International Journal of Business and Applied Social Science (IJBASS)

E-ISSN: 2469-6501
VOL: 6, ISSUE: 8
August/2020
DOI: 10.33642/ijbass.v6n8p9

Effect of a Method Course: Improving Prospective Elementary Teachers' Abilities to Create Addition and Subtraction Word Problems

Onder KOKLU Ph.D.
Assistant Professor
College of Education
Florida Gulf Coast University
Email: okoklu@fgcu.edu
USA

ABSTRACT

The purpose of this research is to explore how a method course improves prospective elementary teachers' knowledge of various structures of addition and subtraction word problems. For this purpose, 55 prospective elementary teachers who were enrolled in a mathematics education method course were asked to pose addition and subtraction word problems before and after completion of the specific unit called "Developing Meanings for the Operations". Problems created by participants were then analyzed and categorized in light of the theoretical frame. Repeated measure design as one of the quasi-experimental designs was used in this study to measure the effects of the instruction over time. One-way ANOVA techniques were applied for data analysis. The findings of this study suggested that although certain types of problems are extensively created by participants before starting the unit, participants created more diverse addition and subtraction word problems upon completion of the specific unit.

KEYWORDS: Addition and subtraction, Problem solving, Prospective teachers, Method course.

1. INTRODUCTION

The study sought to investigate the effect of a mathematics method course in which prospective elementary teachers acquired a thorough conceptual understanding and assimilation of various structures of addition and subtraction word problems. The widespread accountability movement in education has expanded from classrooms and schools to colleges and universities (U.S. Department of Education, 2016). As a consequence, the survival of university teacher preparation programs in the United States likely depends on documenting the positive effects of these programs (Hiebert, Berk, Miller, Gallivan & Meikle, 2019). In this sense, there are some critical questions that have been tried to be answered in research studies (Cochran-Smith, Villegas, Abrams, Chavez-Moreno, Mills, & Stern, 2015; Feuer, Floden, Chudowsky, & Ahn, 2013; Greenberg, McKee, & Walsh, 2013; National Research Council [NRC], 2010). Are prospective teachers developing the knowledge and skills they need to teach effectively? Have graduates acquired the subject matter competencies that they need to be successful? Whether teacher preparation programs make a difference and whether they provide training that is essential for teaching?

One of the most important objectives in teacher education programs should be to foster improvements in prospective teachers' pedagogical knowledge and content knowledge via method courses (Tirosh, 2000; Diez, 2010). Hill, Rowan, and Ball (2005) stressed that teacher preparation programs should efficiently prepare prospective teachers on how to explain mathematical concepts clearly to students and how to assess the thoughts of students as well as how to choose and use the best representations and examples in teaching mathematical concepts in elementary classrooms. Therefore, for the last three decades, educators consequently calling for reform in mathematics education have been emphasizing that having knowledge of students' common conceptions and misconceptions about the subject matter is essential for teaching (e.g., Australian Education Council, 1990; National Council of Teachers of Mathematics, 1989, 1991, 2000). Although numerous reforms were made during these years research studies have consistently reported that prospective teachers' abilities to analyze the reasoning behind students' responses have been and are still poor (Norton, 2019; Chen, S., & Zhang, 2019; Philipp, 2008; Ball, 1990; Even & Markovitz, 1995; Even & Tirosh, 1995; Tirosh, 1993).

In this sense, method courses in teacher preparation programs should be designed to improve prospective teachers' knowledge so that they can accurately represent mathematical ideas, provide mathematical explanations for common rules and procedures, and examine and understand unusual solution methods to problems (Hill, Ball & Schilling, 2008; Ryu, Mentzer, & Knobloch, 2019). Researchers agree that prospective teachers need improved mathematical knowledge in order to better support children's learning of mathematics (Thanheiser, Browning, Edson, Lo, Whitacre, Olanoff, & Morton, 2014; Mewborn, 2001). Thanheiser and colleagues (2014) noted that many studies have identified deficiencies in prospective teachers' mathematical knowledge, whereas very few studies have

International Journal of Business and Applied Social Science (IJBASS)

E-ISSN: 2469-6501
VOL: 6, ISSUE: 8
August/2020
DOI: 10.33642/ijbass.v6n8p9

provided analyses of the development of their knowledge. In order for mathematics teacher educators to be better equipped to support prospective teachers' understanding and awareness of problem structures and problem-solving, the field needs analyses that illuminate viable learning trajectories (Hill, Rowan, and Ball (2005). They reported that mathematical knowledge of teachers and prospective teachers in a way characterizes their ability to understand and use the subject knowledge during mathematics teaching.

1.1. Teachers' knowledge of addition and subtraction word problems

Although there are many other definitions have been made for a problem throughout the history of learning, a problem is mostly defined as any task or activity for which the students have no prescribed or memorized rules or methods, nor is there a perception by students that there is a specific correct solution method (Hiebert, Carpenter, Fennema, Human, Murray, Olivier, Wearne, 1996). Cummins (1991) stated that a problem may not necessarily contain words or phrases. Furthermore, according to Desoete, Roeyers, and Buysse, (2001), there are different types of problems and story problems are not always "non-routine" problems which is a common misbelief among classroom teachers. On the contrary, most researchers (Jitendra, Griffin, Deatline-Buchman, & Sczesniak, 2007; Desoete et.al., 2001) agreed upon the idea that a story or word problem can be "routine" which requires only arithmetic calculations such that students can tell right away whether it is multiplication, division, addition, or subtraction problem.

Problems can play a prominent role in elementary school mathematics because they can provide practice with real-life problems and help students develop their creative, critical, and problem-solving abilities (Carraher, & Schliemann, 2015; Whimbley,&Lochhead,1986; Chapman, 1999; Arcavi, & Friedlander, 2007). However, word problems as currently presented in instruction and textbooks fail to accomplish these goals (Despina, & Harikleia, 2014; Gerofsky 1996; Lave 1992). This failure is due, in part, to the unrealistic approach needed to solve them such as the straightforward application of one arithmetic operation (Depaepe, De Corte, & Verschaffel, 2015). Consequently, when faced with word problems in which context is critical to the solution, students fail to connect school mathematics with their real-world knowledge (Ambrus, Kónya, Kovács, Szitányi, & Csíkos, 2019). Problems that cannot be solved by applying a straightforward arithmetic operation are called problematic (Kenedi, Helsa, Ariani, Zainil, & Hendri, 2019). Several researchers have examined children's lack of use of their real-world knowledge to solve problematic word problems (Gros, Thibaut, & Sander, 2020; Van Dooren, Lem, De Wortelaer, & Verschaffel, 2019; Greer, 1997; Reusser & Stebler, 1997; Verschaffel & De Corte, 1997)

When students are exposed to new problems, the familiar characteristics will assist them in generalizing from similar problems on which they have practiced (Steele, & Johanning, 2004; Zazkis, Liljedahl, & Chernoff, 2008). Furthermore, teachers who are not aware of the variety of situations and corresponding structures may randomly offer problems to students without the proper sequencing to support students' full grasp of the meaning of the operations (An, Kulm, & Wu, 2004; Leung, & Silver, 1997). By knowing the logical structure of these problems, teachers may be able to help students interpret a variety of real-world contexts. More importantly, teachers need to present a variety of problem types (within each structure) as well as recognize which structures cause the greatest challenges for students (Montague, Warger, & Morgan, 2000). Studies (Carpenter, & Moser, 1984; Fuson, Wearne, Hiebert, Murray, Human, Olivier, & Fennema, 1997; Blöte, Van der Burg, & Klein, 2001; Bofferding, 2014; Clements, Sarama, Baroody, & Joswick, 2020) reveal that students do not understand addition and subtraction at a conceptual level especially due to the intensive use of operational approaches. One of the reasons for having difficulty is that students proceed to addition and subtraction operations without learning integers and their characteristics at the conceptual levels (Fuadiah, & Suryadi, 2019; Wessman-Enzinger, & Mooney, 2019). Qualifications of mathematics teachers and their content knowledge are important in helping students overcome the difficulties they have (Baier, Decker, Voss, Kleickmann, Klusmann, & Kunter, 2019; Rice, 2003; Lipowsky, Rakoczy, Pauli, Drollinger-Vetter, Klieme, & Reusser, 2009).

Considering some research studies (Csíkos, & Szitányi, 2020; Soltis, 2019; Verschaffel, De Corte, & Vierstraete, 1999; Lemonidis, & Kaimakami, 2013; Contreras and Martinez-Cruz, 2003; Contreras and Martinez-Cruz, 2007; Roy, 2014) many elementary teachers have difficulties to understand and to solve word problems. A high percentage of incorrect solutions reported some of these research studies were alarming. Why do elementary teachers perform poorly on word problems? According to Contreras and Martinez-Cruz, (2007), one explanation might be that teachers, like schoolchildren, approach word problems in a superficial or mindless way because such problems, as posed in the traditional instructional environment, can be solved by the straightforward application of arithmetic operations. In their research study, they reported that one teacher stated, "I didn't even know that this type of problem existed." Another explanation may be the prospective teachers' insufficient repertoire or understanding of useful heuristic strategies, such as thinking of a simpler analogous problem, making a diagram, or counting by tens and ones (Ulusoy, 2020; Baturo, & Nason, 1996).

Furthermore, according to Ernest (1989), many prospective elementary teachers view mathematics as a body of rules and set procedures. This view is also confirmed by recent studies in the field (Hughes, Swars-Auslander, Stinson, & Fortner, 2019; Lee, Coomes, & Yim, 2019). This view may

International Journal of Business and Applied Social Science (IJBASS)

E-ISSN: 2469-6501
VOL: 6, ISSUE: 8
August/2020
DOI: 10.33642/ijbass.v6n8p9

be mimicked by students. Therefore, a shift in the teaching of mathematics will require changes in teachers' conceptions of the nature of mathematical knowledge (Ribeiro, & Powell, 2019; Cai, Chen, Li, Xu, Zhang, Hu, & Song, 2019). Battista and Clements (2000) emphasized that it is critical for students to develop more complex and abstract mathematical structures because "learning with understanding is essential to enable students to solve the new kinds of problems they will inevitably face in the future" (NCTM 2000, p. 21).

Mamona-Downs and Downs (2004) stated that another explanation for prospective elementary teachers' poor performances in problem-solving might be an insufficient understanding of the enumeration process needed to solve subtraction and addition word problems involving ordinal numbers. They further claimed that this lack of understanding might have prevented the teachers from realizing that they sometimes need to adjust the solution produced by the addition or subtraction of two given numbers. This incomplete understanding might also have prevented them from using appropriate numbers so that it is not necessary to adjust the answer produced by the arithmetic operation (Temur, & Turgut, 2019). According to Contreras (2002), there is no algorithmic hint we can give students to obtain the correct solution to this type of problem. Understanding the enumeration process of addition and subtraction word problems involving ordinal numbers is cognitively complex (Contreras, 2002).

This study addresses the important issue of how to improve prospective elementary teachers' mathematics content knowledge on various addition and subtraction word problems. K–12 students in the United States are now expected to engage in meaningful mathematical activities including problem-solving, argumentation, and recognizing and making use of the structure of the number system (National Governors Association Center for Best Practices [NGA] & Council of Chief State School Officers [CCSSO], 2010). In order for elementary teachers to facilitate such activities, they must have a deep understanding of and flexibility with the mathematics that they teach (Ball, Thames, & Phelps, 2008). However, such understanding and orientation are rare among both prospective and practicing elementary teachers in the United States, as it is in many countries (Ma, 1999; Thanheiser et al., 2014). The research literature documents a trend in which prospective teachers approach mathematical tasks by relying on standard procedures, rather than reasoning flexibly or meaningfully about operations and quantitative relationships (e.g., Hughes et. al. 2019; Lee et. al. 2019; Newton, 2008; Simon, 1993; Thanheiser et al., 2014; Yang, Reys, & Reys, 2009; Vest, 1978). The main goal of this investigation was to explore the prospective elementary teachers' existing knowledge on addition and subtraction word problems and how a method course improves their knowledge of structures of addition and subtraction word problems. More specifically, the research questions in this study are:

1. *What is the prospective elementary teachers' knowledge about problem structures of two basic mathematical operations addition and subtractions?*
2. *What is the effect of an undergraduate mathematics education method course on prospective elementary teachers' knowledge about various problem structures of addition and subtractions?*

2. METHODS

2.1. Research Setting and Participants

This study took place in an undergraduate level mathematics education method course called "MAE4310 Math Content Processes". The course was offered as two sections by the researcher in the Fall 2019 semester in a university located in the southwest of the State of Florida. Participants of this research study were 55 elementary education major students (prospective teachers) enrolled in either of the above-mentioned sections. While 47 of these participants were female, only 8 of them were male. Students enrolled in the course are elementary education students who are concurrently enrolled in a field experience component. The method course was designed for the development of knowledge, skills, and dispositions necessary to prepare prospective teachers to become effective teachers of elementary mathematics. It was specifically designed to involve the learner in an exploratory, hands-on/minds-on problem-solving classroom atmosphere that employs manipulative materials regularly. In addition, parallel to the course textbook "Elementary and Middle School Mathematics: Teaching Developmentally" (Van de Walle, Karp, Bay-Williams, 2013), prospective teachers were engaged in teaching through problem-solving activities as well as in inquiry-based learning activities.

2.2. Procedure

Participants were asked to create 10 addition and 10 subtraction word problems for the 3rd-grade level at the beginning of the semester. All 55 prospective teachers have submitted a total of 1100 addition and subtraction word problems, 550 in each. The same procedure was repeated two more times one at the end of the specific unit called "Developing Meanings for the Operations" and one at the end of the semester to be able to measure the effect of the instruction over time. Upon completion of the instruction of a related unit, participants were expected to improve their abilities to create addition and subtraction word problems by using different structure types.

Repeated measure design as one of the quasi-experimental designs was used in this study to measure the effects of the instruction over time. Specifically, in this study effect of the teaching different word problem structures on prospective teachers' abilities to create different types of

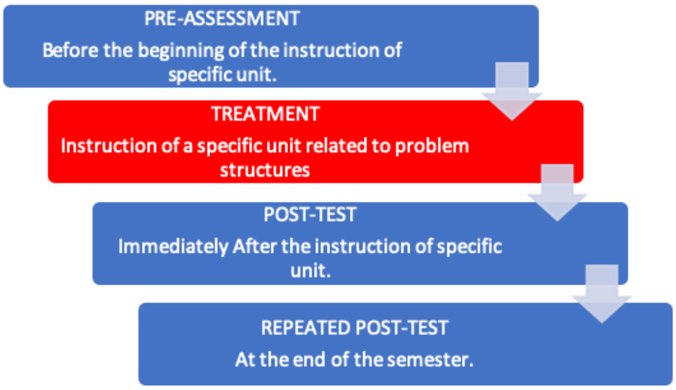
International Journal of Business and Applied Social Science (IJBASS)

E-ISSN: 2469-6501
VOL: 6, ISSUE: 8
August/2020
DOI: 10.33642/ijbass.v6n8p9

problems over a period of time was one of the main interests of this study. Figure-1 represents the experimental design.

As the analysis of data one-way ANOVA techniques was used since repeated measures ANOVA is the equivalent of the one-way ANOVA, but for related or same groups, not independent groups, and is the extension of the dependent t-test. A repeated-measures ANOVA is also referred to as a within-subjects ANOVA or ANOVA for correlated samples. All these names imply the nature of the repeated measures ANOVA, that of a test to detect any overall differences between related means.

Figure-1. Experimental design of the study



2.3. Scoring procedure

Two criteria were considered when scoring participants' work. One is called flexibility which refers to the number of different problem structures that have been used by prospective teachers and the other is the variability which refers to the distribution of created problems among used problem structures. The first one, flexibility, has more importance considering the purpose of the study. Since prospective teachers were expected to use as many different problem structures as they could, flexibility is the main interest of the study. Secondly, to be able to discriminate participants that have the same flexibility score, variability score was used. Here is an example of the scoring process:

If we assume that one participant has created 20 problems by using 5 problem structure, her flexibility score is 5x10=50. And if we assume that the distribution of these 20 problems among 5 problem structure is (3,2,7,2,6), then the standard deviation for this distribution would be (2.09). Since created problems were expected to be distributed as evenly as possible among different structures used, the value of standard deviation has a negative effect on the score. Therefore, for the final calculation of one's score, standard deviation (variation) should be subtracted from the flexibility score. If we go back to the example, the final score for the participant would be 50-2.09 = 47.91.

2.4. The Framework for Categorization of Problems

When students are exposed to new problems, the familiar characteristics will assist them in generalizing from similar problems on which they have practiced. Furthermore, teachers who are not aware of the variety of situations and corresponding structures may randomly offer problems to students without the proper sequencing to support students' full grasp of the meaning of the operations. By knowing the logical structure of these problems, teachers may be able to help students interpret a variety of real-world contexts. More importantly, they will need to present a variety of problem types (within each structure) as well as recognize which structures cause the greatest challenges for students.

Researchers have separated addition and subtraction problems into structures based on the kinds of relationships involved (Verschaffel, Greer, & DeCorte, 2007). These include *join* problems, *separate problems*, *part-part-whole* problems, and *compare* problems (Carpenter, Fennema, Franke, Levi, & Empson, 1999). The basic structures of these four categories of problems are illustrated in figure-2 (Van de Walle et.al., 2013). Each structure has three numbers. Anyone of the three numbers can be the unknown in a word problem. The problems are described in terms of their structure and interpretation and not an addition or subtraction problems. A joining action does not always mean addition, nor does separate always mean subtraction. The same applies to "Part-Part-Whole" and "Compare" problems. Examples for all of these categories are shown in Table-1 below.

International Journal of Business and Applied Social Science (IJBASS)
E-ISSN: 2469-6501
VOL: 6, ISSUE: 8
August/2020
DOI: 10.33642/ijbass.v6n8p9

Figure 2. Four structure types for addition and subtraction word problems

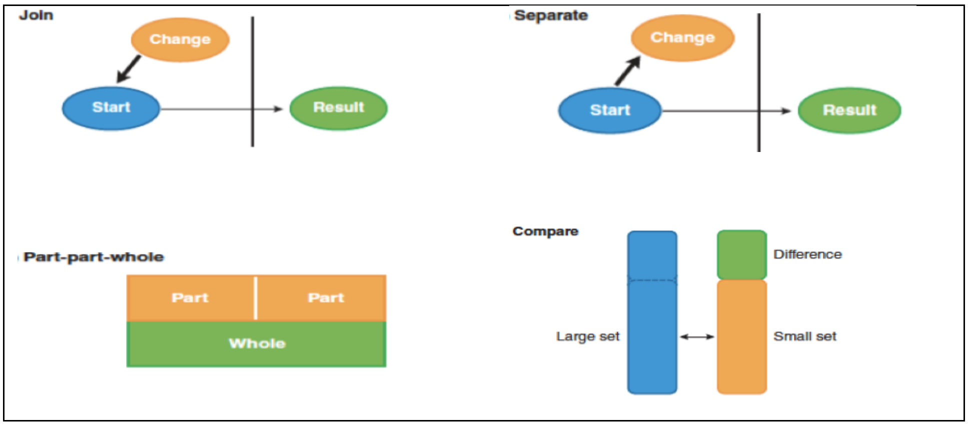


Table 1. Examples of problems in each structure type

Problem Type	Unknown Part	Sample Problem
Join	Start-Unknown	Sandra had some pennies. George gave her 4 more. Now Sandra has 12 pennies. How many pennies did Sandra have at the beginning?
	Change-Unknown	Sandra had 8 pennies. George gave her some more. Now Sandra has 12 pennies. How many did George give her?
	Result-Unknown	Sandra had 8 pennies. George gave her 4 more. How many pennies does Sandra have altogether?
Separate	Start-Unknown	Sandra had some pennies. She gave 4 to George. Now Sandra has 8 pennies left. How many pennies did Sandra have to begin with?
	Change-Unknown	Sandra had 12 pennies. She gave some to George. Now she has 8 pennies. How many did she give to George?
	Result-Unknown	Sandra had 12 pennies. She gave 4 pennies to George. How many pennies does Sandra have now?
Part-Part-Whole	Part-Unknown	George has 12 coins. Eight of his coins are pennies, and the rest are nickels. How many nickels does George have?
	Whole-Unknown	George has 4 pennies, and Sandra has 8 pennies. They put their pennies into a piggy bank. How many pennies did they put into the bank?
Compare	Small-Unknown	George has 4 more pennies than Sandra. George has 12 pennies. How many pennies does Sandra have?
	Large-Unknown	Sandra has 4 fewer pennies than George. Sandra has 8 pennies. How many pennies does George have?
	Difference-Unknown	George has 12 pennies, and Sandra has 8 pennies. How many more pennies does George have than Sandra?

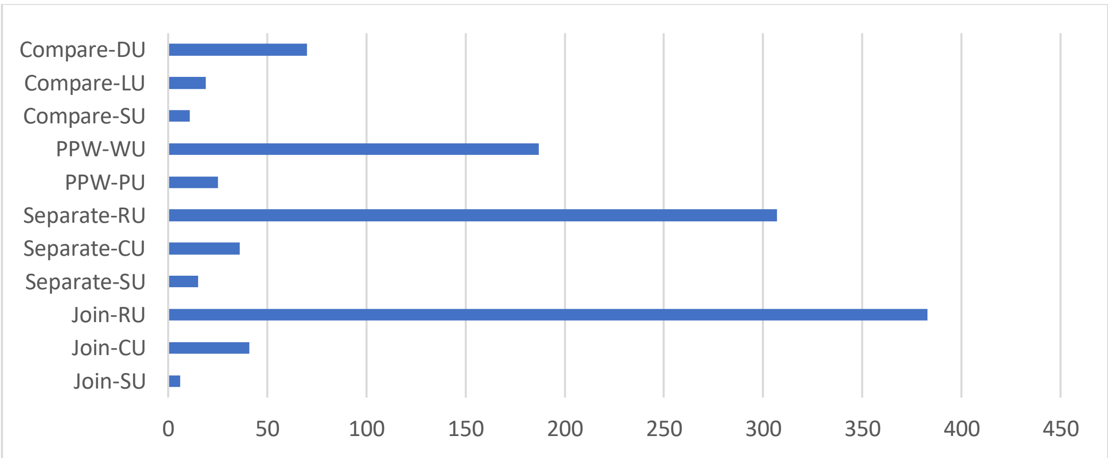
International Journal of Business and Applied Social Science (IJBASS)
E-ISSN: 2469-6501
VOL: 6, ISSUE: 8
August/2020
DOI: 10.33642/ijbass.v6n8p9

3. RESULTS

In response to the research questions mentioned in the first chapter, the following findings have been revealed as a result of data analysis. The results of the study indicated that prospective teachers excessively used certain problem structures when they asked to create addition and subtraction word problems before engaged in problem-posing activities. However, it was observed that they have improved their ability to create problems in more diverse structures upon completion of the specific unit called "teaching addition and subtraction through problem-solving". And it was also clearly observed that their understanding and learning remained effective two months after the completion of the unit. The followings are the detailed results revealed by the analysis of data.

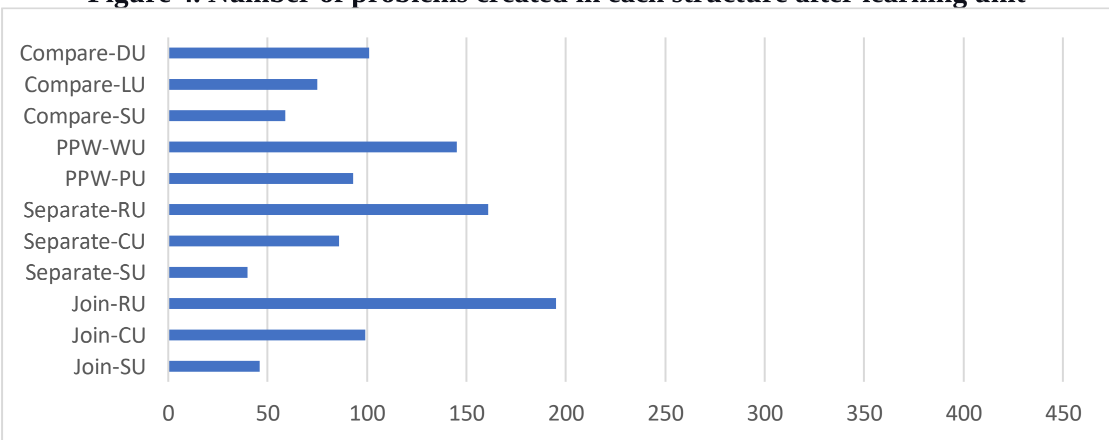
Result (1): Excessive usage of certain problem structures. Results of the study indicated that prospective teachers excessively used certain problem structures when they asked to create addition and subtraction word problems before starting of the teaching unit. Specifically, as seen in the figure-3 below, results showed that they used "Result Unknown" problems more often than the other two types (Start Unknown and Change Unknown) in "Join" and "Separate" problems. Similarly, in Part-Part-Whole" type of questions, they have created more "whole unknown" problems than "part unknown" problems. This result also resembles the results in "Join" and "Separate" problems in which "result from unknown" problems are extensively used. Prospective teachers' over usage of certain structures of addition and subtraction problems may limit their future students in understanding the non-routine problems in mathematics and real life.

Figure 3. Number of problems created in each structure before learning unit



Result (2): Improvement in the usage of more diverse problem structures. Results of the post-assessment have revealed that prospective teachers have managed to create more diverse addition and subtraction problems after engaging in problem-posing activities during the instruction of the special unit (Figure 4). Although they still showed a stronger tendency to create a "result unknown" type of problem, it was observed that problems were distributed more balanced among various problem structure types comparing the pre-assessment results. This result revealed that prospective teachers' abilities and awareness to create problems in different problem structures were improved.

Figure 4. Number of problems created in each structure after learning unit

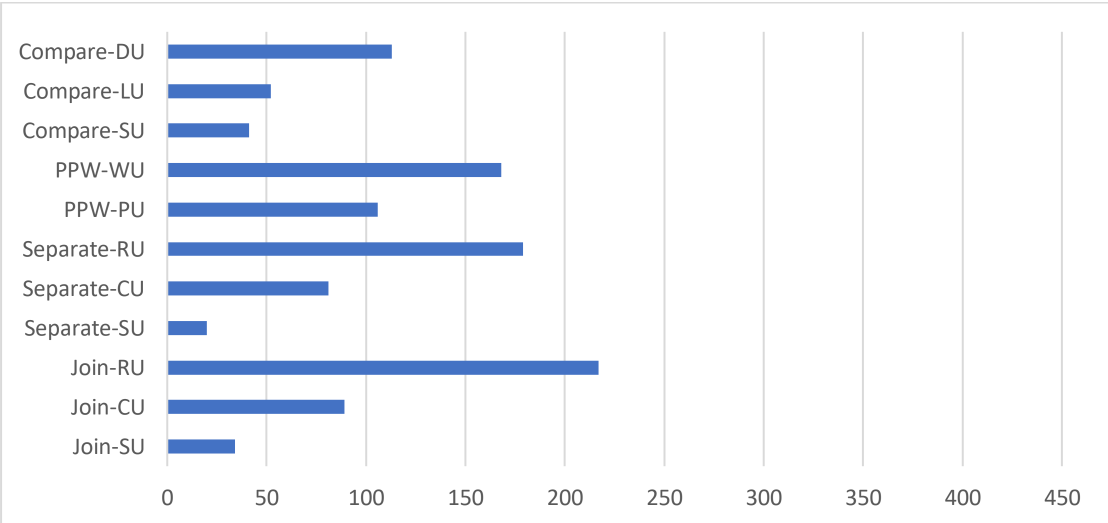


International Journal of Business and Applied Social Science (IJBASS)

E-ISSN: 2469-6501
VOL: 6, ISSUE: 8
August/2020
DOI: 10.33642/ijbass.v6n8p9

Result (3): Improvement is resistant. Results of the repeated post-assessment revealed that prospective teachers have accomplished to preserve their abilities in creating more diverse addition and subtraction problems two months after engaging in problem-posing activities during the instruction of the special unit (Figure 5). Although they showed little less balanced distribution comparing the first post-assessment results, it was observed that problems were still distributed more equally among various problem structure types comparing the pre-assessment results. This result revealed that prospective teachers' abilities and awareness to create problems in different problem structures were sustained over a certain period.

Figure 5. Number of problems created in each structure two months after learning unit



To make more clear comparisons among pretest and post-assessments, several problems created by participants in each problem structure through 3 assessments were organized in a table below (Table 2). For the same purpose, all of the results obtained in these assessments were summarized in a comparative chart below (Figure 6).

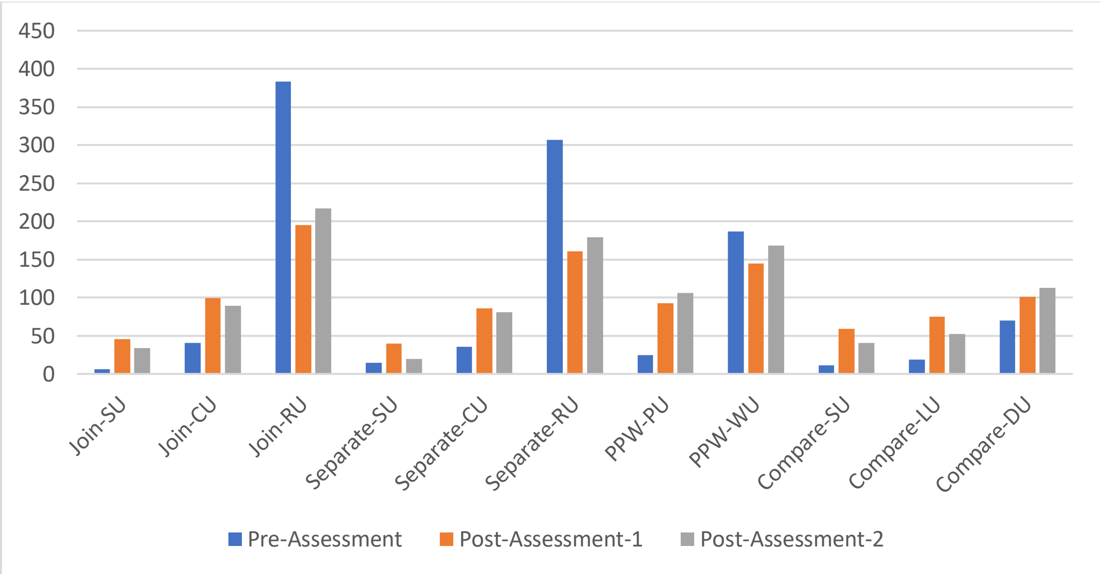
Table 2. Number of problems created in each problem structure across all assessments.

Problem Type	Pre-Assessment	Post-Assessment-1	Post-Assessment-2
JOIN Start Unknown	6	46	34
JOJN-Change Unknown	41	99	89
JOIN-Result Unknown	383	195	217
SEPARATE Start Unknown	15	40	20
SEPARATE Change Unknown	36	86	81
SEPARATE Result Unknown	307	161	179
PPW Part Unknown	25	93	106
PPW Whole Unknown	187	145	168
Compare Small Unknown	11	59	41
Compare Large Unknown	19	75	52
Compare Difference Unknown	70	101	113

International Journal of Business and Applied Social Science (IJBASS)

E-ISSN: 2469-6501
VOL: 6, ISSUE: 8
August/2020
DOI: 10.33642/ijbass.v6n8p9

Figure 6. Number of problems created in each problem structure across all assessments



Result (4): Improvement in the number of problem types used. The results of the study indicate that prospective teachers used more problem structure types after engaging in problem-posing activities in a specific unit comparing the pre-assessment results. As seen in table-3 below, participants used more different problem structure types in post-assessment comparing the pre-assessment. For example, as seen in the table, although 6 participants used only 3 problem structures while creating the 20 problems in pre-assessment, no one used less than 8 problem structures in post-assessment-1 and only one person used 5 structures in post-assessment-2. In pre-assessment, only 3 people used more than 8 structures while 51 people in post-assessment-1 and 36 people in post-assessment-2 used more than 8 problem structures.

Furthermore, in pre-assessment, no one used all of the 11 structures when creating problems, while 24 people in post-assessment-1 and 11 people in post-assessment-2 used all of the 11 problem structures. It is also clearly seen in the table that the average number of different structures used in pre-assessment was 5.63 while the average number of different structures used in post-assessment-1(9.91) and post-assessment-2 (8.75) were found to be way more than comparing the pre-assessment. Moreover, to find out whether these differences are significant or not, ANOVA was run. As seen table-4 below, ANOVA results indicated significant differences between pre-assessment and post-assessment-1 and between pre-assessment and post-assessment-2. However, there was no significant difference found between post-assessment-1 and post-assessment-2 which proves that prospective teachers' abilities and awareness to create problems in different problem structures were sustained over a certain period.

Table 3. Number of different structures used by participant across all assessments

Number of Different Structure	Number of Participants		
	Pre-Assessment	Post-Assessment-1	Post-Assessment-2
3	6		
4	12		
5	9		1
6	20		
7			13
8	5	4	5
9	3	12	17
10		15	8
11		24	11
Total	55	55	55
Mean	5.63	9.91	8.75

International Journal of Business and Applied Social Science (IJBASS)

E-ISSN: 2469-6501
VOL: 6, ISSUE: 8
August/2020
DOI: 10.33642/ijbass.v6n8p9

Table 4. ANOVA results on number of problems used. Multiple comparisons: Tukey HSD

(I) Test_Type	(J) Test_Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
PRE	POST-1	-4,27273*	,25310	,000	-4,8714	-3,6740
	POST-2	-3,69091*	,25310	,000	-4,2896	-3,0922
POST-1	PRE	4,27273*	,25310	,000	3,6740	4,8714
	POST-2	,58182	,25310	,059	-,0169	1,1805
POST-2	PRE	3,69091*	,25310	,000	3,0922	4,2896
	POST-1	-,58182	,25310	,059	-1,1805	,0169

*. The mean difference is significant at the 0.05 level.

Result (5): Improvement in flexibility and variability of problems. Two criteria were considered when scoring participants' work, flexibility, and variability. Flexibility refers to the number of different problem structures that have been used by prospective teachers and variability refers to the distribution of created problems among used problem structures. Since prospective teachers were expected to use as many different problem structures as they could, flexibility is the main interest of the study. Secondly, to be able to discriminate participants that have the same flexibility score, variability score was used. The scoring process was explained in chapter 2 in detail. An ANOVA analysis was run to detect significant differences among repeated measures if any. The results of the analysis (Table-5), clearly indicated significant differences between pre-assessment and post-assessment-1 scores and between pre-assessment and post-assessment-2 scores. However, there was no significant difference found between post-assessment-1 and post-assessment-2 which proves that degree of flexibility and variability in using different problem structures were preserved by prospective teachers over a certain period.

Table 5. ANOVA results on test scores. Multiple comparisons: Tukey HSD

(I) Test_Type	(J) Test_Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
PRE	POST-1	-43,92350*	2,56278	,000	-49,9856	-37,8614
	POST-2	-38,01770*	2,56278	,000	-44,0798	-31,9556
POST-1	PRE	43,92350*	2,56278	,000	37,8614	49,9856
	POST-2	5,90580	2,56278	,058	-,1563	11,9679
POST-2	PRE	38,01770*	2,56278	,000	31,9556	44,0798
	POST-1	-5,90580	2,56278	,058	-11,9679	,1563

*. The mean difference is significant at the 0.05 level.

For detailed analysis, ANOVA analysis was run to be able to detect significant differences among repeated measures in each problem structure. As clearly seen in table-6 below, in each problem structure, significant differences were detected between pre and repeated post-assessments. However, there was no significant difference detected between post-assessment-1 and post-assessment-2 in any of the 11 problem structures. This detailed results also proved one more time that prospective teachers made a significant improvement towards understanding and using various problem structures when they asked to create addition and subtraction word problems upon completion of the specific unit in which they were engaged in problem-posing activities and they have learned different types of problem structures. These results from repeated measures

International Journal of Business and Applied Social Science (IJBASS)

E-ISSN: 2469-6501
VOL: 6, ISSUE: 8
August/2020
DOI: 10.33642/ijbass.v6n8p9

also proved that this understanding persists for a duration of time. Although the results of the first post-assessment indicated a more balanced distribution of problem structures than the second post-assessment, these results were not found to be statistically significant.

Table 6. ANOVA results on number of problems used in each structure.

Multiple comparisons: Tukey HSD

Dependent Variable	(I) Test_Type	(J) Test_Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Comp_SU	PRE	POST-1	-,87273*	,11146	,000	-11,364	-,6091
		POST-2	-,65455*	,11146	,000	-,9182	-,3909
	POST-1	PRE	,87273*	,11146	,000	,6091	11,364
		POST-2	,21818	,11146	,126	-,0455	,4818
Comp_LU	PRE	POST-1	-1,01818*	,13330	,000	-13,335	-,7029
		POST-2	-,65455*	,13330	,000	-,9699	-,3392
	POST-1	PRE	1,01818*	,13330	,000	,7029	13,335
		POST-2	,36364*	,13330	,019	,0483	,6790
Comp_DU	PRE	POST-1	-,56364*	,16509	,002	-,9541	-,1731
		POST-2	-,70909*	,16509	,000	-10,996	-,3186
	POST-1	PRE	,56364*	,16509	,002	,1731	,9541
		POST-2	-,14545	,16509	,653	-,5360	,2451
PPW_PU	PRE	POST-1	-1,23636*	,11790	,000	-15,153	-,9575
		POST-2	-1,45455*	,11790	,000	-17,334	-11,757
	POST-1	PRE	1,23636*	,11790	,000	,9575	15,153
		POST-2	-,21818	,11790	,157	-,4971	,0607
PPW_WU	PRE	POST-1	,76364*	,16735	,000	,3678	11,595
		POST-2	,45455*	,16735	,020	,0587	,8504
	POST-1	PRE	-,76364*	,16735	,000	-11,595	-,3678
		POST-2	-,30909	,16735	,158	-,7049	,0868
Sep_SU	PRE	POST-1	-,45455*	,11157	,000	-,7185	-,1906
		POST-2	-,27273*	,11157	,041	-,5366	-,0088
	POST-1	PRE	,45455*	,11157	,000	,1906	,7185
		POST-2	,18182	,11157	,236	-,0821	,4457
Sep_CU	PRE	POST-1	-,90909*	,12863	,000	-12,134	-,6048
		POST-2	-,85455*	,12863	,000	-11,588	-,5503
	POST-1	PRE	,90909*	,12863	,000	,6048	12,134
		POST-2	,05455	,12863	,906	-,2497	,3588
Sep_RU	PRE	POST-1	2,65455*	,19022	,000	22,046	31,045
		POST-2	2,45455*	,19022	,000	20,046	29,045
	POST-1	PRE	-2,65455*	,19022	,000	-31,045	-22,046
		POST-2	-,20000	,19022	,546	-,6500	,2500
Join_SU	PRE	POST-1	-,72727*	,12151	,000	-10,147	-,4398
		POST-2	-,61818*	,12151	,000	-,9056	-,3307
	POST-1	PRE	,72727*	,12151	,000	,4398	10,147
		POST-2	,10909	,12151	,642	-,1783	,3965
Join_CU	PRE	POST-1	-1,05455*	,12655	,000	-13,539	-,7552
		POST-2	-,92727*	,12655	,000	-12,266	-,6279
	POST-1	PRE	1,05455*	,12655	,000	,7552	13,539
		POST-2	,12727	,12655	,574	-,1721	,4266
Join_RU	PRE	POST-1	3,41818*	,22547	,000	28,848	39,515
		POST-2	3,23636*	,22547	,000	27,030	37,697
	POST-1	PRE	-3,41818*	,22547	,000	-39,515	-28,848
		POST-2	-,18182	,22547	,700	-,7152	,3515

*. The mean difference is significant at the 0.05 level.

4. DISCUSSION

This research study dealt with identifying prospective teachers' current knowledge about creating addition and subtraction problems and effects of an undergraduate mathematics education method course on their knowledge about various problem structures of addition and subtractions. Specifically, the research was originated from questions about extensive usage and overexposure of certain problem structures which may cause difficulties for students in the understanding of different problem situations they faced in later grades. The results of the showed, in general terms, that prospective elementary teachers enrolled in a mathematics

International Journal of Business and Applied Social Science (IJBASS)
E-ISSN: 2469-6501
VOL: 6, ISSUE: 8
August/2020
DOI: 10.33642/ijbass.v6n8p9

method course had limited or no knowledge of different structures of addition and subtraction word problems before engaging in problem-posing activities by using various types of structures. Furthermore, results also clearly indicated that the learning activities in the above-mentioned method course deliberately improved prospective teachers' awareness and abilities to use different structures while creating addition and subtraction problems. Also, the repeated measures method used in this study verified that this improvement has been preserved over some time upon completion of the specific learning unit.

First of all, the results of the study indicated that prospective teachers excessively used certain problem structures when they asked to create addition and subtraction word problems before starting of the teaching unit. This over usage of certain structures of addition and subtraction problems may limit their future students' understanding of non-routine problems in mathematics and real life. Similar concerns have been raised by researchers over the last three decades. For example, Chapman (2004) in her research study, has identified prospective teacher's limited use of word problems and revealed improved results after several interventions with them.

Secondly, the results of the study suggested that prospective teachers used more problem structure types after engaging in problem-posing activities in a specific unit comparing the pre-assessment results. ANOVA results indicated significant differences between pre-assessment and post-assessment-1 and between pre-assessment and post-assessment-2 which substantiated that prospective teachers' abilities and awareness to create problems in different problem structures were sustained over a certain period. In the same way, results also suggested that prospective teachers' flexibility of using various problem structures was significantly improved comparing the assessment results before involving in problem-posing activities. These results notably disclosed the effectiveness of the method course on prospective teachers' knowledge on and abilities to use different structures of word problems.

Finally, the fact that the significantly better performance on the posing different structures of problems in post-assessment and repeated measure afterward aligns so closely with the instructional activities in the content of the method course suggests that these learning opportunities were a major contributor to the relationships that were found. Because considerable time was spent in the method course helping prospective teachers develop their understanding of different structures of addition and subtraction word problems, significant differences in pre and post instructional performances on problem-posing tasks indicated that the learning opportunities in the method course are a major contributor to the detected relationships.

5. CONCLUSION

In conclusion, many links must be explored between teacher preparation and the key-dependent measures of teaching quality and student learning (Diez, 2010). The findings of this study reported only one piece of the larger picture by raising concerns about the quality of teacher preparation programs believing that mathematics teacher educators need to address a particular level or depth of knowledge developed. It was noted that although participants of this study did better on the repeated post-assessment at the end of the semester, their scores were less than the first post-assessment. Since the knowledge assessed by these tasks is important, prospective teachers need more time to practice the knowledge acquired throughout their program until graduation. Their lack of knowledge at this subject most surely affects students' problem-solving abilities which are believed to be one of the most important cognitive components needed to be developed for not only success in mathematics for most of the other field of studies. Teacher educators must decide how much time to spend on which topics during a preparation program. This requires making mindful decisions on curriculum design for the determination of most essential topics to be studied and at what depth. These are difficult decisions. But it is critical for teacher educators to consider these questions deliberately rather than cover briefly all elementary school topics and simply hope that graduates will remember what they studied.

REFERENCES

Ambrus, G., Kónya, E. H., Kovács, Z., Szitányi, J., & Csíkos, C. (2019). A Cross-sectional Analysis of Students' Answers to a Realistic Word Problem from Grade 2 to 10. *International Electronic Journal of Mathematics Education*, *14*(3), 513-521.

An, S., Kulm, G., & Wu, Z. (2004). The pedagogical content knowledge of middle school, mathematics teachers in China and the US. *Journal of mathematics teacher education*, *7*(2), 145-172.

Arcavi, A., & Friedlander, A. (2007). Curriculum developers and problem solving: the case of Israeli elementary school projects. *ZDM*, *39*(5-6), 355-364.

Baier, F., Decker, A. T., Voss, T., Kleickmann, T., Klusmann, U., & Kunter, M. (2019). What makes a good teacher? The relative importance of mathematics teachers' cognitive ability, personality, knowledge, beliefs, and motivation for instructional quality. *British Journal of Educational Psychology*, *89*(4), 767-786.

E-ISSN: 2469-6501
VOL: 6, ISSUE: 8
August/2020
DOI: 10.33642/ijbass.v6n8p9

Ball, D. L. (1990). Prospective elementary and secondary teachers' understanding of division. *Journal for research in mathematics education*, 132-144.

Ball, D. L., Thames, M. H., & Phelps, G. (2008). Content knowledge for teaching: What makes it special. *Journal of teacher education*, *59*(5), 389-407.

Battista, M. T., & Clements, D. H. (2000). Mathematics Curriculum Development as a Scientific Endeavor.

Baturo, A., & Nason, R. (1996). Student teachers' subject matter knowledge within the domain of area measurement. *Educational studies in mathematics*, *31*(3), 235-268.

Blöte, A. W., Van der Burg, E., & Klein, A. S. (2001). Students' flexibility in solving two-digit addition and subtraction problems: Instruction effects. *Journal of Educational Psychology*, *93*(3), 627.

Bofferding, L. (2014). Negative integer understanding: Characterizing first graders' mental models. *Journal for Research in Mathematics Education*, *45*(2), 194-245.

Cai, J., Chen, T., Li, X., Xu, R., Zhang, S., Hu, Y., ... & Song, N. (2019). Exploring the impact of a problem-posing workshop on elementary school mathematics teachers' conceptions on problem posing and lesson design. *International Journal of Educational Research*.

Carpenter, T. P., & Moser, J. M. (1984). The acquisition of addition and subtraction concepts in grades one through three. *Journal for research in Mathematics Education*, 179-202.

Carpenter, T. P., Fennema, E., Franke, M. L., Levi, L., & Empson, S. B. (1999). Children's mathematics. *Cognitively Guided.*

Carraher, D. W., & Schliemann, A. D. (2015). Powerful ideas in elementary school mathematics. *Handbook of international research in mathematics education*, 191-218.

Chapman, O. (2004). Helping pre-service elementary teachers develop flexibility in using word problems in their teaching. *Proceedings of the 26th North American Chapter of PME*, *3*, 1175-1182.

Chapman, O. (1999). Inservice teacher development in mathematical problem solving. *Journal of mathematics teacher education*, *2*(2), 121-142.

Chen, S., & Zhang, B. (2019). Improving Prospective Teachers' Lesson Planning Knowledge and Skills through Lesson Study. In *Theory and Practice of Lesson Study in Mathematics* (pp. 549-575). Springer, Cham.

Clements, D. H., Sarama, J., Baroody, A. J., & Joswick, C. (2020). Efficacy of a learning trajectory approach compared to a teach-to-target approach for addition and subtraction. *ZDM*, 1-12.

Cochran-Smith, M., Villegas, A. M., Abrams, L., Chavez-Moreno, L., Mills, T., & Stern, R. (2015). Critiquing teacher preparation research: An overview of the field, part II. Journal of Teacher Education, 66(2), 109–121.

Contreras, J. N., & Martínez-Cruz, A. M. (2007). Solving problematic addition and subtraction word problems. *Teaching Children Mathematics*, *13*(9), 498-503.

Contreras, J. N., & Martinez-Cruz, A. M. (2003). Preservice Elementary Teachers' Solution Processes to Problematic Addition and Subtraction Word Problems Involving Ordinal Numbers and Their Interpretations of Solutions. International Group for the Psychology of Mathematics Education, 2, 237-244.

Contreras, J. N. (2002). Preservice secondary mathematics teachers' modeling strategies to solve problematic subtraction and addition word problems involving ordinal numbers and their interpretations of solutions. In *Proceedings of the 24th annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education, Vol. 1–4.*

Cummins, D. D. (1991). Children's interpretations of arithmetic word problems. *Cognition and instruction*, *8*(3), 261-289.

Council, A. E. (1990). *A National Statement on Mathematics for Australian Schools. A Joint Project of the States, Territories and the Commonwealth of Australia Initiated by the Australian Education Council*. ERIC Clearinghouse.

Csíkos, C., & Szitányi, J. (2020). Teachers' pedagogical content knowledge in teaching word problem solving strategies. *ZDM*, *52*(1), 165-178.

Depaepe, F., De Corte, E., & Verschaffel, L. (2015). Students' non-realistic mathematical modeling as a drawback of teachers' beliefs about and approaches to word problem solving. In *From beliefs to dynamic affect systems in mathematics education* (pp. 137-156). Springer, Cham.

E-ISSN: 2469-6501
VOL: 6, ISSUE: 8
August/2020
DOI: 10.33642/ijbass.v6n8p9

Desoete, A., Roeyers, H. & Buysse, A. (2001). Metacognition and mathematical problem solving in grade 3. *Journal of Learning Disabilities, 34, 435-449.*

Despina, D., & Harikleia, L. (2014). Addition and subtraction word problems in greek grade a and grade b mathematics textbooks: distribution and children's understanding. *International Journal for Mathematics Teaching and Learning*, *8*, 340.

Diez, M. E. (2010). It is complicated: Unpacking the flow of teacher education's impact on student learning. Journal of Teacher Education, 61(5), 441–450.

Ernest, P. (1989). The knowledge, beliefs and attitudes of the mathematics teacher: A model. *Journal of education for teaching*, *15*(1), 13-33.

Even, R., & Markovits, Z. (1995). Some aspects of teachers' and students' views on student reasoning and knowledge construction. *International Journal of Mathematical Education in Science and Technology*, *26*(4), 531-544.

Even, R., & Tirosh, D. (1995). Subject-matter knowledge and knowledge about students as sources of teacher presentations of the subject-matter. *Educational studies in mathematics*, *29*(1), 1-20.

Feuer, M. J., Floden, R. E., Chudowsky, N., & Ahn, J. (2013). Evaluation of teacher preparation programs: Purposes, methods, and policy options. Washington, DC: National Academy of Education.

Fuadiah, N. F., & Suryadi, D. (2019). Teaching and Learning Activities in Classroom and Their Impact on Student Misunderstanding: A Case Study on Negative Integers. *International Journal of Instruction*, *12*(1), 407-424.

Fuson, K. C., Wearne, D., Hiebert, J. C., Murray, H. G., Human, P. G., Olivier, A. I., ... & Fennema, E. (1997). Children's conceptual structures for multidigit numbers and methods of multidigit addition and subtraction. *Journal for Research in Mathematics Education*, 130-162.

Gerofsky, S. (1996). A linguistic and narrative view of word problems in mathematics education. *For the Learning of Mathematics*, *16*(2), 36-45.

Greenberg, J., McKee, A., & Walsh, K. (2013). Teacher prep review: A review of the nation's teacher preparation programs. Washington, DC: National Council on Teacher Quality.

Greer, B. (1997). Modelling reality in mathematics classrooms: The case of word problems. *Learning and instruction*, *7*(4), 293-307.

Gros, H., Thibaut, J. P., & Sander, E. (2020). Semantic congruence in arithmetic: A new conceptual model for word problem solving. *Educational Psychologist*, *55*(2), 69-87.

Hiebert, J., Carpenter, T., Fennema, E., Human, P., Murray, H., Olivier, A., Wearne, D. (1996). Problem solving as a basis for reform in curriculum and instruction: The case of mathematics. *Educational Researcher, 25(4), 12- 22.*

Hiebert, J., Berk, D., Miller, E., Gallivan, H., & Meikle, E. (2019). Relationships between opportunity to learn mathematics in teacher preparation and graduates' knowledge for teaching mathematics. *Journal for Research in Mathematics Education*, *50*(1), 23-50.

Hill, H. C., Rowan, B., & Ball, D. L. (2005). Effects of teachers' mathematical knowledge for teaching on student achievement. *American educational research journal*, *42*(2), 371-406.

Hill, H. C., Ball, D. L., & Schilling, S. G. (2008). Unpacking pedagogical content knowledge: Conceptualizing and measuring teachers' topic-specific knowledge of students. *Journal for research in mathematics education*, 372-400.

Hughes, P., Swars Auslander, S., Stinson, D. W., & Fortner, C. K. (2019). Elementary teachers' mathematical beliefs and mathematics anxiety: How do they shape instructional practices?. *School Science and Mathematics*, *119*(4), 213-222.

Jitendra, A. K., Griffin, C. C., Deatline-Buchman, A., & Sczesniak, E. (2007). Mathematical word problem solving in third-grade classrooms. *The Journal of Educational Research*, *100*(5), 283-302.

Kenedi, A. K., Helsa, Y., Ariani, Y., Zainil, M., & Hendri, S. (2019). Mathematical Connection of Elementary School Students to Solve Mathematical Problems. *Journal on Mathematics Education*, *10*(1), 69-80.

Lave, J. (1992). Word problems: A microcosm of theories of learning. *Context and cognition: Ways of learning and knowing*, 74-92.

Lee, H. S., Coomes, J., & Yim, J. (2019). Teachers' conceptions of prior knowledge and the potential of a task in teaching practice. *Journal of Mathematics Teacher Education*, *22*(2), 129-151.

International Journal of Business and Applied Social Science (IJBASS)
E-ISSN: 2469-6501
VOL: 6, ISSUE: 8
August/2020
DOI: 10.33642/ijbass.v6n8p9

Lemonidis, C., & Kaimakami, A. (2013). Prospective elementary teachers' knowledge in computational estimation. *Menon: Journal of Educational Research*, (2b), 86-98.

Leung, S. S., & Silver, E. A. (1997). The role of task format, mathematics knowledge, and creative thinking on the arithmetic problem posing of prospective elementary school teachers. *Mathematics Education Research Journal*, *9*(1), 5-24.

Lipowsky, F., Rakoczy, K., Pauli, C., Drollinger-Vetter, B., Klieme, E., & Reusser, K. (2009). Quality of geometry instruction and its short-term impact on students' understanding of the Pythagorean Theorem. *Learning and instruction*, *19*(6), 527-537.

Ma, X. (1999). A meta-analysis of the relationship between anxiety toward mathematics and achievement in mathematics. *Journal for research in mathematics education*, 520-540.

Mamona-Downs, J., & Downs, M. (2004). Realization of techniques in problem solving: the construction of bijections for enumeration tasks. *Educational Studies in Mathematics*, *56*(2-3), 235-253.

Mewborn, D. (2001). Teachers content knowledge, teacher education, and their effects on the preparation of elementary teachers in the United States. *Mathematics Teacher Education and Development*, *3*(1), 28-36.

Montague, M., Warger, C., & Morgan, T. H. (2000). Solve it! Strategy instruction to improve mathematical problem solving. *Learning Disabilities Research & Practice*, *15*(2), 110-116.

National Council of Teachers of Mathematics NCTM, (1989). *Commission on Standards for School Mathematics.* Curriculum and Evaluation Standards for School Mathematics. Reston, VA: The Council, 1989.

National Council of Teachers of Mathematics. Commission on Teaching Standards for School Mathematics. (1991). *Professional standards for teaching mathematics*.

National Council of Teachers of Mathematics. (2000). Principles and standards for school mathematics. Reston, VA.

National Governors Association. & Council of Chief State School Officers (CCSSO). *(2010). Common core state standards for mathematics. Washington, DC: NGA Center for Best Practices and CCSSO*.

National Research Council. (2010). Preparing teachers: Building evidence for sound policy. Washington, DC: The National Academies Press.

Norton, S. (2019). The relationship between mathematical content knowledge and mathematical pedagogical content knowledge of prospective primary teachers. *Journal of Mathematics Teacher Education*, *22*(5), 489-514.

Philipp, R. A. (2008). Motivating Prospective Elementary School Teachers to Learn Mathematics by Focusing upon Children's Mathematical Thinking. Issues in Teacher Education, 17(2), 7-26.

Ribeiro, R. M., & Powell, A. B. (2019). Mathematical modeling and teachers' formation: a discussion on mathematical knowledge for teaching. *Revista de Educação Matemática, São Paulo*, *16*(21), 5-17.

Rice, J. K. (2003). *Teacher quality: Understanding the effectiveness of teacher attributes*. Economic Policy Institute, 1660 L Street, NW, Suite 1200, Washington, DC 20035.

Reusser, K., & Stebler, R. (1997). Every word problem has a solution—The social rationality of mathematical modeling in schools. *Learning and instruction*, *7*(4), 309-327.

Roy, G. J. (2014). Developing Prospective Teachers' Understanding of Addition and Subtraction with Whole Numbers. *Issues in the Undergraduate Mathematics Preparation of School Teachers*, *2*.

Ryu, M., Mentzer, N., & Knobloch, N. (2019). Preservice teachers' experiences of STEM integration: Challenges and implications for integrated STEM teacher preparation. *International Journal of Technology and Design Education*, *29*(3), 493-512.

Soltis, L. A. (2019). Mathematical Dispositions of Novice Upper-Elementary Teachers: A Phenomenological Study.

Steele, D. F., & Johanning, D. I. (2004). A schematic–theoretic view of problem solving and development of algebraic thinking. *Educational Studies in Mathematics*, *57*(1), 65-90.

Temur, O. D., & Turgut, S. (2019). Investigation of Elementary Pre-Service Teachers' Arithmetical Operation Skills. *Acta Didactica Napocensia*, *12*(1), 75-88.

E-ISSN: 2469-6501
VOL: 6, ISSUE: 8
August/2020
DOI: 10.33642/ijbass.v6n8p9

Thanheiser, E., Browning, C., Edson, A. J., Lo, J. J., Whitacre, I., Olanoff, D., & Morton, C. (2014). Prospective elementary mathematics teacher content knowledge: What do we know, what do we not know, and where do we go?. *The Mathematics Enthusiast*, *11*(2), 433-448.

Tirosh, D. (2000). Enhancing prospective teachers' knowledge of children's conceptions: The case of division of fractions. *Journal for research in Mathematics Education*, 5-25.

Tirosh, D. (1993). Teachers' understanding of undefined mathematical expressions. *Substratum: Temas Fundamentales en Psicologia Education*, *1*, 61-86.

Ulusoy, F. (2020). Prospective teachers' skills of attending, interpreting and responding to content-specific characteristics of mathematics instruction in classroom videos. *Teaching and Teacher Education*, *94*, 103103.

U.S. Department of Education. (2016). Teacher preparation issues. Federal Register, 81(210), 75494–75622. Washington, DC: Author. Retrieved from https://www.federalregister.gov/ documents/2016/10/31/2016-24856/teacher-preparation-issues.

Van de Walle, J. A., Karen S. Karp, and Jennifer M. Bay-Williams. (2013). Elementary and Middle School Mathematics: Teaching Developmentally. Professional Development Edition.

Van Dooren, W., Lem, S., De Wortelaer, H., & Verschaffel, L. (2019). Improving realistic word problem solving by using humor. *The Journal of Mathematical Behavior*, *53*, 96-104.

Verschaffel, L., Greer, B., & DeCorte, E. (2007). *Second handbook of research on mathematics teaching and learning.* Whole number concepts and operations, 1, 557-628.

Verschaffel, L., De Corte, E., & Vierstraete, H. (1999). Upper elementary school pupils' difficulties in modeling and solving nonstandard additive word problems involving ordinal numbers. *Journal for Research in Mathematics Education*, 265-285.

Verschaffel, L., & De Corte, E. (1997). Word problems: A vehicle for promoting authentic mathematical understanding and problem solving in the primary school?

Vest, F. (1978). Disposition of Pre-Service Elementary Teachers Related to Measurement and Partition Division. *School Science and Mathematics*, *78*(4), 335-9.

Wessman-Enzinger, N. M., & Mooney, E. S. (2019). Conceptual models for integer addition and subtraction. *International Journal of Mathematical Education in Science and Technology*, 1-28.

Whimbley, A. & Lochhead, J. (1986). *Problem solving and comprehension*. Hillsdale, NJ: Lawrance Erbaum Associates.

Yang, D. C., Reys, R. E., & Reys, B. J. (2009). Number sense strategies used by pre-service teachers in Taiwan. *International Journal of Science and Mathematics Education*, *7*(2), 383-403.

Zazkis, R., Liljedahl, P., & Chernoff, E. J. (2008). The role of examples in forming and refuting generalizations. ZDM, 40(1), 131-141.