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Mathematics' Procedural Knowledge of Form Four Daily School Students in District of Petaling Utama, Selangor

Pengetahuan Prosedural Matematik Murid Tingkatan Empat Sekolah Menengah Harian Biasa Dalam Daerah Petaling Utama, Selangor

Mazlini Adnan, Azhar Ahmad, Mohd Hairi Yusof & Nur Farah Atirah Baharudin

Department of Mathematics, Faculty of Science and Mathematics

Universiti Pendidikan Sultan Idris

Perak, Malaysia

***Abstract*— This study aimed to examine the level of students' procedural knowledge on mathematics. In addition, the difference between conceptual knowledge based on gender and program. Measurement of knowledge is based on the Procedural Knowledge Test (PKT). A total of 350 respondents were selected from four daily secondary schools in Petaling Utama, Selangor as a sample of the study. The data were analyzed using descriptive analysis to find out the level of variables measured. In order to identify the main effects and interactions between gender and program variables, inference analysis is a two-way ANOVA test performed for procedural knowledge dimension. ANOVA test showed no interaction effects between gender for procedural knowledge of mathematics ($p < 0.05$), but it showed a significant effect on the program ($p > 0.05$). In conclusion, mathematical knowledge is very important at the upper secondary level as a high level of mathematical thinking is required to ensure excellent in mathematical achievement. This is effectively as a long time learning system and methods as well as the imitation approach and dependent on the examinations orientation has long been a measure of student achievement. The implication of this study is that basic procedural knowledge of students' mathematics needs to be enhanced to realize Malaysia's aspiration to be in the top third place in international assessments such as TIMSS and PISA.**

Keywords*— procedural knowledge; secondary school mathematics

I. INTRODUCTION

Procedure is a specific step taken one by one (Effendi, Norazah & Sabri, 2007). Additionally, it also involves reading and graphing capabilities, geo builds and performing non-calculating skills such as rounding (Effandi et al., 2007). Rittle-Johnson et al. (2001) stated that the knowledge of procedural is the ability to perform a series of computational work to solve the problem. In other words, knowledge procedural can also be construed as a knowledge showcases capability or ability of a person to indicate measures systematically and orderly work in resolving an issue (Nor Hasnida & Nik Noralhuda, 2010). In the context of mathematics education in high school, procedural knowledge is clearly described as a work of calculations to solve a mathematical problem. In line with what Hiebert (2013) says that the procedural knowledge was divided into two parts, the first is step by step in solving a task and the second is the knowledge of symbolic meaning and its use when expressing ideas in mathematics.

Skemp (1971) details the instrumental and relational understanding that he explored it. Instrumental understanding is more like the current procedural knowledge. Among the importance of this instrumental understanding is that it is easier to understand than relational understanding because some topics such as the operation of two negative numbers or divide by a fraction that are difficult to understand conceptually, in this case, an understanding built instrumental or through a procedural path where students are exposed to the process of switching operations from two negative numbers to "minus multiply minus equal to plus"; and divide by fraction into "reverse the fraction and multiply". This knowledge has always been exposed to students from primary schools, especially through the study conducted by Ismail (2008) which finds that most teachers are still using traditional approaches where the need and process are explained rather than activities that build the concept of learning. As a result, most students on today has an understanding of mathematics in instrumental compared to the little that has understanding of relational or a good conceptual knowledge. However, if taken into account orientation of assessment in Malaysia for the past five decades, mathematics instrumental is a proven approach in producing students who are competent to solve mathematical problems quickly and correctly.

In addition, Ismail (2008) states that student motivation will also increase with the ability to produce correct answers based on this instrumental understanding. With immediate and clear returns or results, instrumental understanding or procedural knowledge, the probability of getting the correct answer to the given training is high. However, despite these advantages, procedural knowledge involves less knowledge than conceptual knowledge that sees the problem fundamentally and wholly.

In Mahayon's study (2005), students are more likely to practice instrumental or role-learning comprehension that causes them to create their own law or generalize laws between operations and use improper reasons for rationalizing the steps taken. This is because students do not understand the basic concepts of algebraic titles and carry out computational

operations based on the logic of logic and the harmony of derivative law created by them. However, if the students have understood the concept of algebra in a relational way (knowing both what to do and why), students will find that their understanding can be adapted to any new task. If they forget the method shown by the current teacher in the classroom, the pupils can rely on the existing understanding of "knowing how and why" to find the same method to solve the problem. However, the reality is that these students are not capable of pursuing their reasoning skills because they understand algebra in an instrumental way. In other words, this students memorizes the rules taught in the classroom. As a result, this student is unable to remember the procedures that the teacher has demonstrated and then try to resolve the problem by transferring the law from one operation to another (Mahayon, 2005).

II. METHODOLOGY

This study design in the form of survey that is using test as a main instrument. This method was conducted on form four students in algebraic topics of mathematic in five secondary schools in Petaling Utama. The population of this study is all form four students in Petaling Utama. The sampling method for this study is a random cluster sampling. The distribution statistics on form four students at secondary school in Petaling Utama are 6512, consisting of 3244 male students (49.82%) and 3268 pupils (50.18%) (PPD Petaling Utama, 2015). Sample size determination for this study was based on sample determination table by Krejcie and Morgan (1970). Therefore, the researcher selected a sample of 400 people involved in this study because taking into account the return of the questionnaire from respondents who normally did not get the full return (Chua, 2012). After the questionnaire received, only 350 respondents from 5 schools were selected to complete all the instruments. From these values, the percentage of science stream students (59.4%) (208) exceeds non-science stream students (40.6%) (142). The number of respondents by gender factor showed that the number of male students (53.4%) (187) was higher than female students (46.6%) (163).

Instruments for measuring this procedural level have been taken and modified from Nik Noralhuda (2011) study. Respondent's procedural knowledge (PK) (13 items) showing the value of Kuder Richardson 21 (KR21) obtained was 0.839 which is equivalent to the alpha of Cronbach 0.839. There are two parts in the instrument used, namely part A: personal information of respondents; part B: Procedural Knowledge Test. Part A contains questions to get respondents' demographic information in terms of program, gender and mathematical grade results at the end of form three. While part B is a question of procedural knowledge test (10 items) which involved optional questions and open questions. This test was analyzed using the SPSS version 21 program.

III. RESULT AND DISCUSSION

A. Procedural knowledge

Overall, the results of the data analysis for the procedural knowledge showed that overall PKT score mean score showed that the level of knowledge of the form four students of SMK in Petaling Utama was at an excellent level (min = 1.51, s.d = 0.975). Specifically, a total of 257 (73.4%) students were at an excellent level, 43 (12.3%) were at moderate level, 14 (4%) were at low level and 36 (10.3%) were very low. The results of this study indicate that the level of four-student PKT level is at an excellent level.

B. Procedural Knowledge of form four students based on gender and program

The template is used to format your paper and style the text. All margins, column widths, line spaces, and text fonts are prescribed; please do not alter them. You may note peculiarities. For example, the head margin in this template measures proportionately more than is customary. This measurement and others are deliberate, using specifications that anticipate your paper as one part of the entire proceedings, and not as an independent document. Please do not revise any of the current designations. Analysis of the difference score for knowledge and the effects of main factors on the independent variables was done using two-way ANOVA analysis.

TABLE I. LEVEL OF PROCEDURAL KNOWLEDGE BASED ON GENDER AND PROGRAM

Variable	Gender	Mean	s.d
Procedural Knowledge	Male	77.51	25.806
	Female	76.50	25.356

Interpretation of the mean value in Table 1 shows the level of procedural knowledge is high for both gender, mean = 77.51 and standard deviation = 25.81 for male while mean = 76.50 and standard deviation = 25.36 for female. From the mean value, it can be seen that female students have overcome male students in procedural knowledge.

TABLE II. LEVEL OF CONCEPTUAL KNOWLEDGE BASED ON PROGRAM

Variable	Program	Mean	s.d
Procedural Knowledge	Science	79.28	24.67
	Non-Science	73.77	26.57

The interpretation of the mean values as in Table 2 shows the level of procedural knowledge with mean findings for both streams is high that are science stream mean = 79.28 with standard deviation = 24.67 and non-science stream with mean = 73.77 with standard deviation = 26.57. In conclusion, the science stream students are higher in their mathematical procedural knowledge rather than non-science stream students.

C. Difference of Procedural Knowledge based on Gender and Program

Before the two-way ANOVA Test can be performed on the procedural knowledge score based on gender and program, testing of the score should be done using the Levene test.

TABLE III. MEAN SCORE OF PROCEDURAL KNOWLEDGE BASED ON GENDER AND PROGRAM

Gender	Program	Mean	s.d	N
Male	Science	79.85	25.014	103
	Non-Science	74.64	26.614	84
	Total	77.51	25.806	187
Female	Science	78.71	24.436	105
	Non-Science	72.50	26.693	58
	Total	76.50	25.356	163
Total	Science	79.28	24.671	208
	Non-Science	73.77	26.572	142
	Total	77.04	25.566	350

Table 3 shows the mean of each group. Mean for male science stream is 79.85, slightly different with male non-science stream with mean 74.64. Mean for female science stream is 78.71 also not much difference with non-science stream female which is 72.50.

TABLE IV. LEVENE TEST SCORE OF PROCEDURAL KNOWLEDGE BASED ON GENDER

F	dkl	dk2	Sig.
0.814	3	346	0.487

The Levene test in Table 4 above shows the variance of each group for independent variables (Score PKT) significantly different F (3,346) = 0.814, p > 0.05. This means the variance value in each group of respondents of the study is no different. The survey data comply with ANOVA test requirements.

TABLE V. ANOVA TEST OF PROCEDURAL KNOWLEDGE BASED ON GENDER AND PROGRAM

Source of Variation	Sums of Square	df	Mean Square	F	Sig.
Model Correction	2788.327[a]	3	929.442	1.427	0.235
Reflection	1931832.613	1	1931832.613	2966.431	0.000
Gender	222.778	1	222.778	0.342	0.559
Program	2698.478	1	2698.478	4.144	0.043
Gender * Program	20.785	1	20.785	0.032	0.858
Error	225326.030	346	651.231		
Total	2305575.000	350			
Total Correction	228114.357	349			

The results of the two-way ANOVA test showed that there was no significant effect of the independent variable Gender [F (l, 346) = 0.342, p> 0.05.] However, there was a significant effect of the independent variables Program [F (l, 346) = 4.14, p <0.05] against the dependent variable of the Procedural Knowledge Level. The effect of the interaction between the two independent variables of Gender and Program to the dependent variable did not exist significantly [F (l, 346) = 20.785, p> 0.05] (Table 5).

The main impact and effect of interactions between the two independent variables accounted for 1.2% of changes in dependent variables. This means that only a slight change of 1.2% of the Procedural Knowledge Level scores in this study is due to gender, Program and combination between gender and Program.

TABLE VI. MEAN OF PROCEDURAL KNOWLEDGE BASED ON GENDER

Gender	Mean	Standard Deviation	95% Confidence Interval	
			Lower Bound	Upper Bound
Male	77.249	1.876	73.559	80.938
Female	75.607	2.087	71.501	79.713

The data in Table 6 Estimated Marginal Means for the independent variables Gender shows the mean value of male (mean = 77.25) over the mean for female (mean = 75.61). This significantly indicates that male students are more likely to have a high level of procedural knowledge than female.

TABLE VII. MEAN OF PROCEDURAL KNOWLEDGE BASED ON PROGRAM

Program	Mean	Standard Deviation	95% Confidence Interval	
			Lower Bound	Upper Bound
Science	79.284	1.770	75.804	82.765
Non-Science	73.571	2.178	69.287	77.856

The data in Table 7, Estimated Marginal Means for Program-independent variables shows the mean value of the science stream (min = 79.28) over the mean of the non-science stream (min = 73.57). This significantly shows that students from the science stream are more likely to have a high level of procedural knowledge than students in non-science streams. The standard deviation value shows the difference obtained when the review is repeated. The small value of the standard deviation in the table indicates that if the review is re-performed, the approximate mean value will be obtained. This shows the data of this study is reliable.

TABLE VIII. MEAN SCORE OF CONCEPTUAL KNOWLEDGE FORM FOUR STUDENT

Gender	Program	Mean	Standard Deviation	95% Confidence Interval	
				Lower Bound	Upper Bound
Male	Science	79.854	2.514	74.909	84.800
	Non-Science	74.643	2.784	69.166	80.119
Female	Science	78.714	2.490	73.816	83.613
	Non-Science	72.500	3.351	65.909	79.091

In Table 8, the mean of the marginal estimation of the combined mean of both independent variables shows the mean value of male students in the science stream (min = 79.85), exceeding the mean value of male students in non-science stream (mean = 74.64) The science stream, (min = 78.71) solves the mean for female in non-science streams (min =

72.50). This suggests that significantly, for male students, a higher level of procedural knowledge for the program of science and the same situation also applies to female. This proves that gender variables have no significant impact on the level of procedural knowledge but program variables have a significant effect on the dependent variable.

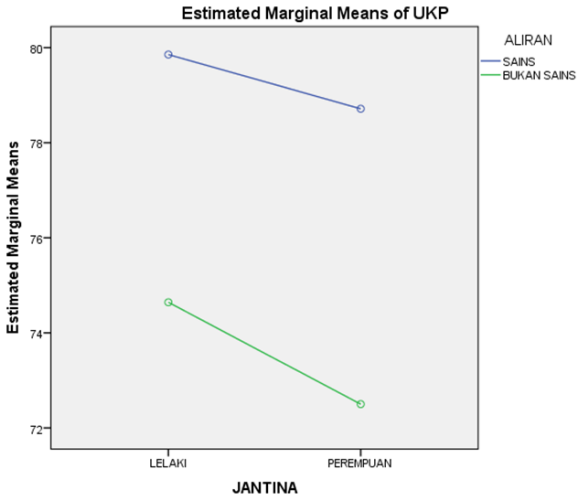

Fig. 1 Graph of Estimated Marginal Mean Procedural Knowledge on Gender

The graph in Figure 1 shows that there is a major effect of the program variable. However, in terms of gender, they do not interact (graphs are not cross-linked) against the dependent variables in this study. In this case there is a parallel effect of interaction between male and female students. Available to both gender of male and female, students from the science stream have higher levels of procedural knowledge than students from non-science streams.

The two-way ANOVA test results for gender and program samples on the variable dependent on the procedural knowledge level indicate that the main effects of the program-independent variables [F (l, 346) = 4.14, p <0.05]. However, for gender-independent variables [F (l, 346) = .342, p> 0.05], it was found to have no effect on the level of procedural knowledge of the form four students studied. The effect of the interaction between the two independent variables against dependent variables [F (l, 346) = 20.785, p> 0.05], does not exist significantly.

The results of the data analysis also showed that the main effects and interaction effects between the two independent variables accounted for as little as 1.2 % of the change in the level of procedural knowledge of mathematical form four students. This means that less than 2.0 % of the mathematical knowledge level score is due to gender and program factors while more than 98.0 % is due to other factors that have not been studied in this study.

The research data showed that for gender-independent variables, mean for male (mean = 77.25) was higher than for female (mean = 75.61). This shows that male students are more likely to have higher levels of procedural knowledge than female. For program independent variables shows the mean value of the science stream (mean = 79.28) over the mean of the non-science stream (mean = 73.57). Significantly, it indicates that students from the science stream are more likely to have a high level of procedural knowledge than students in non-science streams.

In addition, for the combination of both independent variables of the study, the results of the data analysis showed that the mean value of male students in the science stream (mean = 79.85), exceeds the mean value of male students in non-science stream (mean = 74.64) in the science stream, (mean = 78.71) coping mean for female in non-science stream (mean = 72.50). This suggests that significantly, for male students, a higher level of procedural knowledge for the program of science and the same situation also applies to female. This proves that gender variables do not have a significant impact on procedural knowledge but program variables have a significant effect on the dependent variable.

The graphs of both independent variable, steep, but not independent variables in the plots profile graph clearly show that the tendency of mastering procedural knowledge among form four students is influenced by gender and program factors. But both are unrelated or in other words both are aligned based on almost parallel lines.

This finding is in line with the study by Mahayon (2005), finding that the procedural process in algebra is more easily understood and followed by students based on the methods and approaches that have long been practiced by teachers through imitation and linear learning. In addition, students are also more likely to understand the process based on the procedure steps shown through examples and guides as in the reference book and the answer scheme given (Faridah, 2004). Through a study conducted by Ismail (2008), most teachers still use traditional approaches where the need and processes are given an explanation rather than an activity that builds the concept of learning. As a result, most of today's students have instrumental mathematics rather than those with relational understanding or good conceptual knowledge. This finding supports the findings of the researcher in this study which shows that most respondents are more in control of procedural knowledge. However, if taken into account with the orientation of assessment in Malaysia over the past five decades, instrumental mathematics is a proven approach in producing students who are competent to solve mathematical problems quickly and correctly.

IV. CONCLUSION

In conclusion, mathematical knowledge is very important in the upper secondary level since a high level of mathematical thinking is needed to ensure success in mathematical achievement. Thus, students are expected to achieve a formal level of thinking as the topics contained in

the upper secondary syllabus deal with abstract matters that require students to have an appropriate form of thought in looking at the relevance of the concepts of the new concepts learned. The findings show that mathematical knowledge of the dimensions of procedural knowledge shows that there are differences in which male students are more likely to master the procedural knowledge. According to psychology, girls are easier to understand a cognitive knowledge because of their ability to examine and analyze critically. However, boys are more focused on mastering hands-on or process knowledge. Based on the findings, it also shows that the program also affects students' mathematical achievement, especially at upper secondary level. In line with the findings of this study which shows students of science stream more prominent to master procedural knowledge than students in non-science streams.

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