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The English language level of proficiency on mathematical problem solving skills

Reem Hisham Mohammad Abuqutaish[1]
[1]IB-MYP English Language and Literature Teacher
Mashrek International School
reem.abuqutaish@mashrek.edu.jo

Norma Al-Zayed[2]
Middle East University/ Amman-Jordan
English Department at Middle East University
Faculty of Arts and Sciences
Amman P.O.Box.383 Amman 11381 Jordan
Nzayed@meu.edu.jo

Abstract

This study aimed to examine the effect of the students' level of proficiency in the English language on their mathematical problem solving skills, and how the instructional design for mathematical problem solving may be altered to meet the individual students' needs. The findings revealed that the students' level of proficiency in the English Language, the language of instruction, directly affected the students' performance in the mathematical problem solving test. The participants in the advanced group obtained higher means and percentages of correct answers across the different categories of the mathematical problem solving test.

Keywords: Effect, English, Proficiency, Mathematical, Word problems.

El nivel de dominio del idioma inglés en habilidades de resolución de problemas matemáticos

Resumen

Este estudio tuvo como objetivo examinar el efecto del nivel de competencia de los estudiantes en el idioma inglés en sus habilidades de resolución de problemas matemáticos, y cómo el diseño instrucción

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para la resolución de problemas matemáticos puede modificarse para satisfacer las necesidades individuales de los estudiantes. Los resultados revelaron que el nivel de competencia de los estudiantes en el idioma inglés, el idioma de instrucción, afectó directamente el rendimiento de los estudiantes en la prueba de resolución de problemas matemáticos. Los participantes en el grupo avanzado obtuvieron medias y porcentajes más altos de respuestas correctas en las diferentes categorías de la prueba de resolución de problemas matemáticos.

Palabras clave: Efecto, Inglés, Competencia, Matemática, Problemas verbales.

1. INTRODUCTION

Language is a medium through which ideas are expressed. It is a verbal means of communication that allows the transmission of an unlimited range of subject matter. Language plays a critical role in the learning process as it allows the learner to understand a certain subject. English, as a distinctive language, has left its mark as an influential, global medium of communication. It is widely used in various countries in a variety of settings. Its prevalent use as a lingua franca led to its wide implementation in schools and other academic institutions as a means of instruction. English proficiency is an essential component of performance when used as the medium of instruction in academic settings. Mathematical learning is mediated through language. Mathematical worded problems are an example of how language is used to reign over different subject areas.

The aptitude to solve mathematical word problems is an important skill for students of all ages. This skill enables students to form a connection between what they learn inside the classroom and the real-life situations that they are bound to face. Teaching mathematics aims at helping students become critical thinkers who can apply their knowledge meaningfully in their daily lives (HALAI, 1998). Developing mathematical proficiency has been documented as a crucial issue for children and their education. Mathematical development which happens in the early years is extremely important for the students' success and achievement both in school and in life pursuits (KILPATRICK, SWAFFORD, & FINDELL, 2001). Not only is mathematics important because of its application of basic numeracy skills, but it also functions as the main vehicle for developing student's logical thinking and higher- order cognitive skills. Many other scientific fields, such as physics, statistics and engineering depend on mathematics, so mathematical proficiency is a prerequisite for understanding other subject areas.

One of the most important critical components of learning mathematics is solving word problems. Young pupils who are repeatedly exposed to and engaged in meaningful problem solving develop a repertoire of problem-solving strategies. However, students normally think that solving word problems is one of the hardest and most distasteful tasks in mathematics. Students' achievement and attitude towards mathematics is affected by mathematics anxiety (HEMBREE, 1990). The difficulty students' face arises from the fact that the students have to conceptualize the problem and decide on the correct mathematical procedure to solve it. Yet, actually comprehending the words that represent the problem and correctly interpreting them to arrive at the actual question is the basic difficulty that faces most. This becomes even harder for students whose native language is different from that in which the word problem is presented. Previous research studies done on the relationship between language proficiency and mathematical proficiency had conflicting views; some deemed that each proficiency is reliant on the other (HOLTON, ANDERSON, THOMAS, and FLETCHER, 1999, in ALBERT, 2001) while others decided that each was autonomous (CHOMSKY, 1975).

In a thriving learning community where international schools are becoming widespread, the issue of the relationship between English proficiency, as English is used as the language of instruction, and the students' ability to solve word problems is becoming of great importance. Therefore, the researcher decided to investigate this issue by studying the effect the former has on the latter.

Questions of the Study

- What is the effect of the pupils' level of proficiency in the English Language on their Mathematical problem solving skills?

- How can the instructional design for mathematical problem solving be altered to meet students' needs?

With the growth of international schools in Jordan being a recent trend, studies investigating the effect of the language of instruction on the students' ability to perform in various other subject areas are comparatively low. There is a gap in the literature that this study aims to diminish. The findings of this study may help explain some possible reasons that lie behind the students' achievement in mathematical word-problem solving. Thus, if these reasons are better understood, researchers, administrators and teachers will be more capable of anticipating problems and designing alternative plans that would help ease the predicament at hand.

SWELLER (1994) points out some of the factors which ascertain the difficulty of material that needs to be learned. He suggests that to reduce difficulty while learning or engaging in intellectual activities, which is widely believed to happen through schema acquisition and automation, Cognitive Load Theory (CLT) can be used for the structuring of information by focusing cognitive activity on schema acquisition. It is indicated that CLT can use instructional design to manipulate learning and problem solving difficulty. Sweller indicates that intrinsic cognitive load is stable for a given area as it is a fundamental constituent of the subject. Element interactivity characterizes intrinsic cognitive load. The learning of most schemas' elements must be done concurrently because these elements interact, and it is their interaction that is of the utmost importance. Intrinsic cognitive load will be high if interactions between many elements must be learned, whereas it is low if elements can be learned consecutively rather than simultaneously because they do not interact. Furthermore, it is suggested that extraneous cognitive load that obstructs learning is caused by high element interactivity. This condition of high element interactivity can be used to explain why some material is difficult to learn and to understand.

Brunken, PLASS and LEUTNER (2003) describe three types of cognitive load: intrinsic, extraneous and germane. Intrinsic cognitive load is inherent in the subject and determined by its complexity. For instance, learning a word in any foreign language is less complex than learning the grammar of the same language. This is the result of the syntax requiring an understanding of the words that make sentences, in addition to the rules of the order of words and the tenses that should be used (ANTONENKO and NIEDERHAUSER, 2010). Extraneous load, on the other hand, is known as unneeded information processing which comes from the instructional design rather than from the subject itself (CIERNIAK, SCHEITER and GERJETS, 2009). Germane cognitive load is advantageous. It is relevant to rich schema acquisition and automation as it draws the learner's attention towards the learning process. Automation is acquired through exposure and practice, and automation of schemas decreases cognitive load. For example, commonly used skills, like reading, can be done automatically, in a routine way and without effort, even though the connected tasks may be complicated (BURKES, 2007). Germane and extraneous cognitive load may be altered by the instructional design, whereas the intrinsic cognitive load remains unchanged.

2. METHODOLOGY

The methodological approach adopted for the current study is a quantitative and qualitative one. The test provided the quantitative data which tackled the first question of the study, while the interviews offered additional information that expanded the understanding regarding the reasons behind the results from the teachers' perspectives. The interviews also shed light on the accommodations that must be undertook to alter the instructional design so as to maximize the students' potential while solving mathematical word problems.

The population of this study consists of all third grade students currently enrolled in Mashrek International School in Amman, Jordan. A sample of 76 third-grade students from Mashrek International School was selected purposively to achieve the aim of the study. The sample consisted of 44 male students, and 32 female students, aged between 8-9 years old. The sample was divided into three groups on the basis of the students' level of proficiency in the English language. The advanced group consisted of thirty participants, the intermediate group consisted of twenty-seven participants, while the basic group included 19 participants.

The demographic data of the participants included their gender and nationality. 66 of the participants are Jordanian students, while the rest have the following nationalities: two are Palestinian, one is Lebanese, two are American, one is Chinese, one is French, One is Albanian, one is Indian, and one is Spanish. All of the students have been learning in English as the language of instruction since they first entered the school. This study utilizes qualitative and quantitative methods in assembling and analyzing the required data. A test and open-ended interviews are both used in drawing the conclusions of the research.

The first instrument used was a test designed to unveil the relationship between English proficiency and mathematical worded problems which was implemented to collect the data required to answer the first question of the research. The test comprised of 8 mathematical word problems printed on booklets. The word problems included two easy-math-easy-English, two easy-math-hard-English, two hard-math-easy

English, and two hard-math-hard-English problems. The test was adopted and adapted from the study conducted by BARBU and BEAL (2010). Addition word problems, through single steps, were used as the easy math problems, whereas the difficult math problems involved single or multi-digit multiplication and division. Each word problem was designed to be presented in two versions, one that used easy-English, and one which was presented in hard-English. A semi- random order of the word-problems was used to ensure that the easy-English and hard-English versions of the same word problem did not follow each other immediately. The complexity of the word problems was changed by altering the vocabulary and grammatical structures used. To assess the difficulty of the word problem, an online readability assessment tool was used. This software calculates the text's difficulty by considering both vocabulary frequency and grammatical complexity. The test questions were based on the common core standards, and similar to the students' solving experience in everyday mathematics class. The items were revised and changed to create harder versions to make the problem solving test applicable and purposeful.

The students were divided into three groups based on their level of proficiency in English, which was determined based on the students' performance in the end of the first term summative assessments. The three groups consisted of students who were classified as having advanced, intermediate or basic levels of proficiency. The same test was administrated to the three groups, in order for the test to show whether the students' level of proficiency in the English language actually affected the students' performance in the mathematical problem solving test or not.

The second instrument was informal, open-ended interviews; the researcher conducted interviews with teachers and administrators to highlight the reasons which lay behind the students' achievement in the test. The interviews also revealed how the instructional design, from the interviewees' perspective, can be altered to better accommodate the students' needs.

The following procedures were followed to analyze the test:

1. After administrating the test, the researcher analyzed the students' responses and recorded the correct and wrong answers. On each problem, the students were given a score of 0 or 1 indicating whether the correct answer was achieved or not. Each student completed eight problems, two each for easy-math-easy-English, easy-math-hard-English, hard-math-easy-English, and hard-math-hard-English. Scores and ratings were averaged across the two problems in each of these four categories for each student.

2. For each category, the researcher calculated the mean and the standard deviation to better explain the results. Then the frequency and percentages of correct answers were recorded to ease the process of comparison across the different levels.

3. RESULTS AND DISCUSSION

To answer the first question of the research, the results obtained were analyzed by calculating the mean and the standard deviation of the four main categories (easy-math-easy-English, hard-math-easy-English, easy-math-hard-English, and hard-math-hard-English) in an attempt to find whether a relationship between the students' level of proficiency and their ability to solve mathematical word problems actually existed or not.

Table (1) below shows the mean which is recorded with the standard deviation written next to it between parentheses. The frequency of the correct answers for both questions within the same category was also recorded, in addition to the percentage of the correct answers to make the comparisons between the advanced, intermediate and basic groups easier.

Table 1: Means, Standard Deviations, Frequencies and Percentages for the Problem Solving Test

Difficulty of English Text	Difficulty of Math Problem	Advanced			Intermediate			Basic		
		Mean (Standard Deviation)	fr.	%	Mean (Standard Deviation)	fr.	%	Mean (Standard Deviation)	fr.	%
Easy English	Easy Math	0.93 (0.17)	56	93.3 %	0.75 (0.34)	41	75.9 %	0.42 (0.44)	16	42.1 %
	Hard Math	0.83 (0.27)	52	86.7 %	0.74 (0.34)	41	75.9 %	0.42 (0.37)	16	42.1 %
Hard English	Easy Math	0.83 (0.27)	50	83.3 %	0.70 (0.36)	38	70.4 %	0.29 (0.40)	11	28.9
	Hard Math	0.83 (0.27)	49	81.7 %	0.65 (0.36)	35	64.8 %	0.29 (0.37)	11	28.9 %

Each word problem is discussed separately. The students' performance, as shown in the table, evidently shows that the students' work was best for the easy-English easy-math problems, and poorest for the hard-English hard-math problems.

A) Easy-Math- Easy- English Question (1) and (2)

1) You can see a toucan in the rain forest with its long, colorful beak. A toucan's beak is usually 6 inches long. A toucan's body is usually 12 inches longer than its beak. How long is a toucan's body?

2) Very big bamboo plants grow in the thick rain forests. A very big bamboo plant can grow up to 9 inches every day. If one bamboo tree is 35 inches long, how long will it be after one day?

Using the online readability software, question 1 was rated as having an average grade level of about 5. This question was both easy in terms of the language used to show the story problem, and the mathematical operation the actual computation required. Question 2 was rated as an average grade 4 text. This question was also easy in terms of the mathematical operation it required, as well as the language used.

As shown in table (1), the students included in the advanced group, based on their advanced level of proficiency, performed best in this category. The performance mean in this category was 0.93 with a standard deviation of 0.17. The students included in the intermediate group also performed best in the questions solved within this category. The students' answers received a mean of 0.75, and a standard deviation of 0.34. Table (1) also shows that the basic group's performance in the same category was best compared to the other categories. The students' performance within the basic group received a mean of 0.42 and a standard deviation of 0.44. The low standard deviation within the three groups shows that the numbers are close to the average, which illustrates the consistency and proximity in the students' answers within the same group.

In terms of the frequency and percentage of the participants' correct answers, the advanced group obtained 56 correct answers for the easy-math-easy-English category, which shows an excellent percentage of 93.3%. In comparison, the intermediate group got 41 correct answers, which equals 75.9 %. The basic group received the lowest percentage, 42.1%, with only 16 correct answers. The three groups' performance varies significantly across the same category. The advanced group did markedly better compared to the intermediate and basic groups.

B) Hard-Math- Easy- English Question (3) and (4)

3) Cashews, Brazil nuts, and peanuts originally grew in rain forests. Anne made a trail mix with 9 cups of each. How many cups of cashews, Brazil nuts, and peanuts did she use to make the mix?

4) Chocolate comes from the rain forest cocoa plant, but today most of the cocoa is grown by farmers. One ounce of milk chocolate has 9 grams of fat. How many ounces of milk have 18 grams of fat?

Both questions 3 and 4 were given an average grade level of about grade five. These questions were included in the easy English category because the texts were simple in terms of words and linguistic structures, and they were also included in the hard math category because they required higher level computational skills; including multiplication and division. The table illustrates that the performance of the advanced, intermediate and basic group differs considerably, again, for this category. The advanced group performed well in this category with a mean of 0.83 and a standard deviation of 0.27. The intermediate groups' participants scored a mean of 0.74 and a standard deviation of 0.34, while the respondents in the basic group scored a mean of 0.42 and a standard deviation of 0.37.

The advanced group was in the lead again with the percentage showing the correct answers, the respondents had 52 correct answers which shows a percentage of 86.7 %. The intermediate group answered 41 correct questions, and they received a percentage of 75.9 %. The basic group scored 16 correct answers, with a percentage of 42.1%. It is noticeable, again, that the frequencies and percentages of correct answers show a descending order from advanced to basic groups. The percentage of correct answers is reduced considerably moving from the advanced group, through the intermediate, to the basic group.

C) Easy-Math- Hard- English Question (5) and (6)

You can recognize a toucan in the rain forest by its stretched, multi-colored beak. A toucan’s beak is frequently 6 inches long. A toucan’s body is typically 12 inches longer than its beak. What is the total length of a toucan’s body?

Enormous bamboo plants sprout in the densely crammed rain forests. A giant bamboo plant increases 9 inches in length a day. How long will a 35 inches long bamboo tree be one day later?

These questions are the revised items of questions 1 and 2. Question 5 was rated as an average grade six question, while question 6 received an average grade 7 readability result. Some vocabulary items were altered and replaced by more challenging words to create the desired complexity effect. As shown in table (1), the advanced group’s participants did much better in this category when compared with the other groups, with a noticeable difference in the mean scored across the three different groups. The advanced group scored a mean of 0.83 with a low standard deviation of 0.27. The intermediate group was next with regards to the accuracy of performance. The groups mean equaled 0.70, and the standard deviation was 0.36. The basic group got a lower mean than the two previous groups, which equaled 0.29 and the standard deviation measured was 0.40.

The advanced group had 50 correct answers in this category, with a high percentage of 83.3%. The intermediate group came next in terms of the percentage it received, which was 70.4% corresponding to the 38 correct answers. The frequency of the basic group's correct answers was 11, which was translated into a percentage of 28.9%. This category makes it even more obvious that the percentages become significantly less with each group's performance.

D) Hard -Math- Hard- English Question (7) and (8)

Chocolate is produced by the rain forest cocoa plant, but today the majority of the cocoa is cultivated by farmers. One ounce of milk chocolate contains 9 grams of fat. How many ounces of milk hold 18 grams of fat?

Cashews, Brazil nuts, and peanuts initially grew in rain forests. Anne made a trail blend with 9 cups of each. How many cups of the various kinds of nuts were used in total?

Questions 7 and 8 are the revised items of questions 3 and 4. The complexity of the word problems was modified by adjusting the vocabulary items and the grammatical structure of the questions. Question 7 was rated as an average grade 7, while question 8 received a readability result of about grade 6. The advanced group achieved a mean of 0.83, and a standard deviation of 0.27. The intermediate group got its lowest mean in this category, which measured 0.65 with a standard deviation of 0.36. The basic group's mean was measured as 0.29 with a 0.37 standard deviation.

Forty-nine correct answers were attained by the advanced group, with a percentage of 81.7%. This percentage is still considered a high one, especially when compared with the intermediate group, which got a 64.8% with its participants’ 35 correct answers, and the basic group, which obtained a percentage of 28.9% with its respondents’ 11 correct answers. The percentages calculated for the hard-math-hard-English category show the lowest percentages in comparison with the other categories. This is an indicator that the students’ faced the most difficulties while dealing with these questions. Yet, the advanced group got a high percentage compared to the other two groups.

To comment on the results of the mathematical problem solving test and to answer the second question of the study, interviews were conducted with the students’ home room teachers, in addition to the program coordinator and the head of primary school at Mashrek International School.

4. CONCLUSION

Results obtained from the test indicated that the level of English proficiency directly affected the students’ problem solving skills. The students who were classified in the advanced group obtained higher results compared to the intermediate and basic leveled students. The more complex the word problems became, the more difficulties the students, especially in the intermediate and basic levels, faced. In the easy-math-easy-English word problems, the advanced group received a mean of 0.93, which was the highest compared to the intermediate and basic groups with their means of 0.75 and 0.42 respectively. The same results, in terms of the students' achievement, were replicated through the remaining categories. In the hard-math-easy-English category, the advanced group, once again, got the highest mean of 0.83, while the means for the intermediate group was 0.74 and for the basic group was 0.42, in that order. In the remaining categories, the advanced group maintained its mean scores regardless of the complexity of the word problems, with a mean of 0.83 for the easy-math and the hard-math versions. In comparison, the intermediate and basic groups got a mean of 0.70 and 0.29 respectively for the easy-math version, and 0.65 and 0.29 for the hard-math version of the harder text.

Results of the interviews with academic experts and educationalists elucidated that the instructional design may be altered to accommodate for the individual students' needs through using the framework of differentiation, whether in tasks, content, or assessments, choosing word problems that tackle situations that the students have already learned about or encountered, using manipulative to ease the translation of abstract ideas into concrete, or visual, representations, in addition to using oral self-language and translating it into mathematical terminology to allow students to acquire the needed definitions and theorems that would enable them to translate the language into mathematical symbols and equations.

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