CONCEPTUAL AND PROCEDURAL KNOWLEDGE IN MATHEMATICS OF PRESERVICE TEACHERS IN THE COUNTRYSIDE

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Abstract

Mathematical competence rests on developing knowledge of concepts and procedures. It is, therefore, the aim of mathematics instruction to develop conceptual and procedural knowledge of students. This study examined the conceptual and procedural knowledge of the 151 randomly selected the first year preservice teachers using a validated teacher-made achievement test on signed numbers. The results of the study revealed that the level of conceptual and procedural knowledge of signed numbers was very high. Using Pearson's r at .05 level of significance, it was found out that students' conceptual knowledge and their procedural knowledge of signed numbers were not significantly related. Possible reasons were discussed, and recommendations were provided.

Keywords: signed numbers, mathematics competence, signed numbers test, student teachers, math instruction

I. INTRODUCTION

Mathematics instruction aims at conceptual understanding and computational skills. Consequently, conceptual learning and skill development are viewed as parallel processes that stimulate each other. Studies show that conceptual understanding facilitates the development of procedures (Blote, Klein, & Beishuizen, 2000; Carpenter, Franke, Jacobs, Fennema, & Empson, 1997; Hiebert & Wearne,1996). On the other hand, practicing skills to automatize them is an essential condition for reducing working memory load (Tronsky & Royer,2002), which in turn is necessary for the construction of new conceptual knowledge (Sweller,1988).

Also, Heibert (2013) also asserts that mathematical competence lies on developing knowledge of concepts and procedures. He pointed out that the relations between conceptual and procedural knowledge are often bi-directional and iterative. Resnick and Ford (1981) noted: "the relationship between computational skills and conceptual understanding is one of the oldest concerns in the psychology of mathematics."

In this study, conceptual knowledge is an implicit or explicit understanding of the principles that governs a domain and of the interrelations between units of knowledge areas. This knowledge is flexible and not tied to specific problem types and is, therefore, generalizable. Furthermore, it may not be verbalizable. To assess conceptual knowledge, researchers often use new tasks, such as counting in nonstandard ways or evaluating unfamiliar procedures. Since children are not familiar with the process for answering an activity, they need to bank on their knowledge of concepts to create ways for solving problems (e.g., Bisanz &LeFevre,1992; Briars & Siegler, 1984;

Gelman & Meck, 1983; Greeno et al., 1984; Hiebert & Wearne, 1996; Siegler & Crowley,1994). In contrast to conceptual knowledge, procedural knowledge is the capacity to “execute action sequences to solve problems.” This type is tied to specific problem types and therefore is not widely generalizable. To assess procedural knowledge, researchers typically use routine tasks, such as counting a row of objects or solving standard arithmetic computations, because children are likely to use previously learned step-by-step solution methods to solve the problems (e.g., Briars & Siegler, 1984; Hiebert & Wearne, 1996).

Research on this topic has tended to provide empirical support for the correlation of these two types of knowledge. For example, in a study, Rittle-Johnson & Alibali (1999), Rittle-Johnson, Sieger, Alibali (2001) found out that there is a causal relation between conceptual and procedural knowledge and suggest that conceptual knowledge may have a greater influence on procedural knowledge than the reverse. The relationship between the two types of knowledge at the elementary level had been extensively studied. However, studies like this are rare in the Philippine setting, especially at the college level. The aim of the present study was to investigate the conceptual and procedural knowledge of Freshmen Preservice Teachers on Signed Numbers and examine if there is a relationship that exists between the two types of knowledge.

II. METHODOLOGY

2.1 Design

This study employed the descriptive-correlational research design. It attempted to determine the relationship between the level of conceptual and procedural knowledge of the students in signed numbers.

Participants

The participants of the study were the 151 first-year preservice teachers of a State University of a lower class city of one of the poorest regions in the Philippines. This number constitutes 85% of the total enrollees of the year. Eighty-Six or 55% of them were enrolled in the Bachelor of Elementary Education (BEED) while the remaining 45% were enrolled in the Bachelor of Secondary Education (BSED) program. The age range of the students was 16 to 34 with a mean age of 17.57 years. Of the 151 students, the majority were females (81.46%) while only 18.54% were males. As to the last school attended, 138 or 91.39% graduated from public high schools, while only 13 or 8.61% graduated from private schools. The study utilized stratified sampling procedure. Seventy-seven (77) BSEd students and 74 BEEd students were the final respondents of the study. They were randomly selected employing the table of random numbers.

To determine the conceptual and procedural knowledge of the students, a questionnaire and an achievement test in signed numbers were developed. The achievement test in mathematics had two parts which included 20 multiple choice items intended to measure the conceptual knowledge and another 20 multiple choice items to measure the procedural knowledge of the students. For each part, the items consisted of five (5) items each on addition, subtraction, multiplication, and division of signed numbers. The validated achievement test yielded a reliability coefficient of 0.87. To determine the level of conceptual and procedural knowledge, the following score range and the corresponding verbal interpretations were used:

2.2 Data Analysis

The data gathered were analyzed using descriptive statistics such as frequency counts, means, and standard deviations, t-test for independent samples

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and Pearson's r. The null hypotheses were tested at the 0.05 level of significance.

III. RESULTS AND DISCUSSIONS

The distributions of the scores of the students on the test that measured their conceptual and procedural knowledge on signed numbers are shown in Table 2.

As gleaned from Table 2, the majority of the first-year preservice teachers posted high to very high level of both the conceptual and procedural knowledge of operations of signed numbers. The same table, however, indicates that the percent of students who posted the very high level of procedural knowledge is higher (57.6%) than the percent of students who posted the very high level of conceptual knowledge (49.7%).

Overall, the descriptive statistics shown in Table 3 revealed that the mean scores of the students in both the conceptual and procedural knowledge tests were comparable (16.25 and16.53, respectively). The mean performance scores (MPS) for both subtests indicates that the students were able to answer about eight items correctly out of 10.

The correlation between the conceptual and procedural knowledge of the students on signed numbers was found not significant as shown in Table 4. Hence the null hypothesis of no significant relationship

Table 1. Preservice Teachers' Distribution of Scores in the Conceptual and Procedural Knowledge on Signed Numbers

Score Range	Interpretation	Conceptual Knowledge		Procedural Knowledge	
		f	Percent	f	Percent
17 – 20	Very High	75	49.7%	87	57.6%
13 – 16	High	67	44.3%	50	33.1%
9 – 12	Moderately High	9	6.0%	14	9.3%
5 – 8	Low	0	-	0	-
0 – 4	Very Low	0	-	0	-
		151	100%	151	100%

Table 2. Conceptual and Procedural Scores of Preservice Teachers on Signed Numbers

Descriptive Statistics	Conceptual Knowledge	Procedural Knowledge
Range	9 – 19	11 – 20
Mean	16.25	16.53
S.D.	2.02	2.30
MPS	81.25	82.65

Table 3. Pearson Correlation Between Preservice Teachers' Conceptual Knowledge and Procedural Knowledge of Signed Numbers

Variables	Correlation		Significance (α =.05; df = 149)	
	r	Interpretation	Computed t-value	Critical Value
Conceptual Knowledge vs. Procedural Knowledge	0.01	Negligible	0.0769$^{(ns)}$	1.96

(ns) – not significant

between the conceptual knowledge and procedural knowledge of the students cannot be rejected.

The College of Education at the State University admits students, which is typical among public colleges and universities where the average age is a little over 17 years old, female dominated and mostly products of public high schools. In general, Tables 2 and 3 revealed that the performance of these students in both the conceptual knowledge and procedural knowledge are both very high. However, in Table 2, the percent of students who posted the very high level of procedural knowledge was higher than the percent of students who posted the very high level of conceptual knowledge on signed numbers.

The correlation between the conceptual knowledge and procedural knowledge of the students did not come out significant as evident in Table 4. This means that a student with a high score in conceptual knowledge may obtain a score of either very high, moderately high, very low, low in procedural knowledge. In other words, score in conceptual knowledge may not predict the score in procedural knowledge. This result is entirely contradictory to many research findings and theories about the two types of knowledge.

Conceptual knowledge backups and leads to procedural knowledge (Rittle-Johnson et al., 2015). Rittle-Johnson and Alibali (1999) mentioned four types of evidence from research on mathematics learning that supports the idea that "conceptual understanding plays a role in the generation and adoption of procedures." First, children with greater conceptual understanding tend to have higher procedural skills. He proceeded by giving an example that "children who have a better understanding of place value are more likely to successfully use the borrowing procedure for multi-digit subtraction (Heibert & Wearne, 1996). The correlation between conceptual and procedural knowledge has also been found in many other domains of mathematics, single-digit arithmetic (Baroody &Gammon,1984; Cowan & Renton,1996), fractions arithmetic (Brynes & Wasik, 1991), and proportional reasoning (Dixon & Moore, 1996). The second, in several domains, conceptual understanding precedes procedural skill (Rittle-Johnson and Alibali, 1999). Conceptual knowledge also seems to precede procedural knowledge in several other mathematical domains, including integer addition and subtraction (Brynes, 1992), fraction addition (Brynes & Wasik, 19991), and proportional reasoning (Dixon & Moore, 1996). These findings suggest that conceptual knowledge has a positive influence on procedural knowledge. Third, understanding about concepts as well as procedures can lead to increased procedural skill; and fourth, increasing conceptual knowledge leads to procedural generation. Whichever of these types a situation would fall, the fact remains that the two variables strongly affects each other.

With strong evidence cited, what possible reasons why is the conceptual knowledge of sampled participants not related to its procedural understanding? Why is the finding of present study different from the previous? Putting significant factors in control (i.e. validity and reliability of the instrument, administration of the instrument, venue of testing, test administrator's personality and others), one factor that may contribute to the major finding is the language barrier. When asked why obtained a very high score in procedural knowledge but moderately high score in conceptual knowledge, some participants (mostly graduates of barangay schools) said that they "do not understand some items (stem and options of items) in the test" so they resorted to "guessing." Some students explain that some of their teachers in math would explain concepts, principles, and theories in mother-tongue (dialect) so that when a test comes, and the items are in

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English, they resort to guessing. This scenario points to the importance of developing language proficiency of students, especially preservice teachers- the future educators of our land. It is worth noting that language competence is a major factor. Student's competency in English (high school grade in English) and their ability in reading (indicated by Differential Aptitude Test in Language Usage) were significant predictors of success in the students' academic work (Cananua-Labid, 2012). On the grounds of students' explanation, the task of obtaining answers to computational may not be difficult on the part of students especially if the item would not involve English sentence but a mathematical sentence like (-16) + (-23) + (+59) – (-14) = ?.

Limitations of this study are worthy of discussion. First, the direct measure of preservice teachers in the countryside was constrained to first-year students of Samar State University. Second, while the achievement test on conceptual and procedural knowledge was validated and reliability coefficient was obtained through test-retest, careful consideration should be made in developing each item. If not, use a standardized instrument to measure conceptual and procedural knowledge is recommended. Further studies would probably benefit from using qualitative research methods.

IV. CONCLUSIONS

The first year pre-service teachers of Samar State University posted high to very high level of both the conceptual and procedural knowledge on signed numbers. Overall, the descriptive statistics revealed that the mean scores of the students in both the conceptual and procedural knowledge tests were comparable (16.25 and16.53, respectively). The correlation between the conceptual and procedural knowledge of the students on signed numbers was found not significant.

Despite the limitations mentioned above and a finding that is contrary to most literature, the result of the study is a stimulus to continue this line of research and further pursue the studying of these types of knowledge of preservice teachers in the city or region, if not the whole country.

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