Conceptual and Procedural Values and Skills in Mathematics of Teacher Education Students

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***Abstract*—**The mathematical skills that learners possess are said to be influenced by how they view mathematics learning. High level of knowledge of procedures in Mathematics is based on a solid foundation of conceptual knowledge. The study determined the level of conceptual and procedural values and skills of teacher education students and their relations to gender and learning resources and the difference of the conceptual and procedural values and skills among the respondent groups. Using descriptive-correlational and comparative designs, 265 elementary teacher education students served as respondents. Data from an adapted instrument was statistically treated using frequency counts, percentages, means, multiple regression analysis, and analysis of variance. An analysis of errors provided qualitative data. Majority of the respondents are female, have inadequate learning resources at home, and have very high conceptual and procedural values, very good procedural skills, and poor conceptual skills. The conceptual and procedural values and skills have no significant relationship to gender and learning resources. Procedural and conceptual values were not significantly related to procedural and conceptual skills. There is a significant difference in the procedural and conceptual values and skills among the respondents by year level. There is a need to strengthen conceptual skills as early as basic education.

***Keywords*—** Teacher education, conceptual values, conceptual skills, procedural values, procedural skills. mathematics

I. Introduction

Mathematical proficiency suggests a balance between procedural and conceptual understanding. Students should be engaged in doing mathematics, not only performing procedures but as well as exploring mathematics in the contexts that will make procedures useful. Mathematics education needs to consider the relationship between conceptual and procedural approaches and how these two impact and deepen student learning in mathematics.

Conceptual and procedural knowledge exist on a learning continuum and cannot be separated (Star, 2002). Although the two cannot always be separated, it is but necessary to distinguish them. Conceptual knowledge is defined as learning that involves understanding and interpreting concepts and the relations between concepts. Conversely, procedural knowledge is learning that involves only memorizing operations with no understanding of the underlying meaning (Arslan, 2010). The relationship between concepts and procedures has been examined in order to better understand children's tendencies to learn algorithms by rote without developing any understanding of what they are doing (Hiebert, 1986).

The mathematical skills that learners possess are said to be influenced by how they view mathematics learning. High level of knowledge of procedures in Mathematics is based on a solid foundation of conceptual knowledge. Even mathematicians had invented formulas based on mathematical concepts. In a mathematics class, it is observable that students can produce correct answers to various kinds of problems, but their understanding of the underlying concepts is lacking. Students are able to perform the required operations but there is little depth in understanding on how and why the process works. Procedural knowledge is important but students also need to have conceptual understanding.

The study was conducted to determine the level of conceptual and procedural values and skills of the teacher education students in the College of Education of the University of Eastern Philippines. It also tried to look into the significant relationship between the gender and learning resources of the respondents to their level of conceptual and procedural values and skills, and to find out the significant difference of the conceptual and procedural values and skills of the respondents in terms of year level.

II. Methodology

The study used the descriptive-correlational and comparative designs. An adapted instrument (Kajander, 2007) was used to gather data from 265 elementary teacher education students comprising of 100 freshmen, 69 sophomore and 96 juniors. The questionnaire is composed of two parts. Part I is a checklist about the conceptual and procedural values while part II is composed of mathematical exercises that will measure the respondents level of conceptual and procedural skills. The respondents' sex, learning resources, conceptual and procedural values, and conceptual and procedural skills were organized using frequency counts, percentages and weighted mean. The learning resources were categorized as: 0 - 2 (Inadequate); 3 - 4 (Adequate) and 5 (Very Adequate). The weighted mean for the respondents' level of conceptual and procedural values was classified as: 4.20 - 5.00 (Very High); 3.40 – 4.19 (High); 2.60 – 3.39 (Average); 1.80 – 2.59 (Low); and 1.00 – 1.79 (Very Low). The scores for the conceptual and procedural skills was categorized as: 9 - 10 (Excellent); 7 - 8 (Very Good); 5 - 6 (Good); 3 - 4 (Fair); and 0 - 2 (Poor). Multiple regression analysis was used to determine the relationship between the sex and learning resources of the respondents to their level of conceptual and procedural values and skills, while analysis of

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variance was used to find out the significant difference of the conceptual and procedural values and skills among the respondent groups

III. Results And Discussion

Table 1 presents the frequency distribution on the profile of the respondents in terms of sex, learning resources, and level of conceptual and procedural values and skills. Out of 265 respondents, 217 or 81.9 percent were female and 48 or 18.1 percent were male. The respondents' learning resources at home are inadequate.

Majority of the respondents had very good procedural skills where 122 or 46.0 percent had very good performance; 98 or 37.0 percent had good performance; 12 or 4.5 percent had excellent performance; and only less than 13.0 percent had fair and poor performance. An analysis of the items reveal that majority got correct answers in the first three questions on procedural skills which entail multiplication of decimals, subtraction of integers and addition of fractions. However, on the fourth question on stating the rule of a pattern, majority of the respondents had no answer. In the fifth question on computing the perimeter and the area of a figure, majority got correct in the perimeter question while most of the respondents got correct answer in the area question. However, a considerable percentage of respondents failed to indicate the correct unit of measure for area.

With regards to their level of conceptual skills, 215 or 81.1 percent had poor performance; 41 or 15.5 percent had fair performance; 8 or 3.0 percent had good performance and only 1 or 0.4 percent had very good performance. In contrast to the procedural skills, most of the respondents had no answer to the first three questions on conceptual skills. The questions asked how the procedure works in the procedural skills questions through illustrating the procedure through diagrams, drawings or models. Most of the respondents had answers but these were just reiteration of the procedure or the rules and not conceptualization of the mathematical principle. Majority had no answers in the fourth and fifth questions for conceptual skills.

Generally, the respondents did not perform well in the items that require conceptual skills. This shows that the respondents performed well in the items that require procedural skills. The result can be attributed to the fact that students can actually solve mathematical problems by following some rules or procedures but have little conceptual knowledge on how they were able to come up with the correct answers.

Majority of the respondents had very high level conceptual and procedural values in Mathematics. This shows that the respondents strongly believe in the importance of mastering procedures and the foundation concepts of these procedures. Tables 2a and 2b show the item analysis of the conceptual and procedural values.

Table 1a. Profile Of The Respondents

Profile	f	%
Sex		
Male	48	18.1
Female	217	81.9
TOTAL	265	100.0
Learning Resources		
Inadequate	198	74.7
Adequate	64	24.2
Very Adequate	3	1.1
TOTAL	265	100.0
Level of Conceptual Values		
High	41	15.5
Very High	224	84.5
TOTAL	265	100.0
Level of Procedural Values		
High	36	13.6
Very High	229	86.4
TOTAL	265	100.0
Level of Conceptual Skills		
Poor	215	81.1
Fair	41	15.5
Good	8	3.0
Very Good	1	0.4
TOTAL	265	100.0
Level of Procedural Skills		
Poor	4	1.5
Fair	29	10.9
Good	98	37.0
Very Good	122	46.0
Excellent	12	4.5
TOTAL	265	100.0

Test of Relationship between Respondents' Profile and Level of Procedural Values

Multiple regression analysis was utilized to test the relationship of respondent's profile and level of procedural values. Generally, the analysis result showed a significant R - value of 0.064 with a coefficient of determination equal to 0.004 (Table 2a) which means that only 0.4 percent of the variance in procedural values percentage can be attributed to the independent variables. An F- value of 0.534 and significance value of 0.587 (Table 2b) suggested a not significant relationship between the respondents' profile and level of procedural values because the p-value is greater than the 0.05 alpha level. Therefore, the effect of the independent variables is generally not significant.

Beta coefficient in table 2c indicated that the independent variables, sex ($\beta = 0.055$, sig. = 0.302) and learning resources ($\beta = .000$, sig. = 0.988) showed a not significant relationship with the procedural values. This entails that the respondents procedural values is not affected by their sex and their number of learning resources.

Table 2a. Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
.064	.004	-.004	.33068

a. Predictors: (Constant), Learning Resources, Sex
Dependent Variable: Procedural Values

TABLE 2B. ANALYSIS OF VARIANCE

	Sum of Squares	df	Mean Square	F	Sig.
Regression	.117	2	.058	.534	.587
Residual	28.650	262	.109		
Total	28.767	264			

TABLE 2C. BETA COEFFICIENTS

	Unstandardized Coefficients		Sig.
	B	Std. Error	
Sex	.055	.053	.302
Learning Resources	.000	.018	.988

Test of Relationship between Respondents' Profile and Level of Conceptual Values

To test the relationship of respondent's profile and level of conceptual values, multiple regression analysis was used. Generally, the analysis result showed a significant R - value of 0.018 with a coefficient of determination equal to 0.000 (Table 3a) which means no percent of the variance in conceptual values percentage can be attributed to the independent variables. An F-value of 0.045 and significance value of 0.956 (Table 3b) suggested a not significant relationship between the respondents' profile and level of conceptual values because the p-value is greater than the 0.05 alpha level. Therefore, the effect of the independent variables is generally not significant.

Beta coefficient in table 3c indicated that the independent variables, sex (β = 0.014, sig. = 0.789) and learning resources (β = -.002, sig. = 0.900) showed a not significant relationship with the conceptual values. This implies that sex and learning resources does not predict their level of conceptual values towards mathematics.

TABLE 3A. MODEL SUMMARY

R	R Square	Adjusted R Square	Std. Error of the Estimate
.018	.000	-.007	.33775

b. Predictors: (Constant), Learning Resources, Sex
Dependent Variable: Conceptual Values

TABLE 3B. ANALYSIS OF VARIANCE

	Sum of Squares	df	Mean Square	F	Sig.
Regression	.010	2	.005	.04	.95
Residual	29.887	26 2	.114	5	6
Total	29.898	26 4			

TABLE 3C. BETA COEFFICIENTS

	Unstandardized Coefficients		Sig.
	B	Std. Error	
Sex	.014	.054	.789
Learning Resources	-.002	.019	.900

Test of Relationship between Respondents' Profile and Level of Procedural Skills

To find the relationship of respondent's profile and level of procedural skills, multiple regression analysis was employed. The regression analysis showed an overall correlation value of 0.063 with a coefficient of determination equal to 0.004 (Table 4a) which means 0.4 percent of the variance in procedural skills can be attributed to the independent variables. An F- value of 0.526 and significance value of 0.592 (Table 4b) suggested a not significant relationship between the respondents' profile and level of procedural skills because the p-value is greater than the 0.05 alpha level. Therefore, the effect of the independent variables is generally not significant.

Beta coefficient in table 4c indicated that the independent variables, sex (β = -0.123, sig. = 0.616) and learning resources (β = -.078, sig. = 0.366) showed a not significant relationship with the procedural skills.

TABLE 4A. MODEL SUMMARY

R	R Square	Adjusted R Square	Std. Error of the Estimate
.063	.004	-.004	1.53796

c. Predictors: (Constant), Learning Resources, Sex
Dependent Variable: Procedural Skills

TABLE 4B. ANALYSIS OF VARIANCE

	Sum of Squares	df	Mean Square	F	Sig.
Regression	2.489	2	1.244	.526	.592
Residual	619.715	262	2.365		
Total	622.204	264			

TABLE 4C. BETA COEFFICIENTS

	Unstandardized Coefficients		Sig.
	B	Std. Error	
Sex	-.123	.245	.616
Learning Resources	-.078	.086	.366

Test of Relationship between Respondents' Profile and Level of Conceptual Skills

Multiple regression analysis was used to test the relationship of respondent's profile and level of conceptual skills. The regression analysis showed an overall correlation value of 0.067 with a coefficient of determination equal to 0.004 (Table 5a) which means 0.4 percent of the variance in conceptual skills percentage can be attributed to the independent variables. An F-value of 0.590 and significance value of 0.555 (Table 5b) suggested a not significant relationship between the respondents' profile and level of conceptual skills because the p-value is greater than the 0.05 alpha level. Therefore, the effect of the independent variables is generally not significant.

Beta coefficient in table 5c indicated that the independent variables, sex (β = -0.189, sig. = 0.438) and learning resources (β = -.066, sig. = 0.437) showed a not significant relationship with the conceptual skills.

TABLE 5A. MODEL SUMMARY

R	R Square	Adjusted R Square	Std. Error of the Estimate
.067	.004	-.003	1.52126

d. Predictors: (Constant), Learning Resources, Sex
Dependent Variable: Conceptual Skills

TABLE 5B. ANALYSIS OF VARIANCE

	Sum of Squares	df	Mean Square	F	Sig.
Regression	2.730	2	1.365	.590	.555
Residual	606.327	262	2.314		
Total	609.057	264			

TABLE 5C. BETA COEFFICIENTS

	Unstandardized Coefficients		Sig.
	B	Std. Error	
Sex	-.189	.243	.438
Learning Resources	-.066	.085	.437

Test of Relationship between Respondents' Level of Conceptual Values and Level of Conceptual Skills

To test the relationship of respondent's level of conceptual values and level of conceptual skills, multiple regression analysis was employed. The regression analysis showed an overall correlation value of 0.008 with a coefficient of determination equal to 0.000 (Table 6a) which means no percent of the variance in conceptual skills percentage can be attributed to the level of conceptual values. An F- value of 0.018 and significance value of 0.895 (Table 6b) suggested a not significant relationship between the level of conceptual values and the level of conceptual skills of the respondents because the p-value is greater than the 0.05 alpha level. Therefore, the effect of the independent variable is generally not significant.

Beta coefficient in table 6c indicated that the conceptual values (β = -0.037, sig. = 0.895) showed a not significant relationship with the conceptual skills.

TABLE 6A. MODEL SUMMARY

R	R Square	Adjusted R Square	Std. Error of the Estimate
.008	.000	-.004	1.52173

e. Predictor: (Constant), Conceptual Values
Dependent Variable: Conceptual Skills

TABLE 6B. ANALYSIS OF VARIANCE

	Sum of Squares	df	Mean Square	F	Sig.
Regression	.041	1	.041	.018	.895
Residual	609.016	263	2.316		
Total	609.057	264			

TABLE 6C. BETA COEFFICIENTS

	Unstandardized Coefficients		Sig.
	B	Std. Error	
Conceptual Values	-.037	.278	.895

Test of Relationship between Respondents' Level of Procedural Values and Level of Procedural Skills

To test the relationship of respondent's level of procedural values and level of procedural skills, multiple regression analysis was utilized. The regression analysis showed an overall correlation value of 0.111 with a coefficient of determination equal to 0.012 (Table 7a) which means that only 1.2 percent of the variance in procedural skills percentage can be attributed to the level of procedural values. An F- value of 3.305 and significance value of 0.070 (Table 7b) suggested a not significant relationship between the level of procedural values and the level of procedural skills of the respondents because the p-value is greater than the 0.05 alpha level. Therefore, the effect of the independent variable is generally not significant.

Beta coefficient in table 5c indicated that the procedural values (β = 0.518, sig. = 0.070) showed a not significant relationship with the procedural skills.

TABLE 7A. MODEL SUMMARY

R	R Square	Adjusted R Square	Std. Error of the Estimate
.111	.012	.009	1.52854

f. Predictor: (Constant), Procedural Values
Dependent Variable: Procedural Skills

TABLE 7B. ANALYSIS OF VARIANCE

	Sum of Squares	df	Mean Square	F	Sig.
Regression	7.722	1	7.722	3.305	.070
Residual	614.482	263	2.336		
Total	622.204	264			

TABLE 7C. BETA COEFFICIENTS

	Unstandardized Coefficients		Sig.
	B	Std. Error	
Procedural Values	.518	.285	.070

Test of Difference of the Conceptual and Procedural Values and Skills Among the Three Year Levels

Analysis of variance was used to test the difference of the conceptual and procedural values and skills among the three year level of the respondents. As shown in table 8, the resultant analysis of variance F- value of 15.260 and significance value of 0.00 (procedural values); F-value of 3.912 and significance value of .021 (conceptual values); F-value of 36.530 and significance value of .000 (procedural skills); and F-value of 17.534 and significance value of .000 (conceptual skills) suggested a significant difference among the three groups of the respondents because the p-values are lesser than the 0.05 alpha level. This implies that the three groups of respondents differ significantly and indicated diverse responses on their conceptual and procedural values and skills. The findings were in agreement with the study of Rittle-Johnson & Schneider (2014) where the symmetry of the relations between conceptual and procedural knowledge also varies between individuals.

TABLE 8. ANALYSIS OF VARIANCE

	Sum of Squares	df	Mean Square	F	Sig.
Procedural Values	3.001	2	1.501	15.260	.000
Between Groups	25.765	262	.098		
Within Groups	28.767	264			
Total					
Conceptual Values	.867	2	.433	3.912	.021
Between Groups	29.031	262	.111		
Within Groups	29.898	264			
Total					
Procedural Skills	135.672	2	67.836	36.530	.000
Between Groups	486.532	262	1.857		
Within Groups	622.204	264			
Total					
Conceptual Skills	71.899	2	35.949	17.534	.000
Between Groups	537.158	262	2.050		
Within Groups	609.057	264			
Total					

IV. Conclusions

The respondents have very high conceptual and procedural values. The procedural skills were very good, however, the respondents have poor conceptual skills. This means that majority of the respondents were able to get the correct answers on the given math problems but were not able to explain or represent the answers conceptually. The poor conceptual skills could also be attributed to the fact that the respondents have inadequate learning resources at home. The conceptual and procedural values and skills have no significant relationship to gender and learning resources. Procedural and conceptual values were not significantly related to procedural and conceptual skills. There is a significant difference in the procedural and conceptual values and skills among the respondents year level.

V. Recommendations

Based on the findings and conclusions of this study, the following are hereby recommended:

1. There is a need to strengthen conceptual skills in Mathematics as early as basic education.
2. Mathematics teachers are encourage to craft procedural lessons that will promote discovery of underlying concepts.
3. Further researches should be conducted. However, factors like age, individual differences, instructional methods, and other variables which could affect the procedural and conceptual knowledge, should be taken into consideration. Another research can also focus on the validity of measures of conceptual and procedural knowledge in mathematics

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