

## The Effectiveness of FEFA in Teaching and Learning Foundations of Applied Mathematics

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### ABSTRACT

*Memorizing formulas is one of the essentials tasks in learning activities. There are many formulas that have been constructed by previous researchers. The formulas developed have their own purpose such as to calculate, to estimate, to analyse and so on. One of the fields that involve more than a hundred formulas is in the education field. In education area, especially for mathematics subjects, students need to memorize the formula to let them easily get the answer to some of the questions given. In UiTM Perak Tapah Campus, there is one subject that requires students to memorize more than twenty formulas. The subject namely the Foundation of Applied Mathematics, which is taken by part three students in the Faculty of Applied Sciences. In previous semester, the failure rate for this subject is increasing and always be the top issue by top management. In this paper, the effectiveness of formula extracted from the given Appendix (FEFA) techniques is discussed. FEFA is one of the tools which will help students to reduce the total number in memorizing the formula. Primary data were gathered using the Quizizz application among 81 students who are taking MAT238 in the semester September-December 2019. The data was analysed by mixed design analysis to assess the effectiveness between pre-workshop and post-workshop. FEFA is found to be one of the good mechanisms to assist students in learning activities.*

**Keywords:** teaching and learning, foundations of applied mathematics, FEFA, Mixed Design

### INTRODUCTION

Nowadays, teaching and learning mathematics has become more challenging, especially in gaining students' involvement in the classroom (Khalid et al., 2018). At the university level, student involvement in all mathematics subjects is essential for them to understand all the topics that have been taught by the educator. Traditionally, in learning mathematics, the formula and concepts are shown without explaining the origin form. These make most of the learners' perception of mathematics is a subject that has a tonne of arbitrary rules, algorithms, theorems, and formulas given by the lecturer to the student. Based on Abdulnour, Nackasha, Hanson, and Coyle (2019), the reason for the formula is given without the derivation is due to the time constraint that faced by instructors. The instructors need to cover all theories and concepts within a limited time in the hope that the students will find the derivation on their own. However, doing this will cause students to be unaware of the importance of the formula derivation. Hence, the students unable to solve most of the questions that is beyond the sets of rules and need critical analysis. This scenario has been proved by Abdulnour et al. (2019) that focus on engineering students at the University of Toronto. Based on that study, the normal practice among engineering students in solving the mathematics questions is memorizing all the formulas and problem solutions without understanding how formulas are derived and unable to find the patterns that connect these kinds of formulas to the

concepts they are learning in class. As the result, they are unable to answers all the problem-solving questions. This finding shows that encouraging critical thinking and reasoning in the classroom is an important part of learning math-based courses.

This scenario not only happens at the university level, but it also occurs at elementary schools. According to Karakus (2014), who is studied about pre-service elementary mathematics teachers' views about geometric construction. He found that pre-service teachers attempted to learn geometry concepts during their past experiences by memorizing formulas or rules and solving problems. This reveals that memorizing a formula, rules, and solving the problems represent the most preferred method of learning geometry.

Furthermore, from the view of instructors' perspective in teaching traditional calculus and its teaching strategies, Ahuja, Lim-Teo, and Lee (1998) believed that the teachers should show how to derive the formulas. So, it will lead students to think creatively rather than just dumping the formulas to them. Ahuja et al. (1998) and Pale (2016) also suggest that the teachers should encourage students to think more about how to get the formula and allow them to experience the excitement that comes from making sense of mathematics, not just memorize the formula as it is. Supposedly, in mathematics problem-solving, students should be guided by reasoning structured not by formula. The reasoning structured can be defined as three main headings. The three main reasons are the ability to interpret the problem, avoid memorization, and focus on the subject and its aspect. It was further found that when students develop formulas by themselves, try different methods, and associate their learnings with daily life, a huge contribution is made to understanding the subject (Ozdemir and Uzel, 2011).

## **PROBLEM DESCRIPTION**

In UiTM Perak Tapah Campus, diploma in Science (AS120) is a program offered by the Faculty of Applied Sciences. There are three mathematics courses offered to AS120 students in the whole semester. For the past semester, the failure rate of mathematics subjects was in the worrying stages especially for the foundation of applied mathematics (MAT238) subjects. Many reasons are identified as high failure factors such as, lack of exercise, not interested in calculation subjects, lack of understanding in basic knowledge of mathematics, many formulas to remember and so on.

In order to tackle the high failure rate, the lecturers have initiated a mathematics workshop named as "Formula Extracted from Appendix" (FEFA) technique. The underlying reason for the high failure rate is the students need to remember more than twenty formulas. The program was made compulsory to all students including repeaters of this subject.

Attempting to memorize formulas and problem solutions without understanding their origin is common among Applied Science students. Most of them are unaware or disregard of how the formulas are derived and they do not find the patterns that connect these formulas to the concepts they are learning in class. In FEFA technique, students are taught how to derive formula from the origin. Once mastered and understanding how to derive the formula and mathematical patterns will save students time by giving them tools to quickly solve the difficult problems.

FEFA technique workshop was held on 8th November 2019. This workshop is conducted by an experienced lecturer who has been teaching for more than 5 years. This workshop will teach how to use the provided appendix wisely by extracting the other formulas creatively. There were two topics covered in this workshop as listed in Table 1. In order to check the effectiveness of the workshop, the students were required to answer two sets of tests which are known as pre and post-workshop tests. The pre-workshop test will be held at the beginning of the workshop which is before the technique is introduced

and the post-workshop test is at the end of the workshop. This technique will increase the students' understanding of how to apply the correct formula rather than just memorizing the formulas.

Table 1: The Workshop Contents

Chapter	Topic	Descriptions
Chapter 1	Inverse Trigonometric Functions	<ul style="list-style-type: none"> <li>This chapter covered differentiation and integration involving inverse trigonometric functions.</li> <li>There are 12 formulas in this chapter (6 for differentiation and 6 for integration)</li> <li>In the provided appendix, there are only 3 integration formulas.</li> </ul>
Chapter 2	Hyperbolic and Inverse Hyperbolic Functions	<ul style="list-style-type: none"> <li>This chapter covered differentiation and integration involving hyperbolic and inverse hyperbolic functions.</li> <li>There are 24 formulas in this chapter (6 for differentiation of hyperbolic functions, 6 for integration of hyperbolic functions, 6 for differentiation of inverse hyperbolic functions and 6 for integration of inverse hyperbolic functions)</li> <li>In the provided appendix, there are only 8 integration formulas for hyperbolic and inverse hyperbolic functions.</li> </ul>

## RESEARCH METHOD

Memorizing formulas is found to be a common problem faced by Foundations of Applied Mathematics (MAT238) students. Therefore, the FEFA technique is introduced to the students. This technique will assist students in extracting other formulas from the given appendix during their exams. By using this technique, the number of formulas that need to be memorized can be reduced and at the same time, the students' understanding of applying the formula will be increased.

The population of this research is all full-time students of Diploma in Science in UiTM Tapah Campus who had attended the FEFA workshop for Foundations of Applied Mathematics (MAT238) course for the semester September – December 2019. Since all the students in this population have equal probability to be chosen as the sample, then the sampling method that will be used in this study is a Random Sampling Method as suggested by Taherdoost (2016). According to Jawale (2012), this method of sampling is the least biased method of sampling.

In data collection, primary data were gathered from the students who had attended the workshop. The students were required to answer two sets of tests (pre-workshop and post-workshop) through the Quizizz application. This application is one of the platforms that offers an instructive game-based application, which permits multiplayer exercises in concurrent and convert study hall practices into a more intelligent and fun experience (Zhao, 2019). Besides that, according to Junior (2020), this application has a lot of advantages. Some of the advantages are it can be accessed using mobile devices and available in both operational systems, iOS and Android. The students of lecturers are not required to download any application in order to answer or create the quiz. So, it is very convenient to everyone.

The pre-workshop test was given to the participants at the beginning of the workshop before the technique was introduced. The test consisted of 10 questions that were designed to have two levels of the question. 5 questions need to apply the basic knowledge of calculus (direct application of formula) and the other 5

questions are required to apply substitution before applying the formula. The results of this test were taken as a pre-workshop score. At the end of the workshop, they were given the same set of questions to measure the understanding and the effectiveness of this technique to the students and it will be called a post-workshop test. The results from this test now were taken as post-workshop scores. In this study, 81 students were involved in the sampling. The main criteria of the sampling is the students must answer both questionnaire (pre-workshop and post-workshop).

The scores from both tests will be compared and analysed. The analysis method that will be used in this research is the mixed model ANOVA in statistical software SPSS. According to Field (2009), the mixed design analysis is the analysis that consists of the mixture of between groups and repeated measure variables. The independent variable is suggested to be less than four variables to make it able to interpret the interaction. Therefore, in this study, the mixed design analysis was used to assess the effect of time factors (Pre-workshop and Post-workshop) and two targeted variables (Basic Knowledge and Applied Knowledge). Hence, it will measure the effectiveness of FEFA technique in students' understanding.

## FINDINGS AND DISCUSSION

Table 2: Two levels of workshop variable

Within-Subjects Factors	
Measure: MEASURE_1	
Type_workshop	Dependent Variable
1	Pre_workshop
2	Post_workshop

Table 3: Sample size for basic and applied knowledge

Between-Subjects Factors			
		Value Label	N
Knowledge	0	Basic_knowledge	81
	1	App_knowledge	81

The first two tables simply list the two levels of the type of workshop variable and the sample size for basic knowledge and applied knowledge. Several statistics are presented in the next descriptive table (Table 4). The most relevant for the study purpose are the two marginal means for Type\_workshop (Pre\_workshop and Post\_workshop) and the four cell means representing the before-after workshop scores of basic and applied knowledge. As stated in the table, mean for basic knowledge has increased from 3.3086 (pre-workshop) to 4.4321 (post-workshop). Similar to the mean of applied knowledge that has dramatically rise from 2.7531 (pre-workshop) to 4.4321(post-workshop). In addition, the average of mean also positively changed from 3.0309 (pre-workshop) to 4.4321 (post-workshop). Furthermore, this finding can be supported by the value of standard deviation of the mean. The average standard deviation for pre-workshop is 1.20775 while the standard deviation for post-workshop is 0.80276. As the value is a little bit more than one and another less than 1, thus it points out that the values tend to be close to

the mean. Hence, the result indicated that there is a statistically increase of both basic and applied knowledge score from the pre-workshop to the post-workshop.

Table 4: Descriptive Statistics

	Knowledge	Mean	Std. Deviation	N
<b>Pre_workshop</b>	Basic_knowledge	3.3086	1.11402	81
	App_knowledge	2.7531	1.24027	81
	Total	3.0309	1.20775	162
<b>Post_workshop</b>	Basic_knowledge	4.4321	0.72350	81
	App_knowledge	4.4321	0.87946	81
	Total	4.4321	0.80276	162

The table shows the result of Tests of Within-Subjects Effects, the results for the main effects of the within-groups factor, type\_workshop, and type\_workshop x knowledge interaction effect (Table 5). The most relevant portions of this table are the F-values, significance levels and effects sizes. The Sig. column reveals probabilities for both type\_workshop main effect (0.000) and the type\_workshop x knowledge (0.018) are both less than 0.05, so we can conclude that these are both significant effects. Besides, the Partial Eta Squared for both shows a large and medium effect which is 0.514 for type\_workshop and 0.040 for type\_workshop x knowledge. This statement can be supported by Cohen (1988) who has discussed the time effect analysis.

Table 5: Tests of Within-Subjects Effects

Measure: MEASURE_1							
Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
<b>Type_workshop</b>	Sphericity Assumed	159.040	1	159.040	169.406	.000	.514
	Greenhouse-Geisser	159.040	1.000	159.040	169.406	.000	.514
	Huynh-Feldt	159.040	1.000	159.040	169.406	.000	.514
	Lower-bound	159.040	1.000	159.040	169.406	.000	.514
<b>Type_workshop * Knowledge</b>	Sphericity Assumed	6.250	1	6.250	6.657	.011	.040
	Greenhouse-Geisser	6.250	1.000	6.250	6.657	.011	.040
	Huynh-Feldt	6.250	1.000	6.250	6.657	.011	.040
	Lower-bound	6.250	1.000	6.250	6.657	.011	.040
<b>Error(Type_workshop)</b>	Sphericity Assumed	150.210	160	.939			
	Greenhouse-Geisser	150.210	160.000	.939			
	Huynh-Feldt	150.210	160.000	.939			
	Lower-bound	150.210	160.000	.939			

Table 6 presents the ANOVA results for our between-groups variable, knowledge. The probability in the Sig. column is 0.018 and less than 0.05, so we can conclude that the main effect for knowledge is significant.

Table 6: Tests of Between-Subjects Effects

<b>Measure: MEASURE_1</b>						
<b>Transformed Variable: Average</b>						
<b>Source</b>	<b>Type III Sum of Squares</b>	<b>df</b>	<b>Mean Square</b>	<b>F</b>	<b>Sig.</b>	<b>Partial Eta Squared</b>
<b>Intercept</b>	4511.361	1	4511.361	4103.828	.000	.962
<b>Knowledge</b>	6.250	1	6.250	5.685	.018	.034
<b>Error</b>	175.889	160	1.099			

### Estimated Marginal Means

This section organizes the means into three tables, one for the marginal means of each of the two main effects and a third table which displays the cell means for the interaction effect. The marginal means for the main effect of knowledge are shown in Table 7.

Table 7: Knowledge

<b>Measure: MEASURE_1</b>				
<b>Knowledge</b>	<b>Mean</b>	<b>Std. Error</b>	<b>95% Confidence Interval</b>	
			<b>Lower Bound</b>	<b>Upper Bound</b>
<b>Basic_knowledge</b>	3.870	.082	3.708	4.033
<b>App_knowledge</b>	3.593	.082	3.430	3.755

Recall that the main effects of gender was significant and the mean workshop score for basic knowledge (3.870) appears to be greater than applied knowledge (3.593). It is an appropriate interpretation since students who already sit for Calculus I, will have a good basic knowledge compared to applied knowledge.

Table 8: Type\_workshop

<b>Type_workshop</b>	<b>Mean</b>	<b>Std. Error</b>	<b>95% Confidence Interval</b>	
			<b>Lower Bound</b>	<b>Upper Bound</b>
<b>1</b>	3.031	.093	2.848	3.214
<b>2</b>	4.432	.063	4.307	4.557

Recall that the main effect for type\_workshop was significant, so it is appropriate to conclude that the mean for post\_workshop score was significantly higher (4.432) than the mean score for pre\_workshop (3.031) as shown in Table 8. Thus, this analysis shows that the workshop was effective in increasing the students' knowledge both in basic and applied knowledge. This situation is similar to the research conducted by Yusop et al. (2015) where the mathematical camp has given a positive impact on students' knowledge.

Table 9: Knowledge\*Type\_workshop

Knowledge	Type_workshop	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Basic_knowledge	1	3.309	.131	3.050	3.567
	2	4.432	.089	4.255	4.609
App_knowledge	1	2.753	.131	2.494	3.012
	2	4.432	.089	4.255	4.609

### Profile Plots

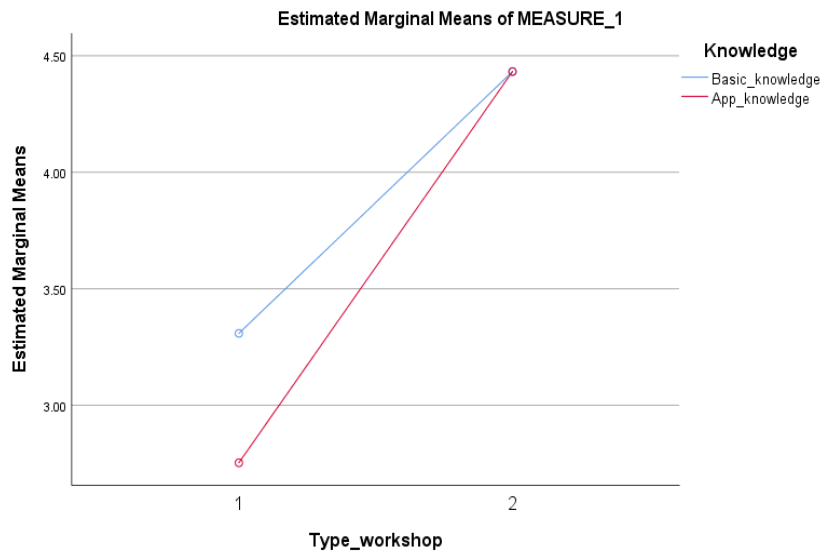


Figure 1: Estimated Marginal Means of MEASURE\_1

Besides that, the interaction of Type\_workshop x Knowledge was also significant. It can be seen in both Table 9 and Figure 1 that the effect of the workshop depended on the students' type of knowledge. Looking at the two lines, it can be seen that there is a dramatic increase in knowledge scores for both basic and applied knowledge. Both basic and applied knowledge has increased from pre\_workshop to post\_workshop. Further, the changes in applied knowledge looks more dramatic compared to basic knowledge. Hence, it shows that the new technique introduced during the workshop has positively improved the students' knowledge.

### CONCLUSION AND RECOMMENDATION

In this research, FEFA technique has been applied to all respondents that attended the workshop. Instead of only asking students to memorize the given formula, this workshop has introduced a technique to guide students in extracting the answer from the given formula provided in appendix. This technique has received good feedback from students, especially the weak students that are struggling in remembering all

the formulas. After the workshop, the students were given a set of post-workshop questions. The score was analysed and separated into two categories which are Basic Knowledge and Applied Knowledge. From the results, it showed that both Basic Knowledge and Applied Knowledge has dramatically increased from the pre-workshop to the post-workshop. Besides, there was a medium time effect for type\_workshop x knowledge, which indicated that the workshop has actually improved the students' understanding.

The finding indicated that a new introduced technique like FEFA is a good mechanism to assist students in the learning process. Other than only asking students to memorize, an innovative technique like FEFA can be introduced to guide students in avoiding simple mistakes in problem solving. This study has a few limitations as it is only conducted for non-mathematical students and involved a short period of time. As it is only involved students in Diploma Sciences, the result might be different when it is conducted on students in different background especially students who study mathematics. Therefore, it is suggested that future researches should involve students with different background of studies and involved certain period of time to measure the effectiveness of the FEFA techniques in solving mathematics problem. In addition, it is also advised to have experimental and control group to see a clear picture of the research. Finally, it is recommended that more creative and innovative techniques should be introduced to help students in solving mathematical problems.

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## CONFLICT OF INTERESTS DECLARATION

The authors declare no conflict of interests regarding the publication of this article.

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