Moderating Language and Number of Mathematical Operations in the Relationship between Problem Solving Scores and Learning Strategies

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Abstract

This study tested the Cognitive Load Theory by investigating the relationship between problem solving and learning strategies when language (Filipino or English) and number of operations in math word problem solving tests (single or multiple) are varied. There were 275 grade five students who answered four sets of math tests (Single-Filipino, Single-English, Multiple-Filipino, and Multiple-English). They also answered the Revised-MSLQ every after each set of math test was answered. Using the Two-way Analysis of Variance, the mean scores for problem solving was significantly higher when the word problem is in Filipino as compared to English. No significant difference was found between single and multiple-operation on mathematics problem solving scores. This indicates that cognitive load occurs in language where problems written in Filipino are easier tasks. Further analysis also showed that the relationship between problem solving and learning strategies were significant when the language used in the math problems was in the students' first language (Filipino) regardless of the number of operations involved. Furthermore, it was found that the relationship between problem solving and learning strategies was strongest when math tests were written in Filipino involving single operation. These results showed that Cognitive Load Theory can occur not only in performance tasks but in language and use of learning strategies.

Introduction

The ability to solve word problems in mathematics is an important skill that needs to be developed by students. Through mathematical problem solving, students are able to apply their knowledge and skills to real world situations. However, solving word problems is one of the most difficult tasks that students consider in mathematics (e.g., Littlefield & Rieser, 1993; Wiest, 2002). The difficulty comes when students have to apply and assemble thoughts, concepts, and procedures to solve the problem (Heinze, 2005). Various models of mathematical problem solving (e.g., Carpenter et al., 1988) assume that the first task for the problem solver is to derive from the text an accurate mental representation of the

problem which will be used as a basis for choosing the solution processes that will operate. However, the most basic difficulty that students face in solving mathematical problems is their ability to understand the problem structure embedded in the word problem (Adams, 2003). It becomes more difficult when students need to comprehend the problem written in their second language (Bernardo, 1999). Various studies have shown that difficulties in mathematical problem solving are associated with difficulties in comprehending the problem especially when it is written in the learner's second language (Stern, 1993). In a study conducted by Cummins, Kintsch, Reusser, and Weimer (1988), they concluded that language comprehension processes determine whether students will be able to correctly understand the pieces of information and how these pieces of information relate to each other. Their choice of solution procedures is dependent on how they understand the elements in a mathematical word problem (Riley & Greeno, 1988). Among bilinguals, researchers have suggested that solving word problems is influenced by linguistic factors (e.g., Clarkson, 1992). Other studies such as De Corte and Verschaffel (1987) have noted that rewording of word problems have systematic effects in the problem solving performance of students. Such effects have often been associated with difficulties in understanding certain types of problems, such as those that use unclear and abstract language (Cummins, Kintsch, Reusser, & Weimer, 1988) or those wherein conceptual relationships expressed in the text do not map on to the quantitative relationships expressed in the problem (Riley & Greeno, 1988).

Problem Solving and Learning Strategies

Learning strategies are techniques that students use in a task such as how they sort out and use a set of skills to learn or finish a specific task successfully and competently (Schumaker, Deshler, Alley, Warner, & Denton, 1982). Such is when students are given mathematical word problems to solve, they use a variety of learning strategies to solve the problems. With this, students who use learning strategies become more effective and independent learners (Schumaker, Deshler, Alley, Warner, & Denton, 1982).

Learning strategies can also be defined as the "steps taken by students to enhance their own learning" (Oxford, 1990, in Oxford, Cho, Leung, & Kim, 2004). With this, learning strategies aid students to become active learners and become responsible for achieving solutions to problems as well as learning.

It is evident in literature that students employ learning strategies to aid them in mathematical problem solving. This was shown in studies by Scheiter, Gerjets, Vollmann, and Catrambone (2009), who found that learners who had more favorable characteristics (i.e., higher prior knowledge, more complex epistemological beliefs, more positive attitudes towards mathematics, better cognitive and metacognitive strategy use) tended to solve more problems correctly. In a study by Adetula (1990), results showed that Nigerian students scored higher in problem solving tests and use of strategies when problems were presented in their native language than in English (second language). This study supports the

Cognitive Load Theory, with the native language as the less difficult task, over English, which can be considered as the more difficult task. From previous studies, we can see that learning strategies are indeed used in mathematical problem solving tasks. In the present study, the researchers used the learning strategies measured by the Motivated Strategies for Learning Questionnaire (MSLQ).

Problem Solving and Number of Operations

Single Operation. This type of mathematical word problem involves using one step (i.e., Addition or Subtraction) in solving the problem (O'Connell, 2007, p.41). In the current study, this type of mathematical word problem is considered as the less difficult task. Various studies have concluded that students were able to solve all mathematics story problems involving single operation than in problems which have multiple operations (e.g., Carpenter, Corbitt, Kepner, Lindquist, & Reyes, 1980; Carpenter, Kepner, Corbitt, Lindquist, & Reyes, 1980, in Littlefield & Rieser, 1993).

Multiple Operation. This type of mathematical word problem involves using two or more steps (e.g., Addition & Subtraction, Addition & Addition) in solving the problem (O'Connell, 2007, p.41). The current study considers this type of mathematics word problem as a more difficult task than problems involving single operation. Studies regarding multiple operation reported that solving mathematical word problems with two or more steps create more difficulty in obtaining the right answers (e.g., Carpenter, Corbitt, Kepner, Lindquist, & Reyes, 1980; Carpenter, Kepner, Corbitt, Lindquist, & Reyes, 1980, in Littlefield & Rieser, 1993).

Problem Solving and Language

Studying language and how one gets hold of their language is indeed cognitive since it involves learning to think and not just learning to talk (Pinker, n.d.). How students understand and make representations to the meaning of a sentence may be inferred from their knowledge of the meanings of the words (Anderson, 1977).

What happens if the language used in presenting mathematical word problems are in the person's first or second language? First language spoken at home has a strong influence on the learning of mathematics at school (Adetula, 1990). This was supported by Bernardo's (1999) study wherein Filipino-English bilingual students and problem solving showed that they performed better in solving arithmetic problems presented in their first language (Filipino) since they are more accustomed to their first language, than in the students' second language (English). With this, we can say that better comprehension of the problem text may result in better problem solving performance.

The language used to express mathematical ideas and problems to students is a concern especially if the students are less proficient in that language. Clarkson (1992) studied on bilingual students in Papua New Guinea where they were tested

in English (not their first language). Results indicated that up to 39% of the errors were related to linguistic factors such as reading mistakes and comprehension errors. Clarkson (1992) also noted that these language errors had lower occurrence in native English speakers tested in English. Moreover, students made more errors in comprehension which resulted in more solution errors when the problem was written using the second and less proficient language of the students (Clarkson, 1992).

With the findings of previous studies, it is important to note the following perspectives on bilingualism in order to find possible explanations for such results. Grosjean (1992) discussed two important views on bilingualism, the monolingual or fractional view and the bilingual or wholistic view. Bilingualism refers to the "regular use of two or more languages" (Grosjean, 1992) while bilinguals are those who need and use two or more languages in their daily lives and have been exposed to both languages for a year or more (Grosjean, 1992; 1998).

The monolingual view of bilingualism mainly posits that "the bilingual has (or should have) two separate and isolable language competencies" (Grosjean, 1992). In addition, this perspective holds that bilinguals are "two monolinguals in one person" (Grosjean, 1998). However, Grosjean (1992) consider this view as having a number of negative consequences in the field research on bilinguals. One argument that Grosjean (1992) stated is that bilinguals have been assessed according to the fluency in the two languages they use. The monolingual view believes that the bilingual should be equally fluent in both languages. According to this view, bilinguals should speak and hear the two languages at the same level; otherwise, they are not considered a real bilingual. Another argument of the fractional view is that using two languages are considered accidental; the use of two languages should be separate, wherein using both languages at the same time (e.g., code-switching) is considered "sloppy language" (Grosjean, 1992). Because of this, the monolingual view does not consider that the competency of one's first language may be affected if it comes in contact with one's second language.

In relation to the present study, the monolingual view argues that students are equally fluent in Filipino (first language) and English (second language). This means that students will obtain the same scores regardless of the language used in writing the mathematical word problem solving tests. This perspective also argues that one's first language does not have any effect when students answer tests in one's second language and vice versa.

The other view of bilingualism is the bilingual or wholistic view, from which the present study finds support in. According to this view, Grosjean (1992) proposes that bilinguals are not two monolinguals in one person; rather, it is "an integrated whole which cannot be easily be decomposed into two separate parts" (Grosjean 1992). The contact between the two languages then forms a new language system, uniquely different from his first language or second language. Another argument of this view is that the two languages may be used separately or at the same time, depending on the call of different situations. In addition, these two languages are said to be rarely equally fluent, which depend on the need for using the language. Grosjean (1992) proposes another concept in relation to the bilingual view; the language learning and language forgetting. According to Grosjean (1992), a

person may shift from one language to another, meaning he may use the first language or the second language depending on the situation, but will never depart from each other.

In another perspective of the wholistic view of bilingualism, Grosjean (1998) discussed the language mode continuum of bilinguals. He stated that in most cases, the bilingual uses the base language as his main language, which is considered to be the most active. The second language may be deactivated and activated, depending on who the bilingual is communicating with. When the second language is deactivated, it may mean that the person one is talking to is monolingual (Grosjean, 1998). When both languages are activated (one is less activated), it may mean that the person he is communicating with is bilingual and prefers to use the two languages as well (Grosjean, 1998).

In relation to the present study, the researchers find support in the bilingual view of bilingualism, wherein the bilinguals' first (Filipino) and second (English) languages are not equally fluent. The first language therefore, is considered as the bilingual's more fluent language, while English is considered as less fluent. In connection with the Cognitive Load Theory, the bilingual's more fluent language is considered as the less difficult task, which may create less cognitive load on the student, therefore performing better in mathematical problem solving tests.

Cognitive Theories

Over the last decade or so, Cognitive Load Theory (Sweller, 1989) has been used to explore several instructional techniques. The theory suggests that an approach for teaching which makes students engage in activities not directed at schema acquisition and automation frequently assumes processing something that is greater than their limits, thus likely to be faulty. Such as when students are given long and narrative problems to solve, they will not be able to use previously acquired schemata to generate solutions. Nevertheless, they may still be able to find a solution, however solutions may be faulty (Sweller & Chandler, 1994).

The Cognitive Load Theory assumes that the human cognitive system can be characterized as consisting of a relatively poor working memory (Miller, 1956) coupled with an effectively limitless long-term memory (Sweller & Chandler, 1994) designed to store a huge number of schemata. Such that if the student has gained "suitable automated schemas, cognitive load will be low, and ample working-memory resources are likely to be free; whereas if the element processing of material must each be considered as a separate element in working memory for the reason that no schema is existing, cognitive load will be high" (Tuovinen & Sweller, 1999).

The applications with other variables are not limited to memory studies only. Studies using this theory in relation to problem solving, language used and learning strategies suggest that when considering intellectual activities (such as solving mathematical problems), cognitive load may be responsible in learning and problem solving difficulty (Sweller & Chandler, 1994). Such that Sweller (1989, 1994) recommended changing problem solving methods so as to avoid means-ends

methods that impose an extensive cognitive load, by using goal-free problems or the use of providing worked examples.

In the present study, the Cognitive Load Theory is used to explain findings of previous studies as to why Filipino students have difficulty in solving mathematical word problems written in their second language (English) as compared when mathematical word problems are written using their first language (Filipino). In a study by Bernardo (1999), he found that the error in choosing and using effective problem solving strategies is often caused by the difficulty in comprehending the word problems. With this, it can be inferred that being able to understand mathematical word problems is a prerequisite for students to be able to choose and use effective learning strategies in solving these problems.

Given the previous studies done regarding students' performance in mathematical problem solving and the language, the researchers sought to know if there will be a change in the relationship between problem solving and learning strategies when the language (English or Filipino) used in writing these problems are varied. Furthermore, the researchers also wanted to know how the number of operations in mathematical word problems would change the relationship between students' scores on problem solving and their use of learning strategies. The number of operations in a mathematical word problem is categorized as either having a single operation (involving one-step operation to arrive at the answer), or multiple operation (involving two steps to arrive at the solution of the problem).

The researchers tested the Cognitive Load Theory in the study which posits that as learners are given easier situations, they perform better (Mayer, Sobko, & Mautone, 2003). In the present study, this theory was tested through mathematical word problems stated in Filipino, involving single operation (as less difficult situations), which was hypothesized to increase the use of learning strategies. In this case, a stronger relationship between the scores in problem solving tests (with single operation written in Filipino) and learning strategies is expected.

If learners use their first language (Filipino) as their medium for learning, less cognitive load is used, and therefore, students will score higher in word problem solving and consequently have increased learning strategies. Bernardo (1999) found that Filipino students solved arithmetic word problems better when the problems were written in Filipino which is their first language. For mathematical word problems involving single operations, O'Connell (2007, p. 41) explained that one-step mathematical word problems are simpler, and given during primary grade levels. With this, several studies have reported that students were able to solve all mathematics story problems involving single operation (e.g., Carpenter, Corbitt, Kepner, Lindquist, & Reyes, 1980; Carpenter, Kepner, Corbitt, Lindquist, & Reyes, 1980, in Littlefield and Rieser, 1993) as opposed to solving mathematical word problems with two or more steps, which create more difficulty in obtaining the right solutions (Littlefield & Rieser, 1993).

The researchers seek to know the relationship between problem solving and learning strategies. Specifically, the study aims to determine if the number of operations in word problems (Single operation or Multiple operations) and the language (Filipino or English) used in mathematical problem solving tests can be

accounted for the significant change in the relationship between problem solving and learning strategies.

The correlation of students' learning strategy and scores in problems written in Filipino or English involving single and multiple operations shall be obtained. From the results of the correlation, we can determine which the two of languages (Filipino or English) used, and which number of operation (Single operation or Multiple operations) have higher correlations with learning strategies.

Method

Research Design

The research design of the study is explanatory as it intended to test the Cognitive Load Theory by studying the relationship between learning strategies and problem solving. Specifically, the study investigated the relationship between learning strategies and the language (English or Filipino) used in mathematical word problem solving tests. The relationship between learning strategies and the number of operations in a mathematics word problem (Single operation or Multiple operations) was also tested.

Participants

The researchers selected grade five students from different private schools in Manila. The initial sample included 320 students with ages ranging from10 to 12. After determining the first language, second language, as well as the proficiency of the students in the two languages, those who did not fit it the criteria were excluded in the study. The participants included the study were 275 (n_{males} = 40.36%; n_{females} = 59.64%) students, who are bilingual and both proficient in English and Filipino. The current study used purposive sampling because it targets grade five students from a private school, who are bilingual, proficient in both English and Filipino, with Filipino as their first language.

Materials and Instruments

Demographic Questionnaire. The participants answered a demographic questionnaire that asked the participants for their class number, grade and section, age, nationality, first language, second language, as well as a self-report questionnaire regarding their proficiency in the two languages. This was measured by using a scale of one to three (1 – Not Proficient, 2 – Proficient, 3 – Very Proficient) in the areas of reading, understanding, speaking, and writing. An average equal or greater than the mean was considered proficient (see Appendix A). Those who rated their proficiency in both languages lower than the mean was excluded from the study.

Motivated Strategies for Learning Questionnaire (MSLQ). The Motivated Strategies for Learning Questionnaire by Pintrich, Smith, Garcia, and McKeachie (1991) was used to measure students' learning strategies. This study only utilized the part of the questionnaire assessing students' cognitive and metacognitive learning strategies consisting of 31 items.

The cognitive and metacognitive section included learning strategies namely Rehearsal (4 items), Elaboration (6 items), Organization (4 items), Critical Thinking (5 items), and Metacognitive Self-regulation (12 items). All items are responded using a seven-point Likert scale (from 1 – Not at all true of me to 7 – Very true of me). In general, if students score above three on the questionnaire, then it means that they are using effective learning strategies. However, students who score below three mean that they are not using effective learning strategies (Pintrich, Smith, Garcia, & McKeachie, 1991). The scale is valid having a significant relationship with all the factors being assessed. It was shown in the confirmatory factor analysis that the learning strategies are under one latent factor. Furthermore, the scale is reliable having a Cronbach's Alpha value ranging from .52 to .93.

Considering that the subscales are under one Latent factor, it is justifiable to test the factorial structure of the items. To determine the possible reduction of factors of the learning strategies, factor analysis was used, specifically principal components analysis. The number of factors was assessed using a scree plot of the Eigenvalues. Since the use of learning strategies overlap, meaning, as students answer the mathematical problem solving tests, the strategies they use are interrelated, then it would be implied that they should be assessed as one, and not separately, the researchers used the unrotated analysis for factor loadings. Since the MSLQ was originally used to assess college students, the researchers consulted the English and Mathematics teachers and coordinators of the school to ensure that the items of the learning strategies questionnaire are answerable and appropriate for their grade five students. The teachers and the coordinators helped in revising the questionnaire by rewording the items to make it understandable for the grade five students. The teachers also helped in rewording the items of the questionnaire to fit with the mathematical word problem solving test that the students answered.

The 31 items of the revised Motivated Strategies for Learning Questionnaire (MSLQ) loaded under one factor using a principal components analysis. The Eigenvalues were assessed using a scree plot which showed that having one factor accounts for a large total variance (50.57%) as compared to two or three factors with very low variance (4.37% and 3.64 respectively). The factor loadings of all items are high (0.4 and above).

Mathematical Word Problem Solving Test. The mathematical word problem solving tests were constructed by the researchers based on the mathematics curriculum of grade five students developed by the Department of Education of the Philippines to ensure appropriateness of the researchers' intended participants in the study. The word problems include contents on addition and subtraction of fractions, decimals, and whole numbers.

The questionnaire included 32 mathematical word problems. Four sets of mathematical word problems were constructed. The first set of mathematical word

problems were written in Filipino involving single operation , the second set was written in English involving Single operation, the third set was written in Filipino involving multiple operations, and the fourth set was written in English involving multiple operations. Equivalence was established between the four sets of problem solving tests. The level of difficulty, length of the statements and the skills being measured were equivalent

The items of the four sets of mathematical problem solving tests were analyzed using the one-parameter Rasch model. The one-parameter Rasch model is a statistical analysis used to determine the item and person reliability of a test. The analysis identifies whether the items are difficult by assessing its logic measure; goodness of fit by examining the in fit mean square values (values should range from 0.80- 1.20); and item discrimination was assessed by looking at point biserial correlation of each item. Computed values for the infit mean square showed that all items were having a good fit.

Procedure

Grade five participants were randomly chosen by the school. The four sets of problem solving tests were administered to the students for two days. On the first day, the students answered two mathematical word problem tests. On the second day, the students answered the remaining two mathematical word problem tests. The students answered the revised Motivated Strategies for Learning Questionnaire (MSLQ) for four times, after they have answered each set of mathematics word problem test.

The participants were asked to complete the participant demographic questionnaire. The first set of mathematical word problem solving test were distributed to the participants. Directions were read and the participants were given 15 minutes to complete the said test.

After 15 minutes, the researchers collected the mathematical word problem solving test and distributed the revised (MSLQ). It was emphasized to the participants that when they answer the items of the revised MSLQ, they should think about the situations they had while answering the mathematical problem solving test that they have just completed. Ten minutes were allotted for answering the learning strategies questionnaire.

The same procedure was done in administering the second set of mathematical problem solving test and the revised MSLQ. On the second day, the third and fourth set of mathematical problem solving test were administered to the students, followed by the revised MSLQ for each set.

The four sets of problems solving tests were given out using counterbalancing technique where the six sections of grade five students answered two different sets at a time on two different days. The second data gathering day was conducted two days after the first data gathering day. Again, the six sections answered different sets of math tests. This counterbalancing technique was done primarily to avoid confounding among variables. This was done by having participants answer different types of tests on different days. Another technique done to make sure that students would not have too much stress in answering all

the four sets of math test in one day was splitting data gathering into two days, which were not consecutive.

Data Analysis

The data collected were statistically analyzed by correlating the scores of students in the mathematical word problem solving tests and the learning strategies from the revised MSLQ. Since the MSLQ is reduced to one factor, the analysis only considered the learning strategy having one dimension.

Scores for mathematics problems written in English and in Filipino with single operation and multiple operations were correlated to the learning strategies assessed in the learning strategies section of the MSLQ.

The differences in the correlations were obtained among the learning strategies with mathematical problems written in Filipino and between learning strategies with mathematical problems written in English. At the same time, the differences in the correlations were obtained among the learning strategies with mathematical problems involving single operation and between learning strategies with mathematical problems involving multiple operations. The correlation coefficients were analyzed further to see whether they are significantly different.

The correlation coefficients obtained from correlating scores from the problem solving test and learning strategies when problem solving is written in English involving single operation and when problem solving test was written in Filipino involving single operation was compared. Similarly, the correlation coefficients obtained from correlating scores from the problem solving test and learning strategies when problem solving is written in English and when problem solving test was written in Filipino was compared. By doing this, the researchers were able to test whether there was a significant change in the correlation coefficients if the language used (Filipino or English) and number of operations in a mathematical word problem (Single operation or Multiple operations) were varied.

Results

The items of the MSLQ were reduced to one factor using principal components analysis. In the further analysis, MSLQ was analyzed as one measure.

In order to determine on whether Filipino or English and Single operation or Multiple operations will differ on students score in the problem solving tests, the two-way ANOVA was used. This was done to establish whether cognitive load is carries on the language and no. of operations in the problem solving task.

Based on the comparison of means for problem solving using two-way ANOVA, there was a significant difference between problem solving tests written in Filipino and English on the problem solving scores of students (F = 78.932, p = 0.00). Means of the problem solving scores of students in written in Filipino (M = 5.95, SD = 2.16) and English (M = 4.74, SD = 2.32) showed that students scored significantly higher on problem solving tests written in Filipino. There was no significant difference on the problem solving scores of students involving single and multiple operations as well as their interaction (F = 1.21, p = 0.27, F = 0.001, p =

0.98). From these results, the researchers can infer that mathematical word problems written in the students' native language was an easier task for them having scored significantly higher on tests written in Filipino as compared when problems are written in English.

Table 1
ANOVA Summary Table

	SS	*df*	*MS*	*F*
Number of Operations	6.11	1	6.11	1.21
Language	396.00*	1	396.00*	78.93*
Number of Operations X Language	0.00	1	0.00	0.001
Error	5498.61	1096	5.02	

Note. * $p < .05$

Given that the current study finds support in the Cognitive Load Theory for the problem solving task, the Two-Way ANOVA was again used to determine whether students really used higher learning strategies when given task is easier. Given that scores on problem solving tests are higher when they are written in Filipino, the researchers wanted to determine whether it is the same on the students' learning strategy. It is assumed that students will have a higher score on learning strategy when problems are written in Filipino given the results for problem solving.

Based on the comparison of means for learning strategy using two-way ANOVA, there was significant difference between problem solving tests are written in Filipino and English (F = 15.43, p = 0.00) on learning strategy. Means of the scores of students in learning strategy when problems are written in Filipino (M = 4.41, SD = 1.35) is significantly higher as compared to English (M = 4.17, SD = 1.43) (See Table 4). In the same way, there was no significant difference on the learning strategy scores of students involving single and multiple operations as well as their interaction (F = 1.21, p = 0.27, F = 0.001, p = 0.98). Results from these analyses show that as students are able to highly use learning strategies when task is easy.

Table 2
ANOVA Summary Table

	SS	*df*	*MS*	*F*
Number of Operations	0.20	1	0.20	0.10
Language	15.43*	1	15.43*	7.98*
Number of operations X Language	7.27	1	7.27	3.76
Error	2118.46	1096	1.93	

* $p < .05$

Means for the four sets of mathematics problems solving tests (Single-Filipino, Single-English, Multiple-Filipino, Multiple-English) were calculated as well. We can see that language is a variable that can be accounted for the significant change in the problem solving scores of students (as tested using the two- way ANOVA).

Comparison of means was tested through two-way ANOVA and it was consistent that both Filipino and English had a difference in the students' problem solving test scores and learning strategies. The revised MSLQ had a Cronbach's Alpha of .97, which indicates a high reliability. The item and person reliability of the tests in mathematical problem solving were adequate using the one-parameter Rasch Model IRT approach.

Table 3
Means and Standard Deviation of Revised MSLQ and Problem Solving

	M	*SD*	*N*	Cronbach's Alpha	
MSLQ (learning Strategies)	4.29	1.40	1100	.97	
Single Operation	4.30	1.32	550		
Multiple Operation	4.27	1.46	550		
Filipino Language	4.41	1.35	550		
English Language	4.17	1.43	550		
Filipino Single Operation	4.50	1.27	275	.96	
English Single Operation	4.10	1.35	275	.96	
Filipino Multiple Operation	4.31	1.42	275	.97	
English Multiple Operation	4.23	1.50	275	.97	
Problem Solving				Item Reliability	Person Reliability
Single Operation	5.27	2.31	550	.96	.55
Multiple Operation	5.42	2.32	550	.97	.55
Filipino Language	5.95	2.16	550	.96	.43
English Language	4.74	2.32	550	.96	.59
Filipino Single Operation	5.87	2.16	275	.95	.48
English Single Operation	4.67	2.3	275	.92	.59
Filipino Multiple Operation	6.02	2.16	275	.95	.44
English Multiple Operation	4.82	2.33	275	.95	.60

Note. MSLQ is a 7-point scale; Problem solving has a total of 8 items

The main analysis of the study was to test the difference in the relationship between problem solving and learning strategies for Filipino and English and Single and multiple operation. It was hypothesized in the study that there will be a stronger relationship between learning strategies and problem solving when problem solving test is written in Filipino involving single operations.

Table 5 shows the correlation coefficients of learning strategies with the problem solving tests.

Table 5
Correlation Coefficients of Problem Solving and Learning Strategies

Type of Math Problem Solving Test	MSLQ
Filipino-Single	.13*
English-Single	-.0402
Filipino-Multiple	.10*
English-Multiple	-.0011

Note. * p < 0.05

Results of the present study showed that only the problem solving test written in Filipino involving single operation is significantly related with learning strategies (r = 0.13, p = 0.02) . Also, the problem solving test written in Filipino involving multiple operations is significantly related with learning strategies (r = 0.10, p = 0.02). Other sets of mathematical problem solving test (Single-English and Multiple-English) showed no significant relationship with learning strategies. These results suggest that only problem solving tests written in the learners' native language is significantly related with learning strategies. Therefore, students are able to use higher learning strategies when they are given word problems written in Filipino.

To determine whether the Pearson r's obtained for the relationship between problem solving and learning strategies across the four types of math tests were significantly different, the r's were compared. The combinations of the comparison are shown in Table 6. It can be determined which type of mathematical problem solving test was the relationship between problem solving and learning strategies strongest.

Table 6
Difference of r's

Type of Math Problem Solving Test and MSLQ	*R*	Type of Math Problem Solving Test and MSLQ	*r*	*p* values
Filipino-Single	.13*	English-Single	-.0402	.04*
Filipino-Single	.13*	Filipino-Multiple	.10*	.72
Filipino-Single	.13*	English-Multiple	-.0011	.13
English-Single	-.0402	Filipino-Multiple	.10*	.10
English-Single	-.0402	English-Multiple	-.0011	.65
Filipino-Multiple	.10*	English-Multiple	-.0011	.24

Note. * p < 0.05

Results showed that only the difference of r's between 0.13 (relationship between Filipino-Single Problem Solving and Learning Strategy) and -.04 (relationship between English-Single Problem Solving and Learning Strategy) is

significant (p = .04). However, results showed that the difference of r's between other sets of math tests and its relationship with learning strategies were all insignificant.

The relationship between problem solving and learning strategies changes when the language used in the problem solving test is varied to English or Filipino. Specifically, the relationship between mathematical problem solving test written in Filipino involving single operation and learning strategies is stronger (r = .13*) as compared to the relationship between problem solving test written in English involving single operation and learning strategies (r = -.04). This result supports the Cognitive Load Theory, which states that when students are given less difficult tasks (problem solving test written in Filipino involving single operation), they score higher and are able to use higher learning strategies.

Discussion

The present study mainly hypothesized that there is a stronger relationship between problem solving and learning strategies when mathematical problem solving tests are easy. The easy task in solving a problem is operationally defined as those problems that are written in Filipino and involving single operation as compared to the relationship between problem solving and learning strategies when problem solving tests are written in English involving multiple operations.

It was found in the present study that the relationship between problem solving and learning strategies is stronger when the word problem is written in Filipino (Students' first language) than in English (Students' second language). The findings of the study were supported by past studies explaining that students' performance on problem solving tests written in their first language are better than when tests were written in the learners' second language (Adetula 1990; Bernardo, 1999). The results are supported by Bernardo's (1999) study, wherein bilingual students scored higher in arithmetic problems written in the language that they are more accustomed with (First language). There are difficulties encountered in the comprehension of a problem that is based on how accustomed the students are with the language used in writing the word problem. This may explain why students scored higher in mathematical problem solving test written in Filipino than in English.

In relation to the use of learning strategies in mathematical problem solving, results showed that students employed higher learning strategies when problem solving tests were written in Filipino than in English. This support Adetula's (1990) study where students scored higher in problem solving tests and employed higher use of strategies when the problems were presented in their native language than in English. In the present study, the same results were found where students obtained higher scores in problem solving and used higher learning strategies when the problem solving test was written in Filipino. In addition, the findings found support in Scheiter, Gerjets, Vollmann, and Catrambone's (2009) study, wherein students who had more favourable characteristics, such as using cognitive and metacognitive strategies solved more problems correctly.

From the results of the present study, the Cognitive Load Theory is extended as manifested in the use of one's native language in a task. The use of one's language in problem solving tasks account for the following new assumptions:

1. One's native language facilitates the use of learning strategies
2. The role of one's native language in the student's ability to solve problems and learning strategies
3. Support for the Wholistic view of Bilingualism in the study
4. Similarity of cognitive load for single and double operations in a problem solving task

From the results of the correlation between problem solving and learning strategies, wherein students scored higher in problem solving tests written in their first language, we can say that one's native language can facilitate the use of learning strategies. This occurs when students use more learning strategies when they are presented with problem solving tests written in their native language, such as Filipino. This means that they are able to allocate more cognitive resources for comprehension of the problem text rather than in understanding the language (such as a second language) used in writing the math problems. In the same way, problem solvers employ higher learning strategies since they are able to utilize more techniques in completing tasks rather than in understanding the language. This is because students allot more time and resources in planning for the solution of the problem such as using learning strategies, whereas if the word problems are written in English, which lessen their time for planning techniques in solving the problems because they will first need to understand the language used in writing the word problems. Therefore, if the problem solving task is written in the students' native language, they are able to fully devote their cognitive resources in using learning strategies when solving the problems and thus lead to the correct answers.

In relation to the Cognitive Load Theory, we can consider a higher use of learning strategies when students are given easier tasks. Such that when students are given less difficult tasks, less cognitive load occurs and therefore they are able to allot more cognitive resources for planning for the solution of a problem with the use of learning strategies.

The allocation of cognitive resources involved in solving problems when written in a second language has two levels of processes that are simultaneously occurring. These two levels of processing involve comprehending the second language and the other in solving the problem which maximizes one's cognitive resources. When there are two or more processes used, the cognitive resources then becomes more limited since both declarative knowledge in processing the language and procedural knowledge in solving the problems are used. The native language serves as an automatic process that lets the learner perform a task without too much conscious awareness and demand little or no effort.

In connection with the Cognitive Load Theory, the learners' first language is considered as which create less cognitive load on the students. Therefore, when the task is written in the students' native language, it would require less cognitive resources because cognitive resources are fully used for solving the problem alone,

and students are able to proceed in solving the problem at once. On the other hand, when the problems are written in the learners' second language, they undergo a parallel process where they find ways to solve the problem and at the same time comprehend the language used to solve that problem. This results to decreased performance as in the case of the results of the present study. There are several processes undertaken in comprehending a second language such as finding meanings of ambiguous concepts, at the same time, there several processes to be undertaken when solving the problem such as assembling thoughts, concepts, and procedures (Heinze, 2005). These processes make students select appropriate learning strategies and arrive at the correct answer to the problem.

The second note explains the role of one's native language in a learner's ability to solve problems with the use of strategies. This may be explained by metalinguistic awareness, which is used to describe the relationship between language and text among bilinguals (Mora, n.d.). This construct refers to the ability of the learner to be aware of his linguistic capabilities. When students are aware of his language, such as his native language, he is able to attend to the task effectively with the use of learning strategies. Thus, his ability to solve the word problems may be enhanced. With this, when students score low in problem solving tests written in their second language such as English, it does not mean that they have low problem solving abilities; rather, their linguistic capabilities in that language (Second language) may be low.

Metalinguistic ability also helps students to view and analyze language as a process and as a technique to aid them in solving the problems (Mora, n.d.). Since the students have an implicit awareness in their first language, they will have better ability to solve the problems and when the problems are contextualized in their own native language. In addition, the ability in solving problems and using learning strategies are better when problem solving tests are written in the native language of the problem solver since they are able to maximize their potential in solving problems.

In view of the role of one's native language in the learner's ability to use strategies, Cognitive Load Theory may be extended by considering the linguistic capabilities of the learners. When students are presented with word problems in their first language, they are implicitly aware of their capabilities in the given language presented in the text. As students recognize that they are capable to read and understand the given text, they recognize that the task given is easy therefore it gives them more room for using techniques in order to arrive at the correct answer to the problem text. Therefore, when students use learning strategies, they are able to complete the task effectively with fewer errors.

Based from the results of the difference between the *r*'s obtained, wherein it was found that there is a stronger relationship between problem solving tests written in Filipino involving single operations, we can consider Grosjean's (1992) Wholistic view of Bilingualism in the present study. The Wholistic view of Bilingualism argues that bilinguals are rarely equally fluent in both languages. They can be competent and fluent in both languages, but the level of fluency may differ depending on "what the language is used for, with whom and where" (Grosjean, 1992). In this case, students may be more fluent in their first language (Filipino),

which accounts for the higher scores in problem solving tests written in their first language.

Another perspective of the Wholistic view is the language mode continuum of bilinguals, wherein the bilinguals' two languages may never depart from each other, but may be activated or deactivated depending on who the person in communicating with. When students are presented with word problems written in their first language (most active language), the second language may be deactivated since the learner may not require the aid of the second language anymore in order to solve the problems. Therefore, they will be able to allot more cognitive resources for understanding the word problems. Whereas when learners are presented with word problems written in their second language (less fluent language), their first language (more fluent language) may need to be activated in order to aid them in understanding some ambiguous words in the problem. Cognitive resources are then divided into both understanding the language with and comprehending the problem as well. Therefore, less cognitive resources are allotted for understanding the problem text, which may lead to lower scores in mathematical problem solving tests.

We can see that language is a variable that plays a significant change in the performance of students especially in mathematical problem solving, while the number of operations in mathematical problems is not a variable that caused any change in the performance and relationship between problem solving and learning strategies. The number of operations involved in problem solving tests is not a variable that accounts for a significant change in the relationship between problem solving and learning strategies since both numbers of operations are not highly different in terms of the level of difficulty; single operation involves one-step to arrive at the answer and multiple operations are limited to two-step operations in solving the problems which are not distinct. When students take mathematical problem solving tests, differences in the number of operations are not noticed by the students. Therefore, the amount of cognitive resources allotted for word problems involving single operation and multiple operations are not changed. In the same way, the use of learning strategies remains constant regardless of the number of operations involved in the word problems. Therefore, their performance and the use of learning strategies on both tests do not change.

Based on the findings of the present study, the Cognitive Load Theory may be extended by adding the role of learning strategies and language on less difficult tasks in the context of mathematical problem solving. When easier tasks (less cognitive load) are correlated with learning strategies, we can expect a linear relationship between the two variables; students who are given less difficult tasks are likely to employ higher learning strategies, and therefore obtain higher scores in those tasks. With this, the learning strategies that students use can be accounted for the improvement of their performance as measured by their problem solving scores.

The findings of the study suggest a call for more enhancement programs for students to make them think in English. The teachers will need to exert more effort on training students to think in English. Based from the results of this study and previous studies, answering mathematical word problems written in the

students' second language such as English, is a weakness in the students since there is an issue that students are less fluent in their second language. Therefore, the teachers should supplement their teaching to enhance more learning strategies for mathematical word problems written in English. When the students are trained to think in English, they will gain more capacities and abilities in the aspect of language in mathematics, thus they are likely to achieve in the subject.

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