Addition of Whole Numbers with Regrouping using the “Soroban”

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Abstract

Addition is one of the basic Arithmetic skills which all pupils must be able to do. Many, pupils can do addition but there are others who face difficulties to solve addition with regrouping problems. This paper describes the experience of a teacher who used the Soroban (Japanese abacus) as a tool to help two of his students who faced difficulties with addition of whole numbers with regrouping to aid them to do the addition problems. The study involves two Year 4 Primary school pupils in an urban school who were able to do addition without regrouping but were unable to do addition with regrouping. The two pupils were selected from two classes based on their low score in the pre-test.

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1. Introduction

Basic operation skills in mathematics are lifelong learning skills of utmost importance in preparing children to face the challenges of the future. Some people may claim that basic operations can today be tackled easily with a calculator. The operation may be done by a machine; however, confidence to do mathematics even for a primary school pupil is when they perform the basic operations without depending on a machine. The machine may not always be available and so the ability to perform a basic mathematics operation correctly will better equip a pupil to face the challenges of the future more confidently.

Hence to ensure that pupils would be able to do addition of two 1-digit numbers correctly the researcher used straws and marbles for the lesson. The researcher was confident that such a simple operation would easily be done by pupils who could count up to 1 000 fluently. In contrast, however, many of the pupils failed to give the correct answers when the concrete objects were no longer used. Among the responses given when adding two 1-digit numbers without the use of concrete materials is as follows.

\[
3 + 2 = 4 \quad \text{or} \quad 7 + 3 = 9 \quad \text{or} \quad 6 + 8 = 13
\]

This was because when they added concrete objects they took for example three marbles and then added the two marbles and finally counted each marble – 1, 2, 3, 4, 5 and gave the correct answer. Without the concrete objects

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they kept three in their mind and showed two fingers to represent two, then instead of counting 4, 5, they counted 3, 4 and this resulted in the incorrect answer of 4. Teaching the pupils not to start counting on from the number in their minds helped all the pupils to overcome the problem with this type of questions.

However, when it came to addition with regrouping the root of the problem is from pupils’ difficulty in understanding the place value system. The following is an example of my pupils place value error in doing addition with regrouping (see Figure 1).

![Figure 1: Sample of pupil’s work illustrating lack of understanding of the place value system](image)

1.1 The Soroban

With the aim to find an alternative method to do addition with regrouping literature was reviewed and the use of concrete objects (Chapin and Johnson, 2000; Booker et al., 2004; Grossnickle and Brueckner, 1963) was suggested. Chapin and Johnson (2000) also suggested a method called partial sum method to do addition with regrouping.

Another source of information was the internet. In the internet, an article by Heffelfinger and Flon (2007) explained about devices used for counting which includes the Romans abacus, the Chinese suan-pan and the Japanese soroban. Our Malaysian Primary School Curriculum has made it compulsory to teach pupils to use the soroban. It has been claimed (Heffelfinger and Flon, 2007) that “learning abacus strengths the students’s sense of number placement value and helps to further a better overall understanding of numbers”.

The soroban is a 1:4 bead system and represents numbers exactly like how we write a number on paper. Addition demands thinking at every stage. Figure 9 shows an example of doing addition with regrouping using the soroban.

![Figure 2: Doing addition using soroban for 13 + 18](image)

Soroban demands the use of complementary numbers to 5 and 10 which in turn demands thinking mathematically. Using the soroban to do addition with regrouping will help develop understanding of the place value system among
pupils because to do addition with regrouping using the soroban, pupils have to use the combination of 5 and combination of 10. In figure 9, the example of 13 + 18 used the combination of 10. It is not done meaninglessly. It shows that if we add 10, we must take away 2 to obtain 8. In almost every step in doing addition with regrouping pupils will be demonstrating understanding of the place value system.

Hence, this study aims to describe the effects of using the soroban on pupils’ performance in doing addition of numbers with regrouping.

2. Methodology

Two Year 4 pupils (a boy and a girl) from an urban primary school in Malaysia were participants of this study. They were selected based on a one hour pre-test that was administered to 60 pupils (2 classes of 30 pupils). The pre-test consisted of 40, addition with regrouping 2-digit by 2-digit questions. One pupil was selected from each class. The pre-test was followed by an interview. Each pupil was interviewed individually.

For the next three days the teaching and learning sessions were conducted. Each participant was taught during a separate session. Each teaching and learning session had duration of 30 minutes and there were three teaching and learning sessions for each participant. For the first teaching and learning session (for both participants), the combination of five was taught. They were then given Exercise 1 to complete. For the first 10 questions, the researcher gave them help. The rest of the questions were done on their own at home and handed in. For the second teaching and learning session (for both participants), the combination of 5 and 10 were taught. They were then given Exercise 2 to complete. Again, for the first 10 questions, help was given. The rest of the questions were done on their own at home and handed in. For the third teaching and learning session (for both participants), again the combination of 5 and 10 were taught. They were then given Exercise 3 to complete. Again, for the first 10 questions, help was given. The rest of the questions were done on their own at home and handed in. They were allowed to take home their work because of time constraint.

After the teaching and learning sessions were over, the following day a post-test was administered. The duration of the test was one hour. This was followed by an interview of each participant individually.

Field notes of observable behaviour were recorded for every teaching and learning session, pre-test and post-test. Interviews were audio taped. All test papers and exercise work were collected. A reflective journal was kept of every interaction with the pupils.

3. Findings

The pre-test revealed that Pupil 1 managed to obtain 2 correct answers. However, the pre-test paper was covered with tally marks. During the interview after the pre-test, the pupil revealed that he drew lines (tally marks) to represent each number and then counted on. He informed me that he did the ones first and then the tens so that he need not draw many lines (see Figure 3).

Figure 3: Pupil 1 using tally marks for each place value column to do addition with regrouping

Examining this pupil’s paper revealed that his problem was forgetting to draw a tally mark for the ‘one ten’ carried to the tens column. So for 97+55, he added 7+5 =12 and wrote ‘2’ in the ones column and carried the ‘one ten’ to
the tens column. He then did 9+5 by drawing his tally marks as he did earlier for the ones column but did not include the carried ‘one ten’ and so he got 14 instead of 15 and a final answer of 142 instead of 152 (see Figure 4).

Figure 4: Pupil 1 using tally marks for each place value column but omitted the carried ‘one ten’

The second pupil, Pupil 2 scored zero on her pre-test and many questions were unanswered in the pre-test. During the interview the researcher told her that he noticed that she was playing during the pre-test. Then she was asked if she could answer the questions on the pre-test and she did not answer. She was asked if she would like to try the test again and she was willing and so she had a second try. As she was doing the problems it was noticed that she had written all two digit answers for all the questions. After the test she was asked why all her answers were two digits only and she replied that since the question has 2-digits, the answers also must have 2-digits. Then she was asked why the last answer had three digits and she said, “Oh! sorry the answer is wrong”. This perception may have developed with the addition without regrouping which always has answers with the same number of place values as the largest number in the question. This perception is in line with Fischbein’s (1987) primacy effect which states that the effects of early information (in this pupil’s case addition without regrouping producing a sum with the number of digits equal to the number of digits of the largest number in the question) predominates judgement and is affected less by later information (in this pupil’s case, addition with regrouping producing sums with the number of digits exceeding the number of digits of the largest number in the questions).

The teaching and learning sessions began with showing the pupils which finger to use to move the beads but both were so confused so the researcher gave up and told them that moving a bead to the horizontal beam means the bead has value. Both pupils used their forefinger to move the beads.

Pupil 1 showed great enthusiasm when called to attend the teaching and learning sessions. The first session was only addition without regrouping but involved combination of 5 on the soroban and so a different type of regrouping was involved. Help was given to do the first 10 questions but it was noticed that every time this pupil (who claimed that his mother had taught him to use the soroban at home) had to be reminded to use the soroban and not his tally marks. Since he did the rest of the questions at home it is not known whether he actually used the soroban or otherwise did the sums. For exercise 1 he got 25 out of 40 correct answers. For exercise 2 he got 8 out of 40 correct answers. Every subsequent teaching and learning sessions were greeted with the same enthusiasm and he always wanted to use the tally marks. When asked if he used the soroban at home, he always replied that his mother helped him so he used it. When asked to demonstrate to do a problem in Exercise 3 using the soroban, he had difficulty using it correctly.

For Exercise 3 he handed in an incomplete worksheet. He did 24 questions and got all 24 correct, so he got 24 out of 40 correct answers. When asked why he had not completed the worksheet he remained silent. When asked if he used the soroban to do the problems, he looked down and nodded his head.

Pupil 2 did not show any enthusiasm to even attend the teaching and learning sessions. She came reluctantly. She claimed that the soroban confused her but even during the first session it was observed that her skills at using the soroban were developing. For Exercise 1 she got 40 out of 40 correct answers. Since they were addition without regrouping questions involving only the combination of 5 on the soroban and after the first 10 questions the rest
were done at home, it is not known how she obtained her answers. The next day the addition with regrouping questions posed difficulty for this pupil not only in using the soroban but also when she obtained a 3-digit answer she wrote her 2-digit answer. The researcher showed her how to write the answer. At first she was reluctant to write the correct three digit answers for the next question but after she was told her that her answer was correct she wrote it but the reluctance still persisted. She only got 3 correct answers for Exercise 2 which consisted of 40 questions. Another reason is because this involved combination of 5 and 10 – a new and difficult skill on the soroban. It was noticed that often she did not move the bead on the tens column. Her third exercise was done well. The exercise used both a combination of 5 and 10 as well and she managed to get 31 out of 40 correct answers. She could write 3-digit answers for a question involving addition of two 2-digit numbers. I asked her if the 3-digit answers were wrong but she confidently said that they were correct. At least she had managed to overcome her misconception of the sum of numbers must have the same number of digits as the biggest number in the question.

Much cannot be explained based on the two pupils’ exercises because a large part of it was done at home because of time constraints in school. The post test however was done in front of me without any help from anyone.

Pupil 1 was reminded to use the soroban and the researcher was present all the time. It was noticed that he did not use the soroban. He kept using his fingers. His answers showed that he had not overcome his problem of not adding the ‘one ten’ that he carried in the tens column. Another new problem was illustrated in the post-test, he had written the sum of the two digits in the tens column in reverse order, that is 14 was written as 41 (see Figure 5).

![Figure 5: Pupil 1’s post-test answer illustrating the sum of the tens column digits written in reverse order](image)

He only got one correct answer out of the 40 questions. During the interview after the post-test, when asked why he had written the answer in reverse order, he went, “Ahh..., I forgot”. He got the one correct response because the sum in the tens column was ‘11’ and he remembered the ‘one ten’ he carried. Since 11 is a palindrome number, he wrote the correct answer. However he forgot about the ‘one ten’ that he carried for the other questions.

The soroban failed to help this pupil in any way to do addition with regrouping. During the interview after the post-test the pupil stated that he found the soroban very confusing. He stated that when he did his home work his mother helped and so he really did not know how to use the soroban to do addition.

Pupil 2 used the soroban all the time during the post-test. The questions which involved combination of 10 alone were done correctly (see Figure 6). She scored 13 out of 40 for the post-test.
Questions which involved both the combination of 5 and 10 were done badly (see Figure 7).

It was observed that she was making several errors as she used the soroban when both combinations were involved. For example when she did 41 + 99, she set 41 on the soroban, but when she added 9 to the ones column, she knew that she had to add one to the tens column and minus 1 from the ones column. Instead she subtracted 1 from both the ones and tens column. So she then had 30, instead of 50. Then she went on to add 9 to the tens column, she added 1 to the hundreds column and subtracted one from the tens column and obtained an answer of 120, instead of 140 (see Figure 8). She may have made the error because to add 1 to 4 in the tens column, she has to use the combination of 5, which is add 5 minus 4 and so she did what was easy for her. She was observed to have problems with all questions that employed both combinations.

Figure 6: Correct answers for questions involving combination of 10 on the soroban

Figure 7: Questions which involved both the combination of 5 and 10 done badly

Figure 8: Pupil 2 obtains the incorrect answer of 120, instead of the correct answer 150 because of error when using the soroban
She however has permanently overcome her misconception she had about addition prior to learning to use the soroban. However, it was not solely the soroban that made her realize her error but the explanation from the researcher. This may be because, when she did Exercise 2 using the soroban she obtained the 3-digit answer and was actually writing a 2-digit answer but was corrected and then on she wrote the 3-digit answers for addition of two 2-digit numbers. However, the soroban illustrating the 3-digit answers may also have reinforced what the researcher had already explained.

During the interview after the post-test, she stated that she did not like using the soroban and that it confused her. She preferred to use her fingers to do addition. She claimed that it did not help her to do addition problems better.

4. Conclusion

This study revealed that the soroban did not have positive effects on pupils with difficulties in doing addition with regrouping. It did not motivate them and the two pupils did not benefit as intended from its use. Although one pupil managed to overcome her misconception during the study but this credit cannot go solely to the use of the soroban but the display of 3-digit answers on the soroban did reinforce the explanation that was given.

It would be interesting to teach a class using the soroban from the time they learn addition without regrouping and see its effect. The fact that these two pupils had already been exposed to other methods to do addition of whole numbers and they were familiar with those methods, they were reluctant to learn a new method. In addition, the soroban made a greater cognitive demand compared to the methods they were already exposed to. Hence they were reluctant to learn to use the soroban to do addition.

A study involving a whole class with all exercises done in class would provide a more realistic picture of the effects of the use of the soroban in doing addition with regrouping as compared to allowing exercises to be done at home as was done in this study.

References


