



Do The Reading Skills Of Emirati Students Impact Their Problem Solving Skills?

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Abstract

Students studying in federal higher educational institutions in the UAE learn English as a second language. Most of the students find it difficult to solve word problems in mathematics. The main objective of this research is to determine if lack of English reading and comprehension skills affect mathematical problem solving skills. Students with varying levels of competency from the first year of the Bachelors study in one of the federal institutions were chosen for this exploratory qualitative study. A reading comprehension test and a set of mathematical word problems with increasing levels of complexity was used for this purpose. The results signified that reading skills had an impact on problem solving skills. Students with poor problem solving skills required extra support to help them cultivate their reading skills. This is the first stage of research done and will be expanded on a large sample by incorporating variables identified after this study.

Keywords: Analogical Reasoning, Comprehension, English as a Second Language, Reading, Relationships, Word Problems.

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Introduction

Analogical reasoning has long been believed to play a central role in mathematics learning and problem solving. Analogical reasoning is the ability to perceive and operate on the basis of corresponding structural similarity in objects whose surface features may or may not be necessarily similar but underlying mathematical model may be similar. Comprehension skills play crucial role in detecting similarity between word problems, which can lead to correct choice of problem solving strategy. Students in federal higher educational institutions in the UAE are learners of English as a second language. Majority of them find it difficult to solve word problems in mathematics. It is found in literature that student's reading and comprehension skills is one of the predictors of problem solving skills.

The purpose of this research is to determine if English language is a barrier in developing mathematical problem solving skills. Students from one of the federal institutions in the UAE participated in this exploratory qualitative study. The reading comprehension test instrument was used to assess the reading ability of students studying in general studies program. Six students with

varying levels of competency were chosen. They were asked to solve a set of mathematical problems with increasing levels of complexity. Their reading and problem solving strategies were recorded and analyzed qualitatively. The results indicated that students with lower ability of problem solving needed more support in developing their reading skills..

Literature Review and Theoretical Framework

Ability to solve word problems based on mathematical concepts is an important course learning outcome in all mathematics courses. Relevant information related to real life experience is presented in word problems in the form of a short narrative which can be transformed into mathematical notation (Selter, 2000). As Daroczy, Wolska, Meurers, and Nuerk (2015) reported in their systematic literature review, many studies have reported that solving word problems in mathematics is a common difficulty for students from elementary to undergraduate studies. Inability to solve word problems can be due to both linguistic and numerical complexity. Hegarty, Mayer, and Monk, (1995) argue that most problem solvers have more difficulty constructing a useful problem representation than in performing the computations necessary to solve the problem. It is important to detect the exact nature of difficulty in order to develop the ability to solve word problems in students.

Telli, Rasch, and Schnotz, (2018) have reported their findings about bilingual students' problem solving strategies, but there is a scarcity of research about connection between linguistic skills and mathematical problem solving skills in Arab students who learn English as their second language. This is the first phase of our research in which linguistic weaknesses of Arab students, leading to incorrect solution of word problems, are identified. Language forms the base of any communication (Bruner, 1990). Language acts as the medium for expressing our thoughts to one another. We use language not only in written and spoken form to communicate, but also to understand word problems in mathematics. According to Haylock and Cockburn (2013), language is an essential factor in mathematics learning, besides concrete manipulation, pictures and symbols.

Comprehending a language in the form of questions in sentences is related to the ability to read them (Auzar, 2017). Reading shapes the students learning process and thoughts. To understand and evaluate the text he/she is reading, a reader activates the schematic procedure and schematic content present in him. This cognitive process is vital to develop one's reading power (Nambiar, 2005). Reading means to understand the reading text, literally, interpretively, critically and creatively. Reading, as a visual process, is translating written symbols (letters) into words. The reader applies appropriate reading strategies to comprehend a text successfully (Zaire, 2012). Questions containing mathematical concepts such as addition, subtraction, multiplication, and division are presented as language in sentences of daily life. Students are dealing with two processes when they convert questions in sentences into figures, namely, the process of understanding series of sentences and the process of converting sentences into figures.

Vocabulary is a key predictor of reading comprehension for all language learners (Ouellette and Beers, 2010). It has been found that weaker vocabulary is one of the reasons that students are unable to use the written tests in order to support the formulation and expression of responses to comprehension (Burgoyne et al, 2009, p.742). Understanding the language of mathematics is important for students to successfully learn mathematics (Moschkovich, 2012). Symbols in mathematics language allows a person to solve his/her life problems which are in direct relation to mathematics. Thus, mathematical word problems should be realistic in terms of language, symbols and situation.

Word problems constitute an important aspect of mathematics and the process of mathematical thinking. Ability to understand the language of mathematical word problems and the ability to read for comprehension are inter-related because both depend on the ability to comprehend a text. Word problems are presented in the form of a short narrative rather than in mathematical notation (Selter, 2000). Many children from kindergarten to adulthood face problems

in solving word problems (Nesher and Teubal, 1975; Riley et al, 1983; Lewis and Mayer, 1987; Hegarty et al, 1992; Verschaffel et al, 1992).

Previous studies show that mathematics performance and reading skills are closely related. According to Light and De Fries (1995), difficulties in arithmetic were associated with reading ability. Linguistic and numerical complexity contributes to the difficulty in solving word problems (Daroczy et al, 2015). Mathematical exercises that present relevant information on a problem as a text and not in the form of mathematical notation are termed as mathematical problems (Rasmussen and King, 2000). Sepeng P. and Sigola (2013) demonstrated that students have difficulty in reading and understanding problems in mathematics. Learning of mathematics requires a transformation from a weak ability to understand mathematics to the ability to master the language of mathematics (Herbel-Eisenmann, 2002). Therefore, to effectively solve a mathematical word problem, students should be able to accurately understand the text of the word problem and perform the required mathematical operations (Lewis and Mayer, 1987; Hegarty et al., 1995; Jitendra and Star, 2012). Understanding of the word problem is a challenge to word problem solvers (Boonen et al., 2013). Problem-solving refers to solving a problem using the required information and operation in cognitive processes.

Word problem solvers can use the problem-model or the direct translation strategy to solve the problem. Problem model strategy users create a qualitative mental representation of the problem statement which is transformed into a solution plan, thus executing the required mathematical operations. Students with limited ability adopt the direct translation method in which the focus is on selecting the presented numbers which form the basis for their mathematical calculations (Marzocchi et al., 2002). Previous studies have shown that students reading comprehension abilities determine their success in word problem solving (Boonen et al., 2013). The problems experienced by students regarding narration problems are related to an accurate comprehension of the text, rather than numbers or operations. According to Murphy and Unthiah (2015), weaker reading comprehension skills may be partly responsible for lower levels of academic development among EAL learners. Decoding (word recognition) and linguistic comprehension (able to use lexical information for sentence and discourse level interpretation) are required for reading (Hoover and Gough, 1990). Bjork and Bowyer-crane (2013) suggest that poor reading comprehension is associated with difficulties in solving word problems, though not numerical operations.

There exists a close relationship between reading comprehension and mathematical ability (Vilarius-Tuohimaa, Aunola and Nurmi, 2008). Abedi and Lord (2001) support the view that lexical complexity such as word frequency, the use of idiomatic phrases and word with multiple meaning, and culturally specific non-mathematical vocabulary items; of mathematical word problems might have an influence on comprehension difficulties for EAL students with mathematical word problems. General steps in the solution of a mathematical problem are understanding the problem, establishing mathematical connections between what is given and what is required; determining the operations to be conducted for the solution, conducting the operations and checking of the accuracy of the solution For reading comprehension, students transfer prior information in to the reading environment, set a goal for reading, make predictions before reading, check the correctness of the predictions after the completion of reading, select suitable strategies, use enhancement strategies when experiencing difficulties, make use of content to guess the meaning of unknown words, summarize the main idea and monitor comprehension.

To go through the stages of problem solving, reading level is important. Reading levels can be classified into free level, teaching level and apprehension level (Shanker and Ekwall, 2000). Free reading level readers are considered good readers as they recognize word automatically, they have knowledge of reading strategies which they use productively during the text comprehension process (Pang, 2008). Readers at teaching level need the support of a teacher or an adult to read and understand a text (Özsoy, Kuruyer, and Çakiroğlu, 2015). Those readers who encounter difficulties in word recognition and in the discrimination of words are termed as weak readers at the apprehension level. They are easily distracted while reading. They lose track when reading, they

read without making predictions or guesses about the text, are at a loss when they do not understand the text and are unable to establish connections between prior and new information.

Grauberg (1998) argues that the problems faced by students who have reading difficulties while learning mathematics can be summed up as not recognizing symbols, having difficulties in organization, and incapable of speaking about the problem and memory. Students' different reading levels can have an effect on their problem solving performances (Pape, 2004). Difficulties in problem solving are generally associated with reading difficulties (Reikaras, 2006). Growing evidence shows that more difficulty arises in constructing a useful problem representation rather than in executing the calculations necessary to figure out the problem (Cardelle-Elawar, 1992; Cummins, Kintsch, Reusser, and Weimer, 1988). While creating a frame work for cognitive theories of problem solving, it is necessary to determine the processes involved in constructing a problem representation and in solving a problem (Mayer, 1992).

One of the two general approaches to understanding mathematical word problems is the direct translation method (Hegarty et al, 1992). In this approach, the student tries to select the numbers in the problem along with the key relational terms such as "more" or "less"; and creates a solution plan involving the combination of the numbers in the problem using the arithmetic operations that could be deciphered from the key words such as addition is related to keyword "more" and "less" is associated with subtraction. In this method, the student does not compose a qualitative representation of the situation described in the problem. Rather, he tries to convert the main propositions in the problem statement to a set of computations that will provide the answer.

In the first stage, the text in mathematics problem is broken into smaller segments (Hegarty et al, 1992). At each segment, the student reads the sentence expressing a piece of information about one of the values in the problem. To construct a text base, the student must integrate the propositional content of the statement with the other information in his/her current representation of the problem. The first stage represents the individual statements. These statements include assignments which express a value for a certain variable; relations which express the quantitative relation between two variables; and questions which express that the value of a certain variable is unknown. Encoding of units of measure and scale conversion is also a part of each statement. This is followed by the integration of the new information in the statement with their current text base. This integration permits connections between the different statements in the problem.

At the second stage of comprehension, the student (problem solver) constructs a representation. This stage reflects the difference between direct translation approach and problem model approach used. In the direct translation approach, the student seeks a key fact in the form of a number such as 90 or a key word such as "more", "less" in the relational statement. Students using the problem model approach construct an object based representation to understand the problem.

The third stage sets in when the student anticipates the arithmetic computations required to solve the problem. A student using the Direct Translation Approach relies on the keywords and number in the statement to solve the problem. On the other hand, the student applying the Problem Model Approach has an object based representation of the problem. This approach allows the student not only to have an accurate solution plan but also to monitor the solution process.

It is very important for students to understand math vocabulary and use it frequently. Solving word problems, following instructions, understanding and using mathematical vocabulary correctly require language proficiency. As such, mathematical reasoning and problem solving are closely associated to language and depend upon a firm understanding of math vocabulary (Dale & Cuevas, 1992).

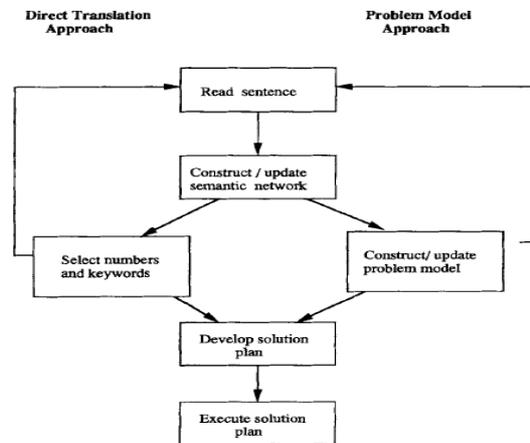
Krulik & Rudnick (1987, p.4) defined problem solving as "The means by which an individual uses previously acquired knowledge, skills and understanding to satisfy the demands of an unfamiliar situation. The student must synthesize what he or she has learned, and apply it to a new and different situation." There is more to problem solving than just converting written language to mathematical signs. To a certain extent, problem solving depends on reading the

problem for understanding, then converting the words to the precise mathematical statements, associating words and the math, and lastly coming up with a solution for the problem.

According to Kintsch and Greeno (1985), solving a mathematical word problem begins with text comprehension. The textual form of the problem forms the base for creating a text representation which serves as the foundation for solving the problem mathematically. Zende (1983) stressed that the ability to comprehend reading had an effect on mathematical problem solving ability.

As Hegarty, Mayer, & Monk (1995) report, one of the two approaches is taken by students while solving word problems in mathematics. The first approach is the direct translation approach, in which a student selects numbers and relational terms, such as more and less. In the second approach, a student read complete description and develops a mathematical model which can lead to a solution. The first approach may give correct solution to simple problems but in order to develop problem solving ability, the second approach, is more robust. In this research, the model proposed by Hegarty, Mayer, & Monk (1995) will be applied for analysing students' problem solving approaches.

Figure 1: Model of comprehension processes for word problems



Source: Hegarty, Mayer, & Monk, (1995)

Methodology

This is an exploratory study for which qualitative approach is more appropriate. Population for this study consists of female students enrolled in general studies program, which is the transition program before they join their degree program. All students have passed the English eligibility test and studying two courses together, one is Academic Reading and Writing and the second is Applied Mathematics. These two courses are compulsory before joining the degree program.

Two students each with low, medium and high scores in English coursework were selected. This was a purposeful sample of 6 students. They were asked to solve the English comprehension test. This test instrument assessed their linguistic and comprehension skill. After administration of English test, these students were selected for assessing mathematical problem solving skills. Mathematics test instrument consisted of word problems on percentages in which, they wrote their step by step answers and confirmed their confidence in the correctness of their answer. Their answers to the test items were analysed and coded.

Findings and Discussion

Errors in the mathematics instrument were classified and coded as shown below.

Category of error	Description	Example
Comprehension	Misunderstanding keyword	Reading discount rate without %.
	Error in selecting information	Finding discount instead of net price.
Transformation	Procedural tendency	Applying un-necessary procedure
	Application of wrong mathematical operation	Dividing by 100 where multiplication is required.
Mathematical processing	Arithmetic error, error in calculation	
	Unfinished answer	
Analogy	High similarity	Structures are same
	Schema involvement	Structures may not be same, but mathematical models may be same.

Errors in the English instrument were coded as shown below.

Category of Error	Description	Example
Comprehension	Unable to understand the context	Unable to understand context of the phrase <i>food flavoring</i>
	Error in selecting information	Unable to decide if a piece of information is given in the text
Vocabulary Error	Weak Vocabulary	Unable to understand the meaning of the word <i>regulate</i>
Grammar Error	Unable to use the correct verb form	Unable to understand that the word <i>consumption</i> is derived from the verb <i>consume</i> Used <i>disturbing</i> instead of <i>disturbed</i>
	Unable to use the correct noun form	Used <i>completing</i> instead of <i>completion</i>
	Unable to use the correct tense	Used <i>studying</i> instead of <i>studied</i>

Two students scored more than 70% in mathematics assessment. They failed to detect analogy due to their poor linguistic skills. It was found that they scored low on grammar and vocabulary skills. Two students scored less than 60% in mathematics assessment and they failed to detect analogy as well as apply the correct mathematical procedure in word problems. These students scored low in comprehension test as well but were successful in solving problems given only in mathematical form. Two students scored less than 40% in mathematics assessment and English comprehension test as well.

Though this analysis was done on a small sample, there is some indication that students' mathematics problem solving skills may be improved by improving their comprehension and vocabulary skills.

Concluding Remarks

Existing literature in this research field, focuses on linguistic problems of native English speaking students or students from European countries (Wilkinson, 2018). Arabic language speakers face more difficulties than these students as the structure and grammar of this language is different than English and many of these students adopt English language as a medium of instruction at a later stage. The results found by this research emphasizes on inter-disciplinary pedagogy where language and mathematics teachers can work together to improve students' mathematics achievements. This study is a small scale study done for the purpose of identifying variables, on which the next step of research will be carried out. A larger sample data will be collected and analysed quantitatively, to predict determinants of successful problem solving strategies.

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