THE OGUAA EDUCATOR

ISSN 0855-0913

VOLUME 12 JUNE, 2018

Published by
COLLEGE OF EDUCATION STUDIES
UNIVERSITY OF CAPE COAST

The Oguaa Educator (*TOE*)

The Oguaa Educator
Vol. 12, June 2018, pp. 28-52

A comparative study of the effect of the methods of Decomposition and Base Complement Addition on Ghanaian children's performance on Compound Subtraction

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Abstract

This paper compares the effects of teaching using the methods of Decomposition and the Base Complement Addition (BCA) on primary school children's ability to solve compound subtraction problems in Ghana. Ninety-six (96) Primary 2 children from two schools participated in the study. For four weeks, children in one of the participating schools were taught using the Base Complement method while their counterparts in the other school were taught using the Decomposition method. A pre-test and a post-test were organized for both groups before and after the teaching sessions respectively. In addition, four weeks after the teaching sessions a retention test was conducted. The study revealed that Base Complement Addition method of performing compound subtraction improved the performance of primary school children better and had a higher power for retention than the Decomposition method. In addition, the differences in performance between the two groups, as measured by the effect sizes (0.585 and 0.499 respectively at the post- and retention-test levels), was medium and therefore non trivial. Interpretation of these effect sizes has been discussed. In addition, recommendations for teacher professional development, curriculum developers and for further studies have been made.

Key words: Compound Subtraction, Method of Decomposition, Base Complement Addition.

Introduction

The importance of subtraction in our daily activities cannot be over emphasized. In the early years of primary education, addition and subtraction are two of the basic operations students encounter in their mathematics lessons. Unfortunately, primary-aged children have been reported in many studies to either lack in computational skills (see for instance, Carpenter, Coburn, Reys, & Wilson, 1978; Carpenter, Kepner, Corbitt, Lindquist, & Reys, 1980; Swanson & Beebe-Frankenberger, 2004; Jordan, Hanich, & Kaplan, 2003) or use rudimentary strategies such as finger counting in solving arithmetic tasks (see for instance Zaslavsky, 1973; Lindemann, Alipour & Fisher, 2011; Davis, 2012; Liutsko, Veraska, & Yakupova, 2017). The situation is even more critical, especially with children's performance on subtraction tasks because subtraction has been revealed to be more difficult than addition at the primary school level. For instance, Carpenter et al. (1978) in discussing the first National Assessment of Education Progress (N.A.E.P.) in the US revealed that, only 55 percent of the nine year olds could complete two-digit subtraction problem with regrouping. In the second N.A.E.P. report, Carpenter et al. (1980) stated that only 75 percent of the thirteen year olds could correctly perform compound subtraction (i.e., subtraction involving whole numbers composed of two, three, four or more digits) with three-digit numbers as against the 85 percent for addition with regrouping; while of the 17 year olds the percentage was 84 and 90 respectively. In other words, even in developed countries such as the US, primary-aged children's performance on addition tasks has been documented to be better than that on subtraction tasks.

In Ghana the situation is no different. The 1992 report on the Criterion-Referenced Test (C.R.T.) conducted and published by the Primary Education Programme (PREP) of the Ministry of Education is noteworthy in this respect (see Adu, 1993). The report showed that only 1.1 percent of the Primary 6 participants tested, achieved over 55 percent pass in Mathematics and about 60 percent could give correct answers to two-digit problems. In addition, primary school children's performance in addition has been by far been better than in subtraction. For instance, the Primary Education Programme (PREP) report (1995) indicated that in 1992 only about 60 percent of participants in primary six could answer correctly compound subtraction involving two digits as against 70 percent for addition with regrouping (see Adu, 1995).

The aforementioned complaints and research reports make it clear that there is the need to take a careful look at the conventional methods of doing subtractions in our primary schools. The need for an effective approach to teaching that helps children to develop effective strategies for solving their subtraction tasks can therefore not be over-emphasized. In Ghana, this need has been compounded by the reported poor performance of our junior high school students in international assessments. A good example is the Trends in International Mathematics and Science Study (TIMSS) at the Eighth Grades in 2003, where Ghana placed last but one or 44 out of 45 countries (see Mullis, Martin, Gonzalez, & Chrostowski, 2004).

Perhaps, the deficiency in computational skills among primary-aged children could be traced to the strategies such children employ in solving their addition and subtraction tasks. In fact, literature is replete with the findings that primary-age children use a lot of informal strategies in solving their addition and subtraction problems (see for instance, Brownell, 1928, 1947; Brownell & Chazal, 1935; Ginsburg, 1975, 1976, 1977; Davydov & Andronov, 1981; Houlihan & Ginsburg, 1981; Resnick & Ford, 1981; Adetula, 1990; Hanich, Jordan, Kaplan & Dick, 2001). These studies have shown that some children count on their fingers, others solve from known combinations, while some give immediate answers, mostly incorrect ones, indicating that they are guessing; to mention just a few. Though these studies have also revealed primary-age children are able to refine their strategies as they progress from primary one or first grade and that later, more efficient strategies evolve which are based either on more sophisticated counting techniques or on a core of known facts, it is also clear that some barriers exist to learning using such informal strategies (Thyne, 1941; Beattie & Deichmann, 1972).

These barriers, if not checked can prevent or delay the development of appropriate addition and subtraction strategies and eventually cause the growing child to have negative feelings about himself or herself, the process of addition/subtraction and mathematics in general.

To overcome such barriers, a number of researchers have argued for the need for teachers to link the mathematical concepts they are teaching to the experience of their students (see Davis & Sullivan, 2011). Davis and Sullivan (2011), for instance relied on the experience their Ghanaian subjects dealt had with contexts involving the use of money to facilitate their learning of number.

This present study, however, sought to focus on compound subtraction because of its numerous applications in social activities, which even primary-aged children face in life outside of school hours such as buying especially when money paid exceeds the selling price of the item being bought (Gyening, 1993). At the time of the study, the primary school syllabus in Ghana recommended the use of the DEC method in the teaching compound subtraction. I argue that this state of affairs (of DEC method being highlighted in the syllabus) is probably due to the fact that literature on compound subtraction has highlighted this method as if it was the most effective method (see, for instance Brownell, 1947; Seville, 1964; Sherill, 1979; Kennedy & Tipps, 1988).

In the literature, another method that has been given prominence is the method of Equal Addition (Murray1941; Ohlsson, Ernest & Rees, 1992). However, I argue that instead of adding any number to both the subtrahend and the minuend, it is easier to think of adding a number that will change the minuend into the nearest tens (i.e., addition to base). Therefore the introduction of the Base Complement Addition (BCA) method in this study is an alternative method to the DEC method.

It is in the light of these that this study was conducted to examine the effectiveness of the methods of Decomposition (DEC) and the Base Complement Addition (BCA) methods in compound subtraction.

Procedure

Two schools in a metropolitan community in Southern Ghana were randomly selected to participate in this study (the name of the community is withheld for anonymity). Participants were from the Primary 2, where compound subtraction (in this study, the subtraction tasks used comprised two-digit numbers as it was the time the curriculum introduced it to primary-aged children in Ghana) was introduced at the time of the study, in each of the two schools were the ones used in the study. A pre-test was structured and administered prior to the teaching sessions to determine the participating children's entry behaviour with reference to speed and accuracy. For four weeks, children in one of the participating schools were taught using the Base Complement Addition (BCA) method while their counterparts in the other school were taught using the Decomposition (DEC) method. To eliminate the possibility of one group being taught with a different expertise from the other, both groups were taught by the researcher. The teaching sessions began the week after the pre-test. A post-test was administered to both groups the week after the last lesson on compound subtraction. The same test items were used as pre-test and post-test to enable (the expected) change in participants' performance to be found. It was made up of 12 items all involving two-digit numbers on compound subtraction. A parallel form of this test was constructed and used for the retention test. It was of the same level of difficulty involving two-digit numbers on compound subtraction. The retention test was administered four weeks after the post-test for both groups. The main activities performed with the two groups are described briefly in the next sections.

To ensure face and content validity, the instruments (pretest, posttest and retention test) were subjected to review by two experts, a mathematics education professor from the Education Faculty of one of the Universities in Ghana and a primary school teacher with about 30 years of experience teaching at the lower primary level in Ghana. In addition, the instruments were piloted and the reliability coefficient calculated using the Kuder-Richardson formula (since the responses were simply scored as correct or incorrect). From the pilot, 0.82, 0.91 and 0.92 were obtained as the coefficients of reliability of for the pretest, posttest and the retention tests respectively.

Weekly Activity with the BCA Group

Week 1

Students were introduced to the fraction boards and squares. After that, accurate representations of numbers on the fraction board using cut out squares were discussed with them. For example, 36 was represented on the fraction board as shown in Figure 1.

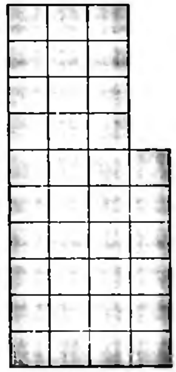


Figure 1: Representation of the number 36

Starting from the left corner, the first three columns of ten were filled and the remaining six were added on by beginning from the bottom of the next column.

Week 2

A demonstration of compound Subtraction was done with students using subtraction board and squares drawn on paper. For example, students were led to discover that to perform 44-28, they needed to begin from an accurate representation of the minuend 44 (see Figure 2A). Then to demonstrate the given subtraction task, they were led to consider removing the relevant number of shaded squares representing the subtrahend 28 from 44 as shown in Figure 2B.

Figure 2A: Representation of 44

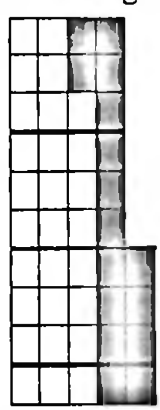


Figure 2B: Representation of the result of 44 - 28

Using questioning techniques, students were led to realize that from Figure 2B, it is clear that after removing the relevant shaded squares (as illustrated by the unshaded portion of two columns of 10 squares and 8 more from the third column) from the representation in Figure 2B to signify subtraction of 28 it was left with 2 shaded squares hanging up in the 3rd column, 10 squares in the 4th column and 4 squares in the 5th column (i.e., leaving a total of 16 shaded squares in Figure 2B). Thus, it could be concluded that Figure 2B is a representation of 44 - 28 = 16.

Week 3

Students were first provided with diagrammatic representations of various two-digit subtractions and encouraged to write down mathematical sentences representing the problems shown as one moves from the left hand diagram to the right hand side diagram as exemplified in Examples 1 and 2.

Example 1:

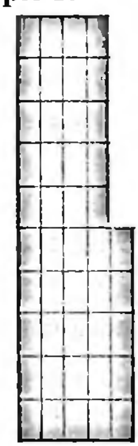


Figure 3A: Representation of 45

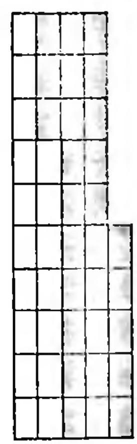


Figure 3B: Representation of the results of 45-17=28

Example 2:

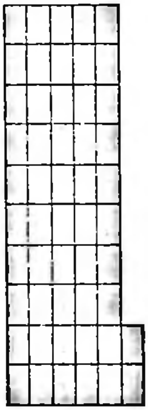


Figure 4A: Representation of 52

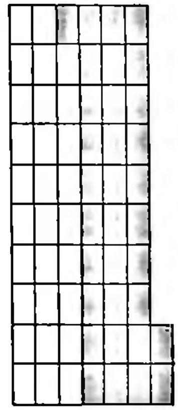


Figure 4B: Representation of 62 - 29

Next, students were provided with a number of representations of subtraction tasks and encouraged to write down equivalent forms of the mathematical sentences whose results are represented by the diagrams. Examples of these tasks are shown in Figures 5A and 5B.

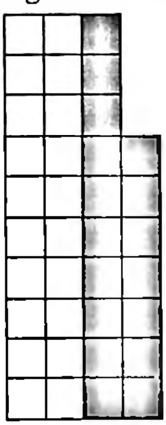


Figure 5A

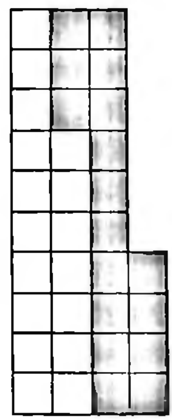


Figure 5B

Using questioning, students were led to explain the subtraction tasks represented first by Figure 5A followed by Figure 5B. The following protocol demonstrates an example of some of the class interactions. Pseudo names are used for the student to ensure anonymity. Also, in the vignettes presented in the sections that follow, the transcript of the interaction with the participant by pseudo name

Ama is used because she was the most articulate in explaining her responses.

Researcher: Ama, imagine that Figure 5A represents a subtraction task in which all the squares in the left hand columns were originally shaded. If we write this subtraction as C – B = D. What will be the value of the number C on the left hand of subtraction sign be?

Researcher: (*Ama scribbles something in the air where the unshaded two columns are, pauses for about 10 seconds and says*) Sir, we will have 37 shaded squares so C will be 37.

Researcher: Now imagine that the unshaded squares on the left represent squares that have been removed in the subtraction task (*pointing at the original representation of the subtraction task under discussion,* C – B = D). What letter of the subtraction task will these unshaded squares on the left hand side (i.e., in the first two columns) represent?

Ama: That will be B

Researcher: What will be the value of B?

Ama: (*Gazes at the fraction squares, quietly moves the head up and down twice as if counting the squares in the two columns and responds)* 20.

Researcher: Can you now tell me the subtraction task represented by Figure 5B?

Ama: (*Pointedly counts the remaining shaded squares*) 10, 11, 12, . . . 17 *(and says)*, 34 minus 17 (*while writing*) 37 – 20 = 17.

Next, Ama's attention was directed at Figure 5B.

Researcher: Now Look carefully at the fraction squares provided in Figure 5B. (*Students draw out their diagrams and begin observing it*). Describe what you see on this Figure.

Ama: There are three columns of ten squares and seven but the first two columns are not shaded. Only the third column and the seven units are shaded.

Researcher: If Figure 5B represents a subtraction task of the form X – Y = Z. What will that task be?

Ama: (*Pauses for about 5 seconds and points four times successively at the diagram while nodding the head each time, and then writes)* 34 – 17 =17.

Researcher: Can you explain why you think this should be the answer?

Ama: The unshaded portion (that is 17 units) represents what has been taken away from the original (which should have been three columns and four or 34) and the shaded column and seven or 17 represents what is left after the subtraction. So we have 37 minus 17 giving us 17.

Using a similar approach, students were led to perform other tasks.

Week 4

This week, using Figure 5A and Figure 5B, participants were also led to realize that removing the three squares hanging up the second column from the left of Figure 5B and fixing them one after the other to the 5th, 6th and 7th vacant positions of the fourth column in Figure 5B gives a picture as seen in Figure 5A.

This means that the task represented in Figure 5B (i.e., 34 – 17) could be transformed into the task in Figure 5A (i.e., 37 – 20) by adding 3 extra to what is being subtracted so the latter becomes a multiple of ten (i.e., 20 in this case) then adding the same 3 to the original 34 from which the subtraction is done (making that to be 37) as in Figure 5A.

Now since it is easier to perform 37 – 20 than 34 – 17 (the essence of base complement addition applied to compound subtraction), participants were encouraged to convert the latter into the former and solve.

From the concrete and iconic forms, participants were then led to perform similar tasks symbolically (i.e., solving compound subtraction without the use of materials) as shown in Example 3.

Example 3:

$$\begin{array}{r} 24 \\ -\ 15 \\ \hline \\ \hline \end{array} \quad \rightarrow \quad \begin{array}{r} 29 \\ -\ 20 \\ \hline \\ \hline \end{array}$$

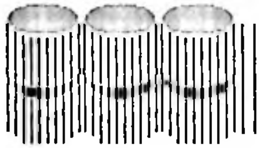
It was explained to participants how the compound subtraction, 24 – 15, was transformed to a simple subtraction, 29 – 20. Considering the subtrahend of the original problem, it could be seen to have 5 in the unit column. Adding the base ten complement of 5 (i.e. 5) to both subtrahend and minuend gives 20 and 29 respectively. Thus, converting into a simpler subtraction task of 29 – 20 with 9 as the result.

Weekly Activity with the Decomposition Group

Week 1

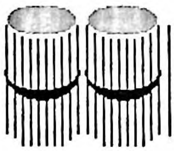
(a) Solve simple subtraction using concrete objects.

Using bundles of sticks 32 could be represented as



3 tens + 2 ones

Taking away 11 (1 ten and 1 one) sticks leaves



2 tens + 1 One = 21

(b) Solve simple subtraction problems without the use of concrete materials.

32-11 = (3 Tens + 2 Ones) – (1 Ten + 1 One)
= (3 Tens – 1 Ten) + (2 Ones – 1 One)
= (2 Tens + 1 One)
= 21

Using the vertical approach, the solution becomes

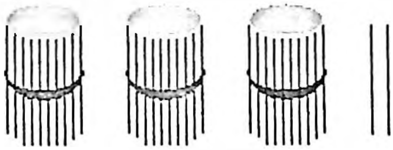
		T	O
32		3	2
- 11	-	1	1
		2	1

Week 2

(a) Solving compound subtraction using concrete materials

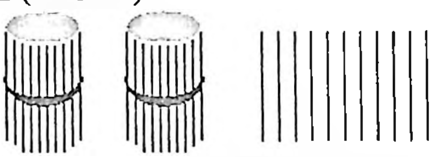
E.g. 32-18

Using bundles of sticks 32 could be represented as



3 tens + 2 ones

To subtract 18 (1 Ten and 8 Ones) there is the need to loosen or untie one bundle of 10 sticks and add them to the 2 loose ones to give a total of 12 (12 ones)



2 Tens + 12 Ones

Taking away (1 Ten and 8 ones) from (2 Tens and 12 Ones) leaves behind (1 Ten and 4 Ones) which is 14.

(b) Solve more compound subtraction problems with the use of materials.

e.g. (i) $\begin{array}{r} 52 \\ -26 \\ \hline \end{array}$ (ii) $\begin{array}{r} 63 \\ -35 \\ \hline \end{array}$

Week 3 and 4

(a) Solving compound subtraction without using materials.

For example

33 – 15	=	(3 Tens + 3 Ones) – (1 Ten + 5 Ones)
	=	(2 Tens + 13 Ones) – (1 Ten + 5 Ones)
	=	(2 Tens – 1 Ten) + (13 Ones + 5 Ones)
	=	(2 Ten + 8 Ones)
	=	18

A vertical representation gives.

		T	O
33	=	^{2}3	^{1}3
- 15	=	- 1	5
		1	8

As was done to the Base Complement Addition group, students in the Decomposition group were also interviewed to see the extent to which they could articulate their thought process.

The vignette below shows an example of one of such interviews with Kofi, one of the most articulate students in this group (the point needs to be made here too that this is a pseudo-name).

Researcher: Now Kofi how would you solve 53–17?

Kofi: *(Kofi pauses for about 10 seconds while looking at the ceiling of the room and responds).* I think it is thirty-six.

Researcher: Are you sure?

Kofi: (*Pauses again, this time for about 5 seconds looking at the ceiling while nodding, and then writes)* 53–17 =36, (*and adds still nodding*), Yes I am sure it is thirty-six.

Researcher: Please explain to me how you got your answer.

Kofi: I know that 53 is 5 tens and 3 ones while 17 is 1 ten and 7 ones. Sir, I started by subtracting from the ones column. But because I cannot take 7 ones from the 3 ones, I changed one of the 5 tens into ones to change the 53 into 4 tens and 13 ones (*then Kofi stops).*

Researcher: (*After about 15 seconds asks)* are you done?

Kofi: No, Sir.

Researcher: Then continue.

Kofi: Okay so instead of (5 tens and 3 ones), I was left with (4 tens and 13 ones). Subtracting the 7 ones from the 13 ones gave me 6 one and the 1 ten from the 4 tens gave me 3 tens. So the answer is 3 tens and 6 ones, which (*and then writes 36 and utters)* 36. So 53–17 = 36.

Using a similar approach, students were led to perform other tasks such as the following.

(b) Solve more compound subtraction problems without materials.
e.g. (i) 32–27 (ii) 43–18 (iii) 38–19

Administration and scoring of tests

The two groups of participants were tested under similar conditions during the Pre-test, Post-test and the Retention tests periods. Each of the tests had questions boldly printed and well spaced out to allow participants' individual work (rough work). The finishing times of participants in both groups were recorded as they submitted their completed test papers. It was done at intervals of one minute by the use of tally marks. The frequencies observed were computed and used for analyses of the speed of students in the two groups of the study. Scoring of the tests was done manually by researchers on either correct or wrong basis. A point was awarded for a correct answer and a zero for a wrong in each of the three tests.

Analyses and Discussion

To test which of the two methods was better at improving the accuracy levels of participants (i.e., on the measure of accuracy), the marks or scores obtained by participants at each of the three test periods (pre-test, post-test, and the delayed post-test) was compared. As will be seen from the analyses below, first group statistics of each group at each test level was calculated to see which group performed better on the average. The analyses of the Base-complement addition group is presented as BCA, while the Decomposition group is presented as DEC. After this, independent samples t-test was conducted on the scores obtained by participants in the two groups (i.e., the BCA and DEC groups) separately during each of the three test periods to check whether any observed differences between the group mean scores were significant. At each of the three test periods, the independent samples t-test was considered appropriate because, as already discussed, participants of the study comprised participants from two completely different schools. The two groups could, therefore, be taken as independent samples that could be compared for possible differences in performance. The analyses at the pre-test level is presented first followed by the post-test level (i.e., immediately after the teaching session) and that at the retention level (i.e., two weeks after the teaching sessions) in that order.

Performance of the two Groups at the pre-test level

One purpose of the analysis at the pre-test level was to see whether any differences existed between the two groups prior to the commencement of the study. Ideally, the pre-test could have been avoided and Analysis of Covariance (ANCOVA) used to test for possible significant differences, if any, at the post-test and retention-test levels. This is because ANCOVA could have made up for any initial differences that existed between the performances of the two groups. However, this was not done because a deliberate decision was made to assign the lower performing group to the Base Complement method, the new method that was not in the curriculum in Ghana at the time of the study. Consequently, independent samples t-test was conducted at the pre-test level (i.e., prior to the teaching sessions) and repeated subsequently at the post-test and retention-test levels. The group statistics at the pre-test level have been presented in Table 1.

Table 1: Group Statistics at the pre-test level

Method	n	Mean	Std. Deviation	Std. Error Mean
DEC	48	8.6667	2.85339	.41185
BCA	48	7.4375	2.85766	.41247

From the group statistics shown in Table 1, it was clear that prior to the commencement of the teaching sessions (pre-test level) the group that was exposed to the method of Decomposition performed better than the group that was exposed to the method of Base Complement Addition. As already explained, to test whether this difference in performance was significant or not, an independence samples t-test was performed.

Table 2: Independence Samples t-test performed at the pre-test level

	Levene's Test for Equality of Variances		t-test for Equality of Means				
	F	Sig	t	df	Sig (2-tailed)	Mean Diff	Std. Error Diff
Equal variances assumed	.010	.919	2.109	94	.038	1.22917	.587
Equal variances not assumed			2.109	94.000	.038	1.22917	.587

From Table 2, it is clear that at the pre-test level the difference between the two groups was not significant (p>0.025 two-tailed). In other words, though the difference in performance was not found to be significant at the 5% level of significance, it is clear from the group means that the group that was later exposed to the method of Decomposition performed slightly better than the group that was exposed to the method of Base Complement Addition prior to the teaching sessions (as reported in Table 1).

Performance of the two groups at the post-test level

The purpose of the analysis at the post-test level was to see whether any differences in performance of the two groups would exist following the implementation of the two treatments (i.e., immediately after the teaching sessions). A similar independence samples t-test was performed on the participants' scores at this post-test level, the group statistics have been presented in Table 3.

Table 3: Group Statistics at the post-test level

Method	n	Mean	Std. Deviation	Std. Error Mean
DEC	48	9.3958	3.77415	.54475
BCA	48	11.0625	1.40525	.20283

From the group statistics shown in Table 3, it was clear that immediately after the teaching sessions (i.e., at the post-test level) the group that was exposed to the method of Base Complement Addition outperformed the group that was exposed to the method of

Decomposition. As already explained, to test whether this difference in performance was significant or not, an independence samples t-test was performed. It is worthy of note that though prior to the commencement of the teaching sessions, there was no significant difference in performance between the two groups, in terms of their mean scores this Base Complement Addition group was the group that performed slightly lesser (see Table 1). However, as Table 3 reveals, immediately after the teaching sessions (post-test level) the Base Complement Addition group had outperformed the Decomposition group. In other words, the Base Complement Addition group improved from being the slightly lower performing of the two groups prior to the teaching sessions to becoming the higher performing group immediately after the teaching sessions. To test whether the difference in the groups' performance at the post-test level was significant, independence samples t-test was performed as was done previously. The results of this test is presented in Table 4.

Table 4: Independence Samples t-test performed at the post-test level

	Levene's Test for Equality of Variances		t-test for Equality of Means				
	F	Sig	t	df	Sig (2-tailed)	Mean Diff	Std. Error Diff
Equal variances assumed	24.867	.000	-2.867	94	.005	-1.66667	.58288
Equal variances not assumed			-2.867	59.786	.006	-1.66667	.58288

A cursory look at Table 4 reveals that at the post-test level the difference between the two groups was significant ($p<0.025$ two-tailed). In other words, the group that was later exposed to the method of Base Complement Addition performed significantly better than the group that was exposed to the method of Decomposition immediately after the teaching sessions at the 5% level.

Sullivan and Fein (2012) have argued that "while a p-value can inform the reader whether an effect exists, the p-value will not reveal the size of the effect. [Therefore], in reporting and interpreting studies, both the substantive significance (effect size) and statistical significance (p- value) are essential results to be reported" (p 279). Guided by this view, a step was taken to test how large the difference in performance between the two groups was (see also Durlak, 2009). The first attempt was to use Hedges' effect size. Hedges' g was initially preferred to Cohen's d and Glass' delta for two reasons. First, according to Grissom and Kim (2005), for smaller samples such as those used in this study g provides a better estimate than d. This is due to the fact though both Hedges' g and Cohen's d pool variances on the assumption the population from which the two samples for the study has been drawn have equal variances, g pools using n - 1 for each sample instead of n. Second in comparison to Glass' delta, Hedges' g was again considered more appropriate because the Glass' delta uses the standard deviation of the control group. And since there was no control group in this study, Glass's delta was deemed not to be suitable in this study.

However, upon computation, Cohen's d and Hedges' g was found to yield the same result of an effect size of 0.585347. Consequently, what is reported here could be taken as either Cohen's d and Hedges' g. It is worth noting that per the interpretation given by both Cohen and Hedges (see Cohen, 1962; Hedges, 1981; Hedges & Oklin, 1985; Grissom & Kim, 2005) this effect size being close to 0.5 is not trivial but medium. In other words, the Base Complement Addition group did not only perform significantly better than the Decomposition group, the difference in performance was within the medium size. Another interpretation is that about 69% of the of the Decomposition group performed below the average person in the Base Complement Addition group (see Coe, 2002).

Performance of the two groups at the retention-test level

As already mentioned participants in this study were assessed four weeks after the teaching sessions to ascertain the extent to which the skills learnt during the teaching sessions were retained. Similar analyses performed at the pre- and post-test levels were conducted. A parallel form of the instrument used during the pre- and post-test was used as the retention test. Table 5 shows the group statistics on the retention test.

Table 5: Group Statistics at the retention-test level

Method	n	Mean	Std. Deviation	Std. Error Mean
DEC	48	8.8542	4.12047	.59474
BCA	48	10.5625	2.54246	.36697

As shown in Table 5, it was obvious that four weeks after the teaching sessions, (i.e., at the retention-test level) the group that was exposed to the method of Base Complement Addition continued to outperform their counterparts who were exposed to the method of Decomposition. To test whether this difference in performance was significant or not, an independence samples t-test was performed as was done previously. The result of this test is presented in Table 6.

Table 6: Independent Sample t-test performance at the retention level

	Levene's Test for Equality of Variances		t-test for Equality of Means				
	F	Sig	t	df	Sig (2-tailed)	Mean Diff	Std. Error Diff
Equal variances assumed	11.808	.001	-2.445	94	.016	-1.70833	.69884
Equal variances not assumed			-2.445	78.257	.017	-1.70833	.69884

A similar trend in performance observed at the post-test level was repeated at the retention level. This is obvious from Table 6, which shows that at the retention-test level, not only did the Base Complement Addition group perform better than the Decomposition group, the difference in performance was significant ($p<0.025$ two-tailed).

In addition, a computation of the size of the difference in performance yielded an effect size of approximately 0.5 (0.49897 to be precise). As was obtained at the post-test level, this effect size was the same value obtained for Cohen's d and Hedges' g. One interpretation of this is that being close to 0.5, this effect size is not trivial but medium. In other words, the Base Complement Addition group did not perform significantly better than the Decomposition group, the difference in performance between the Base Complement Addition group and the Decomposition group was not small but medium. Another interpretation is that close to about 69% of the of the Decomposition group still performed below the average person in the Base Complement Addition group (see Coe, 2002).

Conclusions, Implications and Recommendations

The results of the study have revealed that the performance of the Base Complement Addition (BCA) group on compound subtraction tasks was significantly higher at 95 percent level of confidence, than their counterparts who were exposed to the Decomposition method on measure of accuracy (i.e., immediately after the teaching sessions) and on the measure of retention (i.e., four weeks after the teaching sessions). This finding does not support the findings of a similar study by Essel (2003) who have no significant difference in performance of two groups in a similar study, also conducted in Ghana.

On the face value, the lack of agreement between this study's findings and that of Essel (2003) imply that further research is needed to throw more light on the relative effect of the two methods of compound subtraction. It is recommended that future studies in this direction would need to be done on a large scale to possibly use schools across a number of regions in Ghana.

The aforementioned lack of agreement notwithstanding, the present study has also revealed that size of the differences in performance, as shown by the effect sizes of approximately 0.5 at both the post-test and retention-test levels, are not trivial but medium according to Cohen's (1962) criteria. Such effect sizes, according to Coe (2002), implies statistically that in both cases about 69% of students who were exposed to the Decomposition method could statistically be said to perform below the average person who was exposed to the Base Complement Addition method.

The Decomposition method, at the time of this study, was the conventional method prescribed in the primary school mathematics syllabus in Ghana. This study has, however, highlighted that so far as compound subtraction is concerned, on the measure of accuracy the Base Complement method was a more effective for participants.

Since participants of the study were all Primary 2 students, the implication is that the Base Complement Addition method could be better at improving the performance of primary aged children in compound subtraction in Ghana. Consequently, it is recommended that the BCA algorithm be incorporated into the mainstream of the primary school curriculum in Ghana.

Where necessary, in-service training programmes would need to be organized for teachers on how to incorporate the Base Complement addition method in their teaching of compound subtraction. This recommendation is significant especially in the light of the fact a limitation to the method of Decomposition has long been documented to be problems many primary aged children have with regrouping (see for instance, Johnson, 1938; Brownell, 1947), the ability of children using the method of Base Complement to reduce compound subtraction into simple subtraction points to the possibility of reducing difficulties children have with compound subtraction. This in turn could reduce their fear of mathematics at the early stages and eventually get more Ghanaian students interested in the mathematically related subjects.

References

Adetula, L. O. (1990). Strategies and skills used by Primary School Children to solve Simple Addition and Subtraction Word Problems. *ABACUS - Journal for the Mathematical Association of Nigeria, 20,* 65-76.

Adu, J. K. (1993). *Primary Education Programme (PREP): Mid-Term Evaluation Report on Criterion-Referenced Testing in Mathematics and English for Primary Six Participants.* Accra: Ministry of Education, Ghana.

Adu, J. K. (1995). *Primary Education Programme (PREP): Mid-Term Evaluation Report on Criterion-Referenced Testing in Mathematics and English for Primary Six Participants.* Accra: Ministry of Education, Ghana.

Beattie, I. D., & Deichmann, J. W. (1972). *Error trends in solving format across 1st and 2nd grades.* Paper presented at the annual meeting of the American Education Research Association, Chicago (ERIC Document Reproduction Service No. ED 064 170).

Brownell, W. A. (1928). *The development of children's number ideas in the primary grades.* Supplementary Education Monographs, No. 35. Chicago: University of Chicago Press.

Brownell, W.A. (1947). An Experiment on Borrowing in Third Grade Arithmetic. *Journal of Educational Research, 41,* 161-171.

Brownell, W. A., & Chazal, C. B. (1935). The effects of premature drill in 3rd Grade Arithmetic. *Journal of Education Research, 29,* 17-28.

Carpenter, T. P., Coburn, T. G., Reys, R. E., & Wilson, J. W. (1978). *Results from the First Mathematics Assessment of the National Assessment of Educational Progress.* Reston, VA.:, National Council of Teachers of Mathematics.

Carpenter, T. P., Kepner, H., Corbitt, M. K., Lindquist, M. M., & Reys, R. E. (1980). Results and Implications of the Second NAEP Mathematics Assessments: Elementary School. *Arithmetic Teacher 27*, 10-12, 44-47.

Cockroft, W.H. (1982). *Mathematics Counts.* Report of the committee of Inquiry into the teaching of Mathematics in the Schools under the Chairman of Dr. W.H. Cockroft. London: H.M.S.O.

Coe, R. (2002). *It's the effect size, stupid: What effect size is and why it is important.* Paper presented at the Annual Conference of the British Educational Research Association, University of Exeter, England.

Cohen, J. (1962). The statistical power of abnormal-social psychological research: A review. *The Journal of Abnormal and Social Psychology, 65,* 3, 145-153. Available at http://dx.doi.org/10.1037/h0045186

Cosgrove, G. E. (1957). The Effect on Sixth-Grade Participants' skill in Compound Subtraction When They Experience a New Procedure for Performing This Skill. Doctor's dissertation, Boston University School of Education. In Williams, J.D. (1971). *Teaching Technique in Primary Mathematics* N.F.E.R.

Davis, E. K. (2012). Use of finger counting in primary mathematics: Cases of four primary schools in Cape Coast metropolis of Ghana. *Journal of Science and Mathematics Education, 6,* 1, 29-43.

Davis, E. K., & Sullivan, P. (2011). The complexity of building students' experience: An investigation connecting money recognition and number fluency in Ghana. *Ghana Journal of Education, 3,* 1, 51-63.

Davydov, V. V., & Andronov, V. P. (1981). *Psychological Conditions of the origination of ideas actions* (Project Paper No. 81-2). Madison: Wisconsin Research and Development Centre for individualized Schooling.

Essel, M. A. K. (2003). A Comparison of Two Methods of Compound Subtraction: Decomposition and Base-Complement Addition. *Mathematics Connection*, 3, 75-92.

Ginsburg, H. P. (1975). Young children's informal knowledge of mathematics. *The Journal of Children's Mathematical Behaviour, 1*, 3, 63-156.

Ginsburg H. P. (1976). Learning difficulties in children's arithmetic: A clinical cognitive approach. In A. O. Osbourne (Ed.). *Models for learning mathematics*. Columbus, OH: ERIC.

Ginsburg H. P. (1977). The psychology of arithmetic thinking. *The Journal of Children's Mathematical Behaviour, 1,* 4, 1-89.

Grissom, R. J. and Kim, J. J. (2005). *Effect sizes for research: A broad practical approach*. Mahwah, NJ:Erlbaum.

Grossnickle, F. E., Brueckner, L. J. & Reckzer J. (1968). *Discovering Meanings in Elementary School Mathematics*. New York: Soft, Richard and Wiston, Inc.

Gyening, J. (1993). *Facilitating Compound Subtraction by Equivalent zero Addition (EZA).* Paper presented at a departmental seminar of the Science Education Department, University of Cape Coast, Cape Coast.

Hanich, L, B., Jordan, N. C., Kaplan, D., & Dick, J. (2001). Performance across different areas of mathematical cognition in children with learning difficulties. *Journal of Educational Psychology*, *93*, 3, 615-626.

Hedges L. V., & Olkin I. (1985). *Statistical methods for meta-analysis*. San Diego, CA: Academic Press.

Hedges, L. (1981). Distribution Theory for Glass's Estimator of Effect Size and Related Estimators. *Journal of Educational Statistics, 6*, 2, 107-128.

Houlihan, D. M. & Ginsburg, H. P. (1981). The addition methods of first- and second-grade children. *Journal for Research in Mathematics Education, 12,* 95-106.

Johnson, J. T. (1938). *Relative Merits of Three Methods of Subtraction Contributions to Education.* New York: Bureau of Publication, Teacher's College, Columbia University.

Jordan, N. C., Hanich, L. B., & Kaplan, D. (2003). Arithmetic fact mastery in young children: A longitudinal investigation. *Journal of Experimental Child Psychology, 85*(2), 103-119.

Kennedy, M.L., & Tipps, S. (1988). *Guiding Children's Learning of Mathematics* (5th ed). Belmont, Calfornia: Wadsoworth Publishing Co. Ltd.

Lindemann, O., Alipour, A., & Fischer, M. H. (2011). Finger counting habits in Middle Eastern and Western individuals: An online survey. *Journal of Cross-Cultural Psychology, 42*(4), 566-578.

Liutsko, L., Veraska, A. N., & Yakupova, V. A. (2017). Embodied finger counting in children with different cultural backgrounds and hand dominance. *Psychology in Russia: State of the art.* Avaliable at https://cyberleninka.ru/journal/n/psychology-in-russia-state-of-the-art

Mullis I. V.S., Martin M. O., Gonzalez E. J., & Chrostowski S. J. (2004). *TIMSS 2003 International Mathematics Report: Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades.* Available at https://files.eric.ed.gov/fulltext/ED494650.pdf

Murray, J. (1941). The Relative Merits of Teaching Subtraction. *Studies in Arithmetic*, *2,* 21-70.

Ohlsson, S., Ernest, A., M & Rees, E. (1992). The Cognitive Complexity of Learning and Doing Arithmetic. *Journal for Research in Mathematics Education*, *23*(5), 441- 456.

Resnick, L. B. & Ford, W. W. (1981). *The Psychology of Mathematics for Instruction.* Hillsdale NJ: Lawrence Eribaum Associates.

Seville, E.W. (1964). *Teaching Primary Arithmetic with Mathematical Meaning* (2nd ed.) Welyn Harts: James Nisket & Co. Ltd Digswell Place.

Sherill, J.M (1979). Subtraction: Decomposition Versus Equal Addends. *The Arithmetic Teacher, 27*, 1, 16-17.

Sullivan, G. M. & Fein, R. (2012). Using effect size – or why the p-value is not enough. *Journal of Graduate Medical Education*, 279-282.

Swanson, H. L. & Beebe-Frankenberger, M. (2004). The relationship between working memory and mathematical problem solving in children at risk and not at risk for serious math difficulties. *Journal of Educational Psychology, 96,* 3, 471-491.

Thyne, J. M. (1941). Types of errors in the basic number facts. In J. Murray (Ed). *Studies in arithmetic (Vol. 2). Scottish Council for Research in Education*. London: University of London Press.

Wessman-Enzinger, N. M.(n.d.) *An Investigation of Subtraction Algorithms from the 18th and 19th Centuries- Definitions and Algorithms*. Available at https://www.maa.org/book/export /html/284991

Zaslavsky, C. (1973). Mathematics in the study of African culture. *Arithmetic Teacher, 20,* 532-535.