perlis and [5] in Kulim, Kedah, shows short-term camps improve students' academic performance and skills. [7] found math camps enhance problem-solving abilities and positively impact students' personalities and academic inclinations. Additionally, studies by [8] and [9] highlight camps' benefits on academic knowledge, healthy behaviours, empathy, assertiveness, and emotional self-control. [10] and [11] found summer programmes improve safety, behaviour, health, social development, and academic achievement. Lastly, [12] showed short-term medical camps significantly improve participants' skills, serving as a model for healthcare institutions.

Statistical Method

The article from [13] highlighted that surveys have advantages like greater statistical power, large data collection, and validated models. Pre-tests and post-tests assess students' capabilities, showing improvement after lessons, as seen in [14] English learning study. [15] discussed hypothesis construction, with the null hypothesis indicating no relationship between variables while the alternative hypothesis suggests a relationship. [16] noted that the Kolmogorov-Smirnov test for normality is versatile for various distributions. [17] explained that paired T-tests compare the means of two groups, suitable for before-and-after measurements, and [18] stated they are more powerful than unpaired T-tests. Pearson correlation is for normally distributed data, while Spearman

rank correlation is for non-normal, ordinal, or data with outliers [19]. Spearman correlation is non-parametric and useful for ordinal and continuous data [20]. [21] noted bar graphs are easy to understand, create, and interpret.

Factor of Short-term Camps Influence Student's Performances

According to [22], it was found that camp and mentoring programmes significantly improved students' assessment marks and readiness for upper secondary education, raising average marks by 15% of a standard deviation and readiness by 18% points. The performance gap between boys was narrowed by up to 35% overall and 80% between similar boys with academic competencies increasing by 22% points and personal competencies by 11 points. [23] revealed that study habits, motivation, personality traits, and learning approaches significantly impact academic performance. [24] identified communication, learning facilities, proper guidance, and family stress as factors affecting student performance, with positive impacts from the first three and a negative impact from family stress, [25] highlighted that lack of motivation is the main factor affecting student performance with other factors including parenting style, student characteristics, internet effectiveness, teacher effectiveness, and career choices. According to [26] found that attitudes of parents, students, peers, and teachers positively influence student performance, with self-motivation being crucial for academic success [27, 28, 29] emphasised the importance of teaching aids, teacher competency, motivation, parental education, and socioeconomic status in academic performance. In addition to evaluating the performance before and after the camp, this study will also assess the level of interest of the participants before and after participating in this camp, which is expected that the interest of the participants will increase camp based on some statistical items included in this camp module.

Data and Methodology

Collecting Data

The data was collected from an Awesome Math Camp 2023 – Programme that took place at Universiti Malaysia Terengganu, involving schools from three countries, namely Malaysia, Thailand, and Indonesia. There are 34 participants, and all are involved in this study. The probability sampling method is applied. In total, 13 male students and 21 female students are directly involved in this camp. Each participant will answer a set of questions before and after attending the camp and two sets of data were collected, known as pre- and post-test scores, as shown in the following Table 1. It will meet the requirements for using a quantitative research method. Besides, students are asked to answer a survey that covers their level of understanding through a scale of 1-5 of statistical terms like Table 2 based on the topic delivered during class session. The qualitative data provided a comprehensive understanding of the influence of short-term camps on statistical performance.

Table 1: Pre-post test scores of 34 participants

Student	Pre-test Scores	Post-test Scores
1	12	20
2	7	13
3	9	5
4	5	5

5	5	12
6	8	13
7	8	13
8	10	15
9	3	13
10	4	10
11	3	13
12	6	10
13	5	15
14	5	20
15	6	20
16	14	20
17	8	15
18	2	2
19	9	5
20	9	2
21	8	19
22	7	18
23	7	18
24	7	16
25	6	11
26	0	0
27	7	18
28	7	15
29	6	10
30	7	12
31	5	8
32	5	9
33	9	6
34	4	18

Table 2: Survey question about student understanding of each item

No.	Statistical Item	Scale				
1	Frequency table	1	2	3	4	5
2	Bar chart	1	2	3	4	5
3	Box plot	1	2	3	4	5
4	Average	1	2	3	4	5
5	Mode	1	2	3	4	5
6	Median	1	2	3	4	5
7	First and third quartiles	1	2	3	4	5

8	Range	1	2	3	4	5
9	Interquartile range	1	2	3	4	5
10	Scatter plot	1	2	3	4	5
11	Correlation	1	2	3	4	5

The Likert scale in the table refers to the student's understanding level of each statistical item. Scale 5 (very understanding), scale 4 (understand), scale 3 (lower understanding), scale 2 (not understand), scale 1 (very not understand).

Table 3: Survey question about student interest rate

Scale	Refer To
3	Very interested
2	Interested
1	Not interested

The components in the data were students' scores on the pre-test and post-test, survey data about student interest level in the statistics field and the survey data about students' understanding of 11 statistical items. The 11 statistical items that have been questioned are displayed in Table 2 and Table 3 refers to student's options about their interest level.

Bar Chart

A bar chart was used to illustrate survey data on students' interest in statistics before and after a short-term camp. The survey grouped interest levels into very interested, interested, and not interested. By comparing these groups, changes in enthusiasm due to the camp were assessed. The bar chart effectively tracks changes over time, making it ideal for this analysis, and its simplicity aids in presenting and interpreting the data. This clear visual representation helps communicate the survey results efficiently.

Kolmogorov-Smirnov Test for Normality

The Kolmogorov-Smirnov (K-S) test is a non-parametric test used to check for normality in data. This study applied the K-S test to determine if students' pre- and post-test scores were normally distributed, a crucial first step for further analysis. The hypotheses were:

H_0: *The data of students' pre-test and post-test scores are normally distributed*

H_1: *The data of students' pre-test and post-test scores are not normally distributed*

The test compares the Empirical Distribution Function (EDF) of the sample with the Cumulative Distribution Function (CDF) of the normal distribution. The K-S statistic is the maximum absolute difference between the EDF and CDF.

The methodology that has been carried out is based on the following formula:

(1) Empirical Distribution Function (EDF):

$$F_n = \frac{1}{n}\sum_{i=1}^{n} I(X_i \leq x)\,, \tag{1}$$

where I is the indicator function, n is the sample size and X_i is the sample data points

(2) Cumulative Distribution Function (CDF):

$$F(x) = \frac{1}{2}\left[1 + \text{erf}\left(\frac{x-\mu}{\sigma\sqrt{2}}\right)\right], \tag{2}$$

where μ is the mean, σ is the standard deviation and erf is the error function

(3) The K-S statistic:

$$D_n = \sup_x \ |F_n(x) - F(x)|, \tag{3}$$

where *sup* denotes the supremum (the least upper bond)

The K-S statistic Dn measures the largest difference between a sample distribution and a reference normal distribution. A small Dn indicates a good fit, while a large Dn suggests a deviation from normality. To test significance, compare the maximum absolute difference to the critical value from the Kolmogorov-Smirnov table. For α = 0.05 and n = 34, the critical value is 0.227. If the maximum absolute difference exceeds this critical value, reject the null hypothesis of normality; otherwise, conclude the data is normally distributed.

The Paired t-test

The paired t-test is a statistical method used to compare the means of two related groups, which are the pre-test scores and post-test scores. The purpose is to find out the significant impact that short-term camps have on improving students' statistical performance and uncover their considerable influence on their academic performance.

The following hypotheses have been the focus of this investigation.

H_0: There is no significant difference in the mean scores between the pre-test scores and the post-test scores.

H_1: There is a significant difference in the mean scores between the pre-test scores and the post-test scores.

Based on the sample data above, the method will be conducted using the formulas below:

(4) Calculate the difference d_i between pre-test scores and post-test scores.

$$d_i = X_{1i} - X_{2i}, \tag{4}$$

where X_{1i} are pre-test scores and X_{2i} are post-test scores.

(5) Calculate the Mean of the Differences $\bar{d}$.

$$\bar{d} = \frac{1}{n}\sum_{i=1}^{n} d_i, \tag{5}$$

where n is the number of pairs.

(6) Compute the Standard Deviation of the Differences S_d.

$$S_d = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(d_i - \bar{d})^2}, \tag{6}$$

(7) Find the *t*-Statistic *t*.

$$t = \frac{\bar{d}}{s_d / \sqrt{n}}, \tag{7}$$

(8) Determine the Degree of Freedom (df)

The degree of freedom (df) for the paired *t*-test is *n*-1.

The degree of freedom (df) = 33

(9) Compare with Critical Value:

For α = 0.05 and df = 33, the critical value from the t-distribution table is approximately ± 2.035. If *t* is greater than or less than 2.035, we reject the null hypothesis.

Spearman's Rank Correlation

Spearman's rank correlation measures the strength and direction of association between two ranked variables (student understanding scale for each statistical item and change in students' scores). Changed student score data was recorded by differentiating the pre-test and post-test scores as in Table 4. The student interest scale for each statistical item is in the form of a Likert scale.

Table 4: Change in students' score

Student	Change in Scores
1	8
2	6
3	-4
4	0
5	7
6	5
7	5
8	5
9	10
10	6
11	10
12	4
13	10
14	15
15	14
16	6
17	7
18	0
19	-4
20	-7
21	11
22	11

23	11
24	9
25	5
26	0
27	11
28	8
29	4
30	5
31	3
32	4
33	-3
34	14

To conduct an analysis using the data that has been recorded above, the following hypotheses have been the focus of this investigation.

H_0: There is a significant relationship between understanding levels in each statistical item and changes in students' scores.

H_1: There is not a significant relationship between the understanding level each statistical item and changes in students' scores.

Based on the sample data of change in students' scores and the Likert scale data of student understanding of statistical items, the method will be carried out using the formulas below:

(1) Rank the data

Rank the values of each variable. Assign ranks from 1 to n = 34 for each value, where n is the number of observations. Assume x as the variable for student understanding of statistical item (frequency table) and y as the variable for change in students' scores.

(2) Calculate the difference between the ranks, d_1 and squared the difference between the ranks, d_i^2 .

(3) Each of the calculations was sorted in a table like the following.

Student	**Variable x**	**Variable y**	**Rank x**	**Rank y**	$\boldsymbol{d_1}$	$\boldsymbol{d_i^2}$**.**
1						
n						

(4) Then, sum up the squared difference between the ranks, $\sum d_i^2$.

(5) Apply the Spearman's Rank, ρ with the formula:

(6) $\rho = 1 - \frac{6\sum d_i^2}{n(n^2-1)}$, (8)

where d_1, is the difference between ranks, d_i^2 is the square the difference,

$\sum d_i^2$ is the sum of the squared difference between the ranks.

(7) Repeat the step for each statistical item.

The value of Spearman's rank correlation coefficient ρ ranges must be from -1 to 1. The value of 1 indicates a perfect positive correlation while -1 indicates a perfect negative correlation and no correlation for the value of 0.

Result and Discussion

Bar Chart

Survey data about student interest levels was recorded and displayed using a bar chart in Figure 1 to make it easier for readers to assess the level of student interest level before and after their participation in this short-term camp.

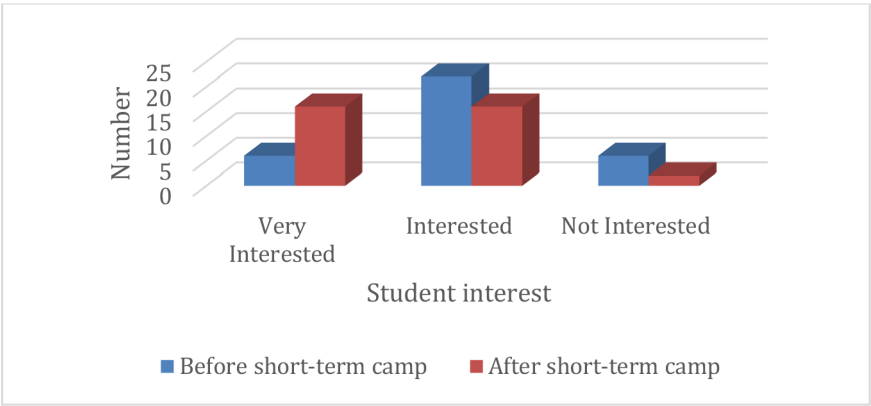

Figure 1: Student's interest in statistic

The bar chart indicates significant changes in students' interest in statistics after the short-term camp. Initially, six students were not interested in statistics, but this number dropped to two after the camp. It can be said that participating in this camp increased their interest in statistics. Before the camp, six students were very interested and 22 were interested, changing to 16 each after the camp. Although the number of students interested in statistics decreased by 27.3%, the number of very interested students increased by 166.67% with most students shifting to the very interested level. It seems that attending this camp has a positive impact on interest levels. Several factors may influence this positive effect such as comfort during the camp, willingness to learn some things, excitement to participate in a foreign camp and ability to share opinions with new friends from a foreign country. These factors can be investigated for future research.

Kolmogorov-Smirnov Test

After conducting the Kolmogorov test for normality on both the pre-test scores and post-test scores of the 34 school students involved, Table 5 shows the descriptive result.

Table 5: The descriptive result

Test	Sample Size	Mean	Standard Deviation	Maximum Absolute Difference
Pre-test scores	34	6.5588	2.74349	0.043137
Post-test scores	34	12.3235	5.68741	0.08026

According to Table 5, the mean pre-test score is 6.5588, while the mean post-test score significantly rises to 12.3235, indicating improved performance after the intervention. The standard deviation for pre-test scores is 2.7435, and for post-test scores, it is 5.6874, showing increased variability after the intervention. The maximum absolute difference for pre-test scores is 0.0431 and for post-test scores is 0.08026, both less than the critical value of 0.227, indicating normal distribution. Based on the Kolmogorov-Smirnov test, with a critical value of 0.227 for n = 34 at $\alpha = 0.05$, the maximum absolute differences for pre-test and post-test scores (0.0431 and 0.08026, respectively) were below the critical value. Thus, the null hypothesis was accepted, confirming that both pre-test and post-test scores are normally distributed.

The paired T-test

After performing a paired t-test on pre-test scores and post-test score data, the results were recorded in Table 6.

Table 6: The Paired T-test results

Test	*n*	Mean	Sd	*t*-statistic	*p*-value
Pre-test scores	34	6.65	2.743	-6.238269935	0.000000479312
Post-test scores		12.32	5.687		

The *p*-value of 0.000000479312 was much smaller than $\alpha = 0.05$, leading to the rejection of the null hypothesis and indicating a significant difference between pre-test and post-test scores. The mean score improved from 6.65 in the pre-test to 12.32 in the post-test, showing effective learning and retention. The standard deviation increased from 2.743 to 5.687, suggesting varied levels of improvement among students. The *t*-statistic of -6.238269 further supports the significance of the results. Overall, these findings demonstrate that the instructional method significantly enhanced students' performance and understanding.

Spearman's Rank Correlation Test

The Spearman's rank correlation test was conducted to understand each statistical item and data change in scores. The descriptive results in Table 7 show the correlation between each statistical item and the change in students' scores.

Table 7: The Spearman's rank correlation test

No.	Statistical Items	*p*-value	ρ	Observation	
1	Frequency Table	0.13494	0.141558	Weak Positive Correlation	Not significant
2	Bar Chart	0.17265	0.084034	Very Weak Positive Correlation	Not significant
3	Box Plot	0.11739	0.01902	Very Weak Positive Correlation	Not significant
4	Average	0.14241	0.11441	Weak Positive Correlation	Not significant
5	Mode	0.17609	0.01688	Very Weak Positive Correlation	Not significant

6	Median	0.19802	0.027578	Very Weak Positive Correlation	Not significant
7	First and third quartiles	0.14202	-0.00129	Negligible Negative correlation	Not significant
8	Range	0.13763	0.19534	Weak Positive Correlation	Not significant
9	Interquartile range	0.12597	0.037892	Very Weak Positive Correlation	Not significant
10	Scatter plot	0.12208	-0.1081	Weak Negative Correlation	Not significant
11	Correlation	0.07548	-0.06791	Very Weak Negative Correlation	Not significant

Table 7 shows that Spearman's rank correlation analysis found weak positive and negative correlations between understanding of each statistical item and students' change scores, but none were statistically significant (all p-values > 0.05). This indicates that the level of knowledge in each statistics item does not significantly impact the student's change score before and after the programme. While some correlations were observed, they were typically weak or very weak, suggesting that these factors are not primary determinants of students' scores. Although weak and negligible correlations were noted, the null hypothesis was rejected, indicating no significant relationship between understanding certain statistical items and students' change scores. It was found that their understanding did not affect them when answering pre- and post-tests. This result contradicted the initial assumption. Maybe they guess the answer and are lucky to guess the correct answer. It may also be that they search for answers using the Google website. Various factors may affect their test, which can be investigated in future studies, such as language factors, diligence when answering questions, understanding of the question itself, and so on. Those factors become interesting to study.

Conclusions

In conclusion, this study successfully achieved its three primary objectives. Firstly, it demonstrated that short-term camps significantly improve students' statistical performance. The analysis of pre- and post-test scores, validated by the Kolmogorov-Smirnov test and paired t-test, showed marked improvement, highlighting the effectiveness of such camps in enhancing statistical understanding and skills in a short time. Secondly, the study revealed that short-term camps positively impact academic skills. Although Spearman's rank correlation indicated a weak relationship between understanding specific statistical items and test score improvements, the overall enhancement in academic skills was evident. This suggests that the comprehensive exposure to statistical concepts during the camp has a beneficial effect on students' academic abilities. Lastly, the study found that participation in short-term camps increased students' interest in statistics. Survey results, visualised through bar charts, showed a notable rise in enthusiasm for the subject post-camp, indicating that the camp effectively fostered greater interest and engagement in statistics.

There are some interesting gaps to explore in the future. It seems that attending this camp has a positive impact on interest levels. Other factors may influence this positive effect such as comfort during the camp, willingness to learn some things, excitement to participate in a foreign camp and ability to share opinions with new friends from a foreign country. These factors can be investigated

for future research. In addition, it was found that their understanding did not affect them when answering pre- and post-tests. This result contradicted the initial assumption. Maybe they guess the answer and are lucky to guess the correct answer. It may also be that they search for answers using the Google website. Various factors may affect their test, which can be investigated in future studies, such as language factors, diligence when answering questions, understanding of the question itself, and so on. Those factors also become interesting to study.

Conflict of Interest Statement

The authors declare that they have no conflict of interest.

Acknowledgements

We would like to thank Universiti Malaysia Terengganu for facilitating our research successfully.

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