MALTA REVIEW OF EDUCATIONAL RESEARCH

Volume 10, No.2, Special Issue, pp. 201-222
Faculty of Education©, UoM, 2016

Language Influence on Solving Arithmetic Word Problems

Esmeralda Zerafa
University of Malta
ecas0001@um.edu.mt

Abstract: In Malta arithmetic word problems are normally presented in English. This may impinge on the performance of pupils whose first language is Maltese. The main aim of this study was to investigate whether language influences pupils' performance on arithmetic word problems. The study was carried out with 30 children in Grade 3 (aged 8 to 9) in the three sectors of the Maltese education system: State, Catholic Church, and Independent. Some participants identified Maltese as their first language whilst others preferred English. Language preference was confirmed through an informal interview with teachers and during the individual informal interviews held with the participants. During the interview they were asked to recall and solve two multi-levelled sets of word problems, one in Maltese and another in English, and to complete a non-verbal computation sheet.

Findings indicated that the pupils found word problems more challenging than non-verbal computations presumably due to the language component. Moreover, it seemed that when problems were in their first language they understood and recalled them better as well as solved them using the correct operation. They also managed to do so quicker without having to translate the word problem since this was already set in their preferred language.

Introduction

The main focus of this research study was to gain insight into whether language has an impact on the solving of arithmetic word problems. In Malta both Maltese and English are official languages. Hence children are expected to develop proficiency in both languages. Nonetheless, the proficiency developed by each pupil varies and a preferred language is normally developed. This study thus aimed at investigating whether this proficiency or language preference influences the solving of arithmetic word problems, specifically at Grade 3 level (ages 7 to 8 years). Moreover, my research partner and I, sought to explore the impact of language in solving arithmetic word problems, whether these were in Maltese or English, and thus compared children's performance in non-verbal computational tasks versus

that in word problems. We aimed at answering the following research questions: Is the use of English in the teaching of arithmetic word problems causing any specific difficulty to those children whose preferred language is Maltese? What effect does language have on the solution of arithmetic word problems?

This research was inspired by a previous study abroad which indicated that learners perform better when presented with word problems in their first language (Bernardo, 2002). It was interesting to study whether this is also the case within the Maltese context. In Malta local schools emphasize teaching mathematics through the English language since textbooks as well as all forms of assessment are in English. However, this inevitably implies that learners who would not have yet developed a high proficiency in the English language, may struggle with comprehending the tasks at hand.

Types of Word Problems

Word problems are an essential element of all mathematics curricula. As indicated by the classic Crockfort Report (1982) "the ability to solve problems is at the heart of mathematics" (p. 9). This is sustained by Van de Walle, Karp and Bay-Williams (2010) who underscored that, "most, if not all, important mathematics concepts and procedures can best be taught through problem solving" (p. 32). As a result, the value of problem solving on mathematical education and its applicability beyond the classroom has been highlighted by curriculum developers and in various reports (Despina and Harikleia, 2014).

Word problems may be divided into two main categories: 'standard' and 'non-standard' (Fairclough, 2002). The former types of problems are probably those encountered most often by our pupils. These problems "require the pupil to apply a computation such as addition or multiplication in a context" (Farrugia, 2003, p. 76). The other forms of word problems generally do not follow a specific procedure and need to be solved using specific tactics thus sometimes making them somewhat more complex. An example of each form of word problem is found in Table 1.

Standard Word Problem	**Non-standard Word Problem**
Ben and Jane have 8 balls altogether. Ben has 3 balls. How many balls does Jane have?	Imagine that you decide to make a Valentine's card for your friend. You can cut the paper into three shapes – round, square, or heart-shaped. You can decorate them with stripes or polka dots. How many different kinds of Valentines can you make? (O'Connell, 2000, p. 121)

Table 1: An example of 'standard' and 'non-standard' word problem.

Sperry Smith (2013) classified standard word problems into 11 categories which she divided into four major groups: *join, separate, part-part whole* and *compare*. For example the *Join* group was made up of three types of word problems. These are:

i. Result unknown e.g. '4+3 = ___'
ii. Change unknown e.g. '4 + ___ = 7'
iii. Start unknown e.g. '___ + 3 = 7'

Table 2 provides the different types of word problems as presented by Sperry Smith (2013) and an example of each.

Join	**(Result Unknown)** Luke has 3 balls. Alex gives him 5 more balls. How many balls does Luke have altogether?	**(Change Unknown)** Luke has 5 balls. How many more balls does he need to have 11 balls altogether?	**(Start Unknown)** Luke had some balls. Alex gave him 5 more balls. Now he has 12 balls. How many balls did Luke have at the beginning?
Separate	**(Result Unknown)** Luke had 12 balls. He gave 4 to Alex. How many balls does he have left?	**(Change Unknown)** Luke had 12 balls. He gave some to Alex. Now he has 4 balls. How many balls did Luke give to Alex?	**(Start Unknown)** Luke had some balls. He gave 4 to Alex. Now he has 8 marbles left. How many marbles did Luke have at the beginning?
Part-Part Whole	**(Whole Unknown)** Luke has 5 blue balls and 3 green balls. How many balls does he have?	**(Part Unknown)** Luke has 12 balls. Six are red and the rest are green. How many green balls does Luke have?	
Compare	**(Difference Unknown)** Luke has 12 balls. Alex has 4 balls. How many more balls does Luke have than Alex?	**(Compare Quantity Unknown)** Luke has 4 balls. Alex has 8 more balls than Luke. How many balls does Alex have?	**(Referent Unknown)** Luke has 12 balls. He has 4 more balls than Alex. How many balls does Alex have?

Table 2: Categories of word problems as per Sperry Smith (2013) and an example of each type.

Research has indicated the indispensability of word problems within the mathematics curriculum and has illustrated that teachers who include problems in their everyday mathematics programme help their pupils to develop reasoning and computational skills (Erdogan, 2015). Nonetheless, solving word problems is rather complex and may be problematic since the processes undertaken are not solely related to numerical processing but also to others of a different nature.

The Linguistic Aspect of Word Problems

Although a variety of word problem types have been identified, it is evident that language plays a crucial role in all of them. As indicated by Sepeng and Madzorera (2014), "the difficult part of solving mathematical word problems appears to be the process of understanding a problem and deciding what operation(s) need(s) to be performed" (p.217). Thus, solving word problems includes a number of cognitive and linguistic processes including comprehension processes (Banks, Jeddeeni and Walker, 2016; Martiniello, 2008; Zhang and Lin, 2015). These complex processes have given rise to an interest in the ways in which language may influence an individual's performance in arithmetic performance. This interest has been accentuated through a number of tests (William, Leatherwood, Ross & Moreau, 2009; Andon, Thompson & Becker, 2012) which have illustrated that individuals who are not fluent in English, may perform more poorly than their peers in other subjects which are not directly related to the language.

When analyzing the linguistic processes to be undertaken in solving word problems, one must take into account the mathematics register (Halliday, 1978) that has an executive function in the linguistic processing. The mathematics register is composed of the terms and symbols that pertain to mathematics itself as well as everyday language and thus has been defined as "a set of meaning that is appropriate to a particular function of language, together with words and structures which express these meanings" (Halliday, ibid. 1978). Difficulties with acquiring the mathematics terms and symbols are rather common (Pimm, 1987).

Moreover, ordinary English which forms part of the mathematics register which pupils are expected to master, may also have an impact on solving of word problems. The first hurdles children must overcome when solving a word problem are to read the problem and understand it. As a result, this is considered to be the first fundamental step to solving word problems (Polya, 1985). This is followed by 'devising a plan', 'carrying out the plan' and 'looking back' (Polya, 1985). Nonetheless none of the latter actions would be possible without the first one. Researchers argue that tasks for different subjects, including mathematics, which have unnecessary complex language,

may influence the outcomes of an assessment (Abedi, 2004; Martiniello, 2006, 2007). The ordinary language used in word problems is thus the main factor that distinguishes them from working out non-verbal computations such as 4 + 3 = 7.

The linguistic aspect of a word problem may increase or decrease the level of difficulty of the problem in a series of ways (Abedi, Hofstetter & Lord, 2004; Pennock-Roman & Rivera, 2011; Rivera & Collum, 2004). Variants of the difficulty of the language component of a word problem include: whether the language presented is the first or second for a learner; the complexity of the sentence structure and vocabulary used; whether the language of the word problem is clear and straightforward; whether additional information is added to the important information needed to solve the problem as well as the order in which the numbers are presented in the word problem.

Solving problems in one's first language – An Advantage?

Notwithstanding all efforts made, it is difficult to strike a perfect balance between the languages used at school and at home, and thus there seems to be a tendency that children still choose their preferred language and identify one of either languages as their mother tongue as the other becomes their second language. Cuevas (1984) argues that "some of the academic language used in materials and discussions in the mathematics class may be especially difficult for second-language learners to follow" (p. 135). Moreover, he concludes that "language plays an important part in the learning of mathematics, and a second-language learner's underachievement in mathematics is likely due in part to the language factors" (pp. 140-141). This corroborates arguments presented by different studies which have indicated that non-English speaking pupils find it harder to follow classes in English than in their first language (Martiniello, 2008; Bernardo & Calleja, 2005). In the local scenario, since textbooks are in English and since National documents (National Curriculum Framework, 2012) have indicated a preference towards using English as the medium for instruction in mathematics, children whose first language is Maltese might be disadvantaged. The extent of this difficulty is evidently dependent on one's proficiency in the second language.

This phenomenon has been looked into as early as 1926 by the International Institute of Teachers College at Columbia University. The research aimed at identifying whether Puerto Rican bilingual students who were in 12th Grade were as advanced in problem solving as monolinguals following the same programme. The study concluded that the problem solving ability of the former group of students was significantly lower than that of the monolingual learners. Over the years, other studies (Martiniello, 2008; Banks, Jeddeeni and Walker, 2016) in this field have had similar results. A study that was particularly relevant to our research was that carried out by Bernardo

(2002). Bernardo's (ibid.) research was conducted with 92 Grade 2 pupils from independent schools in Metro Manila in the Philippines. All the participants reported that they spoke, understood and read both Filipino and English, however almost half identified English as their mother tongue and half reported Filipino as their first language. Two sets of word problems were presented to the students, one in English and one in Filipino, and a non-verbal computation sheet was also administered. Results on the non-verbal sheet were then compared to those on the word problems. Bernardo (2002) concluded that there was "a first language advantage in both understanding the word problem texts and in solving the word problems" (p. 295).

Local Scenario

Local research in this field is yet limited and the implications of the negative impact of solving word problems in a second language are still underestimated. Only two similar studies seem to have been carried out. These were not related to word problem but rather investigated the effects of language, whether first on second, on the achievement in science and physics (Ventura, 1984; Farrell and Ventura, 1998). Both studies were conducted with secondary or post-secondary education students. These studies are relevant because like mathematics, in Malta, the science subjects are taught in English.

Ventura (1984) conducted a local study to investigate the link between language and the science curriculum during the first two years of area secondary schools. This indicated that the students performed better when tests were in Maltese rather than in English when the former language was the students' mother language. On the other hand, Farrell and Ventura (1998) explored whether some pre-university students could understand technical and non-technical words pertaining to the field of Physics. These words were presented in English, as is usual in the Physics classroom, but it is however, a second language to most individuals. The findings of the study determined that "word understanding in Physics is not a matter to be brushed aside" (Farrell and Ventura, ibid., p. 250). The discussions show that even these pre-university students, who were expected to comprehend most of the terms had difficulties in doing so. Both studies (Ventura, 1984; Farrell and Ventura, 1998) concluded that the fact that students are taught science or a science subject through a second language seemed to impinge on student achievement.

Research Methods

The research aims and questions of a study carried out by Bernardo (2002) were very similar to those outlined for this research. Bernardo's (2002) research mainly embraced quantitative data collecting strategies. However, since this specific research was to outline details that would only be visible through a more in depth approach and with a greater descriptive stance, it

was decided that a mixed methods approach would be adopted and thus a mix of quantitative and qualitative research methods would be used. As outlined by Robson (2004) "while a design cannot be fixed and flexible at the same time, it could have a flexible phase followed by a fixed phase (or, more rarely, the reverse sequence)" (p.87).

Sampling

It was decided that a small number of participants would be selected for the main sample. This was done so that more time could be spent with each participant thus the data collected would be more thorough. The sample size was that of 30 participants. After piloting the study at a local independent school with six children, it was decided to include all the three educational sectors in Malta since the pilot sample revealed that the learners were very similar in both language use (which language they preferred) and behaviour. While most schools in Malta are run by the State, others are either run by the Catholic Church or are privately owned (Independent). In collecting data from all three sectors it was decided to group the children according to the sector they were coming from. As a result, 10 pupils were from a State school, 10 pupils were from a Church school and the rest were from an Independent, fee-paying school. When asking the teachers to select 10 pupils from their classrooms we specifically highlighted that the learners had to have different first language preferences and had to have a variety of attainment levels in mathematics. It was also decided that all participants would be at Grade 3 (7 to 8 years old) level. This choice was based on the fact that this is the first year when word problems are introduced formally.

Access

Access to carry out the research in the mentioned schools was obtained through a formal letter to the respective authorities and Heads of Schools asking for their permission to conduct the study within their setting. Later, consent was also sought from each of the participants' parents. Except for asking for the parents' consent, the letter sent to the parents also questioned which language their children made use of mostly at home and thus, which they viewed their child's first language to be. Since the preferred language of the children was a crucial element in the data-collection and analysis phase, it was essential for the researchers to ensure that the first language indicated by the learner was indeed their first language. This would have otherwise changed the reliability of the data.

Research Design

The main source of data collection was through semi-structured interviews that were carried out with each participant on an individual basis. All interviews were tape recorded so that the data could be listened to as often as needed. Moreover since it is fundamental to maintain a high level of reliability during the data collection and analysis processes, both researchers attended each of the interviews. The researchers took separate notes about the unfolding of the interviews. This was especially important for the analysis phase as the different interpretations were taken into account and thus a wider perspective could be taken. Each interview lasted approximately 25 minutes thus interviews took place over approximately four school days at each school. A standard procedure was maintained throughout. Primarily, an informal conversation was carried out with the participants. Since we were interested in understanding what the first and second language of each participant was without relying solely on the feedback provided by the teachers, this triangulation was deemed necessary. During and after the conversation, each of the researchers filled in a Likert Scale to illustrate their observations as to which language was the child's first language and which was his/her second. The Likert Scale, which can be seen in Figure 3.1, required that the researchers and the teacher reflected about whether the first language, as indicated by the children and their parents, was truly their first language. The criteria written in the Likert Scale evolved around the child's use and understanding of this first language during the informal conversation.

Following the informal conversation, the children were given a booklet. The booklet had an A5 blank page that was dedicated to each problem. This was done since it was deemed necessary to keep evidence of the working out which each child would make for each problem. The children were encouraged to draw and to show their working where possible. This gave us richer data that allowed us to understand the level of comprehension that the children had when working out each word problem. The children were then presented with 18 word problems. Nine problems were written in Maltese and the other nine were in English. Thus each child had to complete problems that were in his/her first language as opposed to others that were in his/her second language. The 18 word problems were similar to those selected by Bernardo (2002) for his study. However, the names mentioned in the problems were changed to take into account the cultural context of the children; thus names that are commonly used in Malta were selected. Each set of words (both the set in English and that in Maltese) was composed of different types of word problems in accordance to those presented by Sperry Smith (2013). The list of word problems posed for both the Maltese and English sets are found in the 'Notes' section of this paper. Each word

problem was read out and each participant was first asked to recall the word problem and tell it back to us. This helped us to understand whether the children had any difficulties with memorizing the word problem. Furthermore, we were interested to see whether the children would recall the word problem more effectively when this was in their first language rather than their second. Following this recall, the children were then asked to work out the word problem, using the 'special workbook' given for working and to write an answer in the specific box.

After completing all the word problems, the children were asked to complete a non-verbal computation sheet. The sheet included all the operations needed to solve the word problems in a different combination. It was necessary to give the children this sheet in order to evaluate the abilities of the children in completing the different computations when these were not in a language context. Finally, each participant was awarded with a certificate of participation and a small token to thank him/her for being part of the project.

Following the interviews with the children, informal conversations were also held with each class teacher to gauge the children's abilities in mathematics and to be able to talk about the language preferences of the children once more. Teachers were then asked to complete a Likert Scale that would provide more information about the first and second language of each learner.

Analysis

When analyzing our data we primarily illustrated individual profiles for each learner grouped according to which school type they attended. Each learner was allotted a specific code. If the learner was part of the sample from the State school, an 'S' was placed before a given number from one to ten. On the contrary if the pupils attended a Church or Independent school, the letters 'C' and 'I' were placed before his/her number code. This sort of coding was created to safeguard the pupils' anonymity and confidentiality whilst being able to identify which school sector the child attended.

Each learner profile presented in the full write up included the first language of each learner as well as the scores obtained in the word problems in their first language and those obtained in the word problems set out in their second language. Any additional information deriving from the interviews was also provided through a short paragraph written after the quantitative analysis for each pupil. Following the individual representation of each profile, common themes were identified. These will be now discussed.

The Language Component in Word Problems

The results obtained in the word problems as opposed to the non-verbal computation sheet, evidently highlighted that language, whether first or second, did play a key role in the achievement of pupils in word problems. The scores for each student in the word problems (both in Maltese and in English) were recorded together with their score on the computations sheet. These can be seen in Table 4.

Pupil	Computations Sheet (%)	English set of word Problems (%)	Maltese set of word problems (%)
S1	93	56	33
S2	100	56	78
S3	96	44	11
S4	96	44	78
S5	96	78	78
S6	100	100	100
S7	96	44	78
S8	100	56	67
S9	96	33	56
S10	96	67	56
C1	82	100	56
C2	93	100	22
C3	79	89	67
C4	96	78	78
C5	96	67	78
C6	93	56	33
C7	96	67	44
C8	89	33	33
C9	96	78	78
C10	100	67	89
I1	96	89	33
I2	86	22	22
I3	96	89	44
I4	54	44	11
I5	100	100	100
I6	100	100	67
I7	100	89	67
I8	75	44	44
I9	100	100	100
I10	100	89	56

Table 4: Percentage score obtained in the computations sheet versus the percentage score obtained in both sets of word problems

The children obtained much higher scores in the computations sheet as opposed to the sets of word problems even though the sums given were essentially identical. This result is similar to that obtained in Bernardo's study (2002). Nine children obtained 100% in the non-verbal computation sheet. However 6 children got 100% of the English set of word problems correct and only 3 of the pupils in the sample got 100% of the Maltese set correct. The ratio 3:2:1 indicated that language, which was the only different factor between the computations sheet and the word problem sets, does play an important role and does increase the difficulty of the task. This might be due to the linguistic nature of the task and thus the requirements of literacy skills such as reading and comprehension as well as the reasoning involved in solving a computation within a given context. It was also noted that the impact of language on the solving of word problems was also increased by the fact that the children were not used to working out word problems presented in Maltese since they are not familiar to such sums.

The results obtained showed that all the children in the sample, with the exception of two, obtained a higher percentage of correct computations than the percentage obtained in any of the sets of word problems given. This sustains the argument being put forward and corroborates with other literature which has showed that word problems are more challenging than simple non-verbal computations, since linguistic skills are also involved (Martiniello, 2008; Bank, Jeddeni and Walker, 2016).

Specific cases from our sample population highlighted the impact of language on solving arithmetic word problems. One of the students (C6) did well in the computations sheet however could not work out the problems given. The child's difficulty might have stemmed from the child's lack of skills and knowledge of how to tackle a word problem. This has been identified as one of the aspects which increase the difficulty which the language factor imposes over the child as one must understand the problem and follow a sequence of steps to solve it (Polya, 1985; O'Connell, 2000). I2 exhibited a similar performance (86% in the computation sheet; 22% on each set of word problems). He seemed unable to decode word problems. He himself pointed this out and defended himself by saying that he was absent from class when the children had done word problems.

The First Language Advantage

The next step was to analyse how the participants performed in word problems presented in their first language as opposed to those presented in their second. Fifteen of the 30 pupils interviewed fared better in the set of word problems which was presented in their first language. Another nine of the pupils scored the same result in both sets of problems. Only six children

did better in the set of word problems given in their second language. Furthermore, when this occurred, the difference between the results was of a very narrow margin. These results are presented in Table 5.

Pupil Code	Score obtained in the set of problems presented in the child's first language (/9)	Score obtained in the set of problems presented in the child's second language (/9)
S1	3	5
S2	7	5
S3	4	1
S4	7	4
S5	7	7
S6	9	9
S7	7	4
S8	6	5
S9	5	3
S10	5	6
C1	5	9
C2	4	1
C3	8	6
C4	7	7
C5	7	6
C6	2	2
C7	4	6
C8	3	3
C9	7	7
C10	6	8
I1	8	3
I2	2	2
I3	7	4
I4	4	1
I5	9	9
I6	9	6
I7	8	6
I8	4	4
I9	9	9
I10	8	5

Table 5: *Comparison of the results obtained in the set of problems presented in the children's L1 versus that given in their L2. The shaded boxes represent the children who fared better in the set presented in their L1.*

Findings suggested that children who are presented with word problems in their first language, whether English or Maltese, have an advantage. This

supports international research (Bernardo, 2002; Martiniello, 2008). It was interesting to look into the performance of individual participants. At the beginning of the interview, C1 and C7, indicated that they did not have a preferred language. Nonetheless following insistence they both said their first language was Maltese. However both pupils fared better in the word problems presented in English instead. This may have resulted due to familiarity with the task since the pupils are normally exposed to word problems in English. Since these pupils' language acquisition seemed rather balanced between English and Maltese, the factor of familiarity may have allowed them to achieve more in the English set of problems.

In seven out of the 30 cases the children could solve the most difficult word problem when it was presented in their first language however got this incorrect when presented in their second language. On the contrary, only four out of 30 pupils successfully solved the last problem in the set presented in their second language but were unsuccessful at solving it when this was presented in their first language. In all these four cases the children's first language was Maltese. Here again, familiarity with the word problems may have played a role.

Seven out of the ten children attending the state school translated all the word problems in the English set into Maltese. For example, S1 went through the process of solving the word problems in Maltese even when working out the English set of problems. Similarly, S2 recalled and gave the rationale of each English word problem using the Maltese language. This child stated that he could understand the Maltese set, presented in his mother tongue, better than the English set. Additionally, S4 not only seemed to understand the problems in his mother tongue (L_1 = Maltese) better but also clearly stated that he did so. After solving the last problem in the Maltese set, rated as the most difficult, the researcher asked the child about how he worked out the sum and why he had chosen to add rather than subtract. The child clearly showed his understanding by saying that he opted to add because the phrase said 'he had three more'. On the contrary, the child was not able to carry out such reasoning when solving the set of word problems in his second language, and he added rather than subtracted resulting in an incorrect answer. During the interview whilst tackling problem number 4, he rephrased parts of the problem to Maltese repeatedly although the problem itself was in English. It seemed as if he needed to clarify what the problem was asking him to find out. S7 also had similar reactions to the preceding examples. He too declared that he could understand the Maltese set of word problems better.

In the samples gathered from the church and independent school, a smaller percentage of children, translated the problems into their first language, however the majority still did. An example of this translation occurring in the

church school sample was evident in the interview carried out with C10. C10 translated the word problems presented in his second language which was Maltese, into his first language, in order to solve them. English was his first language. He said it was easier for him to work them out this way. This was also observed with pupil I10. It was interesting to note that she admitted that when it came to working out the Maltese set of word problems she kept forgetting all the details read out as she was constantly trying to translate from Maltese to English which was her first language. We feel that this reflection of hers is very important. She said, "*I am forgetting everything a real lot.*" Pupils who seek to solve word problems in their second language might encounter this same hurdle. When translating from one language to another it is very difficult to keep all the details in mind. Missing one detail may lead one to the wrong answer.

Three children obtained a perfect score in all three aspects of the interview. This indicated that that the learner's overall academic achievement at school, including balanced proficiency in both languages, may also impinge on their performance in solving word problems. It was interesting to note that in two of three cases, during the first part of the interview, these three children told us that they spoke Maltese at home and English at school. This was in agreement with what their teachers had indicated. This balanced exposure and proficiency in the languages might have determined the fact that they scored the same grades in both sets of word problems.

Recalling the word problems and explaining how they were solved

One of the essential parts of each interview was that of asking the children to recall the word problem read out by the researcher. This allowed the researchers to identify whether the children understood the word problem and if they could recall its details and retell it in their own words. Most children found it difficult to recall the word problems and consequently explain the rationale behind which operation they felt was correct to solve the particular word problem whether in English or Maltese. Psychological research has shown that the solution of a problem follows the mental representations formed after reading and understanding that same problem (Kintsch and Greeno, 1985; Cummins et al., 1988). Nonetheless, although solving the problem given, thus having built a representation, most children were not able to explain it or put it down on paper.

Nineteen out of the thirty children interviewed remembered the numbers read out but couldn't say the problem in their own words. Particular children could not recall the story sum and were unable to explain the reason why they had opted for the particular operation. Only one child was able to recall the word problems with ease and explain the reason behind his working without any prompting. The difficulties which hindered children from

recalling might have been shyness, the lack of skills to express one's thoughts aloud or possibly the lack of experience with the task.

Time taken to work out word problems in one's first/second language

Although the exact time taken to work out each set of word problems was not taken, in most interviews both researchers felt that the children worked out the problems given in their first language quicker than those in their second language. There wasn't any case in which the researchers agreed that the opposite had occurred. In all cases, the children were more efficient at decoding the story sum and eliciting the correct computation to be used to get to the correct answer.

Another factor that established the time each child took to work out the sets of word problems, was how many times they asked for a second reading of the problem. The majority of the pupils did ask for a second reading for both the problems presented in their first and second language. These observations may indicate that working out problems in one's second language is not only more challenging than solving them in one's first language but that it also takes up more time and concentration. Moreover, it seemed evident that the participants felt more comfortable working out the problems in their first language.

The impact of identifying keywords in solving word problems

At times it was evident that the children based their choice of operation of specific key words which they identified in the word problems. This was particularly evident in the state school sample. It seemed that their teacher had taught them to associate particular words with certain operations; for instance *altogether* implied *addition*. For example, during S1's interview, she revealed how she was coached to associate specific key words to precise mathematical operations and that thus the term 'altogether' for example always implied addition. Although taught with good intent, such explanations are sometimes misleading as could be seen in this case in which S1 had was supposed to subtract even though the term was present. Similarly S2, was also mislead by the word *altogether* and used addition instead of subtraction.

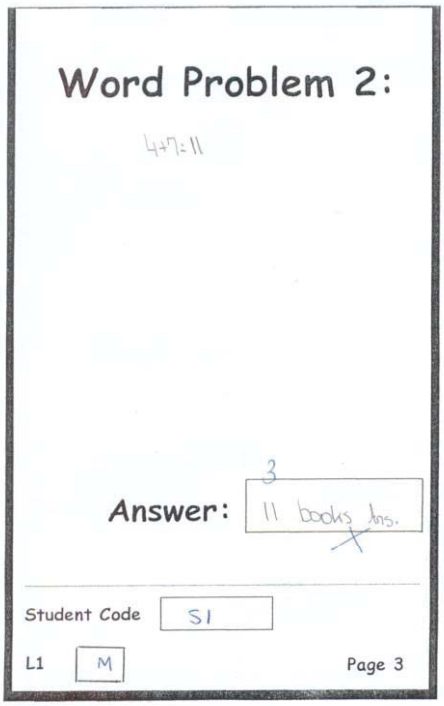

Figure 1.1: ***Answer to problem 2 by S1***

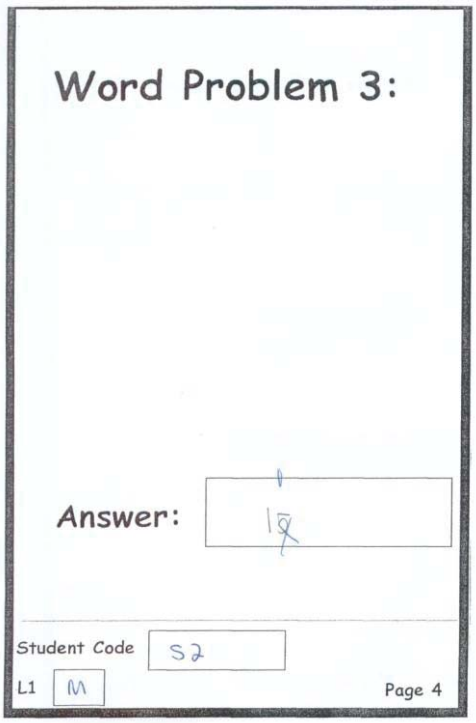

Figure 1.2: ***Answer to problem 3 by S2***

Similar observations were made during the interview with S9 which revealed that the child was in great difficulty during the English set – it was as if she did not understand the language. As with other children from the same class, it seemed that she was constantly on the look-out to identify specific keywords which would help her solve the problem and focused more on this identification than actually trying to understand the problem. This is one of the negative sides of rote learning since it hinders children from learning how to reason things out. As we have seen from these examples such *tricks* do not always work, since, for example, the word *altogether* in word problem number 3 was misleading to those children who were taught to associate the word *altogether* merely with addition.

Varied difficulty levels of word problems

The difficulty level of the different non-verbal computations and that of the various word problems appeared to have had an impact on the overall result obtained by the pupils. Almost all the children, except for one, managed to get the first word problem correct in both sets of word problems. However, as the problems gradually became harder, one could notice that the number of children to get the word problem correct decreased. This agrees with other similar studies (Bernardo, 2002). As in that research, most of the

children did better in the first problems of each set, 'combine, change and compare' (Sperry Smith, 2013). *'Compare'* problems seem to have been the most difficult to solve, as there is quite a discrepancy amongst the number of correct word problems achieved in the first two sections of each set and the last section of problem types.

Most pupils found the computations that required a substitution most difficult. In the computations sheets it was easy for us to note a trend throughout the sample. These seemed to be the types of computations which the children found the most difficult, probably due to their nature. This kind of computation also confused some children when working out the word problems. For example, when working the sets of word problems, S4 experienced difficulties in trying to find out the answer to 4 + x = 7. He would work out the sum correctly; however he could then not identify which part he had managed to solve i.e. which part corresponds to the question posed. For example, if he managed to work out 4 + x = 7 suggesting that x=3 he would still write down 7 as the answer instead of 3. This happened in both sets of problems. This may have happened because we generally call the '7' 'the answer'.

Summary of Results and Recommendations for Further Research

This study has shed light on a number of issues. Primarily it has illustrated how our population found solving word problems more challenging than non-verbal computations. It has indicated that the participants fared better in the word problems presented in their first language as opposed to those in their second. Qualitative observations were also carried out during the interviews during which the researchers noticed that the children seemed to work through the word problems presented in their first language at a faster pace. Moreover, the participants seemed to understand these word problems better, recall them more easily and rely less on keywords to solve them. It was highlighted that the overall attainment of a pupil at school and their proficiency in both languages may impact the outcomes since three of the pupils had a perfect score in all components.

It was also clear that some word problem types are more difficult than others since the children seemed to be able to work out some of the problems but found greater difficulty with others, especially 'compare' types. This corroborates similar research studies (Bernardo; 2002; Sperry Smith, 2013). Finally, it was also shown how the children seemed to be more able to solve the most difficult word problems when these were in their first language rather than in their second. It is imperative to highlight that no generalisations can be made due to the limited sample size and other limitations of the research including variables like gender and aptitudes. However, it is also necessary to indicate that specific traits, such as those

indicated, were observed throughout our sample and thus the necessity of further research in this field is crucial. This research is essential as it might have implications for educational pedagogy (Mestre, 1990) on how the solving word problems should be taught.

It is recommended that further research be carried out with a larger sample. Moreover, similar studies should be conducted in the upper years of the primary school when word problems become more complex. It would also be interesting to explore different strategies for teaching word problems to understand which strategies seem more effective with learners. The investigation of the influence of learning mathematics in a second language in other areas of the mathematics curriculum and on assessment, both summative and formative, may also be beneficial. Whether learning mathematics through a second language has an impact on the affective domain, for example, on the enthusiasm and participation level of the pupils should also be looked into. This would be fundamental to identifying the implications of our choice of teaching and assessing mathematics through a second language and might help professionals to develop new strategies which would allow educators to reach out to more learners.

Acknowledgments

This study was carried out together with Ms Sara Ann Baldacchino.
Special thanks go to Dr Marie Therese Farrugia, Senior Lecturer in Primary Mathematics at the University of Malta, for supervising this work and to Prof. Antoinette Camilleri Grima for acting as advisor on the same project.

References

Abedi, J., Hofstetter, C. H., & Lord, C. (2004). Assessment accommodations for English language learners: Implications for policy-based empirical research. *Review of Educational Research, 74 (*1), 1–28.

Andon, A., Thompson, C. G., & Becker, B. J. (2012). A quantitative synthesis of the immigrant achievement gap across OECD countries. *Large-Scale Assessments in Education, 2* (7), 1–20.

Banks, K., Jeddeeni, A., & Walker, C. (2016). Assessing the Effect of Language Demand in Bundles of Math Word Problems. *International Journal of Testing*, 1-19. http://dx.doi.org/10.1080/15305058.2015.1113972

Bernardo, A. B. I. (2002). *Language and mathematical problem solving among bilinguals. The Journal of Psychology 136* (3), 283-297.

Bernardo, A. & Calleja, M. (2005). The Effects of Stating Problems in Bilingual Students' First and Second Languages on Solving Mathematical Word Problems. *The Journal Of Genetic Psychology*,*166*(1), 117-129. http://dx.doi.org/10.3200/gntp.166.1.117-129

Cockcroft, W. (1982). *Mathematics counts.* London: HMSO.

Cuevas, G. J. (1984). Mathematics learning in English as a second language. *Journal for Research in Mathematics Education 15* (2), 134-144.

Cummins, D. D., Kintsch, W., Reusser, K., and Weimer, R. (1988). The role of understanding in solving word problems. *Cognitive Psychology, 20,* 405438.

Halliday, M. A. K. (1978). *Language and social semiotic.* London: Edward Arnold.

Despina, D. and Harikleia, L. (2014). *Addition and Subtraction Word Problems in* Greek Grade A and Grade B Mathematics Textbooks: Distribution and Children's Understanding. *International Journal for Mathematics Teaching and Learning.* Accessed online on http://www.cimt.plymouth.ac.uk/journal/erdogan.pdf, 5th April, 2016.

Erdogan, A. (2016). Turkish Primary School Students' Strategies in Solving Non-routine mathematical problem and some implications for the curriculum design and implementation. *International Journal for Mathematics Teaching and Learning.* Accessed online on http://www.cimt.plymouth.ac.uk/journal/erdogan.pdf, 2nd April, 2016.

Fairclough, R. (2002). Developing problem-solving skills in mathematics. In V. Koshy and J. Murray (Eds.), *Unlocking Numeracy*. London: David Fulton Publishers.

Farrell, M. P. and Ventura, F. (1998). Words and Understanding in Physics. *Language and Education*, *12* (4), 243-253.

Farrugia, M. T. (2003). Teaching and Learning Primary Mathematics. In S. Gatt and Y. Vella (Eds.) (2003). *Constructivist Teaching in Primary School*. Malta: Agenda.

Kintsch, W. and Greeno, J. G. (1985). Understanding and solving word arithmetic problems. *Psychological Review, 92,* 109-129.

Martiniello, M. (2006). *Sources of Differential Item Functioning for English learners in word math problems.* Paper presented at the annual meeting of the Northeastern Educational Research Association, New York.

Martiniello, M. (2007). *Curricular content, language, and the differential performance of English learners and non-English learners in word math problems*. Paper presented at the annual meeting of the American Educational Research Association, Chicago.

Martiniello, M. (2008). Language and the Performance of English-Language Learners in Math Word Problems. *Harvard Educational Review*, *78*(2), 333-368. http://dx.doi.org/10.17763/haer.78.2.70783570r1111t32

Mestre, J. P. (1990). The role of language comprehension in mathematics and problem solving. In R, R. Cocking and J, P. Mestre (Eds.). *Linguistic and Cultural Influences on Learning Mathematics* (pp.201-220). Philadelphia: Lawrence Erlbaum Associates.

Ministry of Education, Youth and Employment, (2012). *National Curriculum Framework (NCF).* Malta: Ministry of Education, Youth and Employment.

O'Connell, S. (2000). *Introduction to problem solving: strategies for the elementary math classroom.* Portsmouth, NH: Heinemann.

Pennock-Roman, M. & Rivera, C. (2011). Mean Effects of Test Accommodations for ELLs and Non-ELLs: A Meta-Analysis of Experimental Studies. *Educational Measurement: Issues And Practice*,*30*(3), 10-28. http://dx.doi.org/10.1111/j.1745-3992.2011.00207.x

Pimm, D. (1987). *Speaking mathematically: communication in mathematics classrooms.* London: Routledge.

Polya, G. (1985). *How to solve it*. (2nd edn.). Middlesex: Penguin Books Ltd.

Rivera, C., & Collum, E. (2004). An analysis of state assessment policies addressing the accommodation of English language learners. Commissioned Paper Synopsis at the NAGB Conference on Increasing the Participation of SD and LEP Students in NAEP.

Robson, C. (2004). *Real World Research (2nd ed)*. USA: Blackwell Publishing.

Sepeng, P. and Madzorera, A. (2014). Sources of Difficulty in Comprehending and Solving Mathematical Word Problems. *International Journal of Educational Science, 6* (2), 217-225.

Sperry Smith, S. (2013). *Early Childhood Mathematics*. (5th Edn.). Boston: Pearson Education.

Van De Walle, J., Karp, K. S., and Bay-Williams, J. M. (2010). *Elementary and middle school mathematics: Teaching Developmentally* (7th Edn.). Boston: Pearson Education.

Ventura, F. (1984). *Language and the science curriculum. Education (Malta), 4* (2) 15-18.

Williams, K., Leathwood, C., Ross, A., & Moreau, M-P. (2009). *Thematic review: Ethnic minorities.* Institute for Policy Studies in Education. London: London Metropolitan University.

Zhang, X. & Lin, D. (2015). Pathways to arithmetic: The role of visual-spatial and language skills in written arithmetic, arithmetic word problems, and nonsymbolic arithmetic. *Contemporary Educational Psychology*, *41*, 188-197. http://dx.doi.org/10.1016/j.cedpsych.2015.01.005

Notes

English set of word problems

1. Tina has 3 books. Sam has 5 books. How many books do they have altogether? (3+5=___)

2. Tina has 4 books. Sam has some books. They have 7 books altogether. How many books does Sam have? (4+___=7; 7-4=___)

3. Tina and Sam have 8 books altogether. Tina has 7 books. How many does Sam have? (7+___=8; 8-7=___)

4. Tina has 6 books. Then she gives 4 books to Sam. How many books does Tina have now? (6-4=___)

5. Tina has 8 books. Then she gives some to Sam. Now Tina has 3 books. How many books did she give to Sam? (8-3=___; 3+___=8)

6. Tina has some books. Then she gives 2 books to Sam. Now Tina has
   6 books. How many books did she have in the beginning? (___-2=6; 2+6=___)

7. Tina has 5 books. Sam has 8 books. How many books does Sam have more than Tina? (8-5=___)

8. Tina has 3 books. Sam has 4 books more than Tina. How many books does Sam have? (3+4=___)

9. Tina has 9 books. She has 4 books more than Sam. How many books does Sam have? (9-4=___)

Maltese set of word problems

10. Tina u Sam għandhom ftit kotba. Tina għandha żewġ kotba. Sam għandu erba' kotba. Kemm għandhom kotba b'kollox? (2+4=___)

11. Tina għandha xi kotba. Sam għandu sitt kotba. Flimkien għandhom disa kotba. Kemm għandha kotba Tina? (___+6=9; 9-6=___)

12. Tina u Sam għandhom erba' kotba b'kollox. Sam għandu tliet kotba. Kemm għandha kotba Tina? (___+3=4; 4-3=___)

13. Tina għandha tliet kotba. Imbagħad Sam taha ħames kotba. Issa Tina, kemm għandha kotba? (3+5=___)

14. Tina għandha żewġ kotba. Imbagħad Sam taha ftit kotba oħra. Tina issa għandha disa' kotba. Sam kemm taha kotba lil Tina? (2+___=9; 9-2=___)

15. Tina għandha xi kotba. Imbagħad Sam taha tliet kotba oħra. Issa Tina għandha ħames kotba. Kemm kellha kotba Tina fil-bidu? (___+3=5; 5-3=___)

16. Tina għandha sitt kotba. Sam għandu żewġ kotba. Sam kemm għandu kotba inqas minn Tina? (6-2=___; 2+___=6)

17. Tina għandha ħames kotba. Sam għandu tliet kotba inqas minn Tina. Kemm għandu kotba Sam? (5-3=___; 3+___=5)

18. Tina għandha erba' kotba. Hija għandha tliet kotba inqas minn Sam. Kemm għandu kotba Sam? (4+3=__)