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Research Article:

Impact of Concrete-Pictorial-Abstract Approach with Collaborative Lesson Research on Year Four Pupils' Proficiency in Volume

Mohd Shafian Shafiee[1] and Chew Cheng Meng[2, 3*]

[1]Institut Pendidikan Guru Kampus Pulau Pinang, 11700 Gelugor, Pulau Pinang, Malaysia
[2]School of Educational Studies, Universiti Sains Malaysia, 11800 USM Pulau Pinang, Malaysia
[3]School of Education, Humanities and Social Sciences, Wawasan Open University, 54, Jalan Sultan Ahmad Shah, 10050 George Town, Pulau Pinang, Malaysia

*Corresponding author: cmchew@usm.my; cmchew@wou.edu.my

ABSTRACT

This study aimed to determine the impact of concrete-pictorial-abstract (CPA) approach with collaborative lesson research (CLR) on Year Four pupils' proficiency in volume. The counterbalanced research design, which consisted of three different groups of year four pupils with three treatments applied to each group, was used with the Proficiency in Volume Test (PVT) administered before and after each of the three CLR cycles. Cluster sampling was used to select three groups of 115 Year Four pupils consisting of 59 males and 56 females. PVT consisted of five questions based on the five strands of proficiency in volume: Q1 (conceptual understanding), Q2 (procedural fluency), Q3 (strategic competence), Q4 (adaptive reasoning), and Q5 (productive disposition). It has a total score of 15 and the indicators of proficiency in volume are low proficiency (0–4), average proficiency (5–10), and high proficiency (11–15). The data were analysed using the paired-sample *CLR cycles*-test and one-way ANOVA in SPSS version 24. The results of the paired-sample *t*-test showed that there was a significant difference between the mean scores of the pre- and post-tests for each CLR cycle. The results of the paired-sample *t*-test for cube in the first, second and third cycles of CLR were: $t = -6.74$, df = 37, $p < 0.05$; $t = -19.82$, df = 37, $p < 0.05$; and $t = -22.10$, df = 38, $p < 0.05$, respectively. The results of the paired-sample *t*-test for cuboid in the first, second and third cycles of CLR were: $t = 3.15$, df = 37, $p < 0.05$; $t = 9.87$, df = 38, $p < 0.05$; and $t = 20.76$, df = 37, $p < 0.05$, respectively. The results of one-way ANOVA showed that there was a significant in the post-test mean scores between the first, second and third CLR cycles. The result of one-way ANOVA for cube was $F(2,112) = 53.32$, $p < 0.05$, while for cuboid it was $F(2,112) = 71.16$, $p < 0.05$. The CLR cycles carried out helped teachers in developing better teaching plans based on the CPA approach as well as enhancing Year Four pupils' proficiency in volume.

Keywords: Concrete-pictorial-abstract approach, collaborative lesson research, proficiency in volume, primary school

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INTRODUCTION

Lesson Study (LS) is an innovative practice used by teachers in Japan to improve their knowledge and skills and also share their views with each other related to teaching and learning. LS has played an important role as a professional development in Japan since the beginning of early education a hundred years ago (Takahashi & Yoshida, 2004). As the LS process takes place, participants or members (usually teachers) are given the opportunity to reflect on the teacher's teaching and pupils' learning in the lesson (Murata & Takahashi, 2002).

LS conducted in the classroom is an effective step in providing direct and indirect training to teachers. LS has also become one of the main mediums for new practical teachers to learn teaching and learning methods in the classroom from older teachers (Takahashi & McDougal, 2016). Sharing knowledge and experience scientifically through the systematic steps of LS allows teachers to appreciate and build self-confidence while teaching in the classroom. Murata and Takahashi (2002) reported that the difficulty faced by teachers in Japan is to incorporate new teaching ideas and materials in the classroom except by looking at its implementation method first, taking advantage of it, trying it themselves in a more objective manner as well as helping teachers understand other problems that arise in the classroom. According to Takahashi and Yoshida (2004), some lessons obtained in the practice of LS are understanding the idea of teaching based on practice, changing teachers' perspectives on teaching and learning, reviewing teaching and learning methods based on pupils' responses and working with members in implementing it.

Although LS has been credited for supporting significant changes in teaching in Japan, its effectiveness outside of Japan has been inconclusive (Takahashi & McDougal, 2016). Thus, in 2016, Takahashi and McDougal introduced Collaborative Lesson Research (CLR) which is an improvement on LS practices that have been used in Japan and other countries around the world including Malaysia (e.g., Chew et al., 2015). They claimed that certain institutional structures and practices are important for maximising the impact of LS but are neglected outside of Japan and these structures and practices are included in CLR. The idea is to make CLR more effective and appropriately modified based on the current situations of the school as explained in detail in the Lesson Study versus Collaborative Lesson Research section. However, to date, there is yet a study that investigates the impact of Concrete-Pictorial-Abstract (CPA) approach with CLR on Year Four pupils' proficiency in volume in the research literature. Based on the research of Takahashi and Yoshida (2016), CLR might have a potential impact on primary pupils' proficiency in volume in Malaysia. Also through CLR, the problems faced by pupils and teachers in the teaching and learning of volume might be improved.

LITERATURE REVIEW

Lesson Study (LS) versus Collaborative Lesson Research (CLR)

LS has long been practised because of its effectiveness in improving teachers' teaching and learning methods in the classroom based on studies that had been conducted (Fernandez & Yoshida, 2004; Lewis, 2002). Lewis (2002) states that LS is a cycle in which teachers discuss together to consider long-term goals for their pupils, bring these goals into actual teaching research, and conduct collaborative monitoring, discussion and refinement of lesson plans that have been conducted. LS is made up of five main steps: (1) identify research focus, (2) plan research lesson, (3) teach research lesson, (4) analyse research lesson, and (5) review and revise (Lewis, 2002), but CLR is a cycle that has six main components: (1) a clear research purpose, (2) Kyouzai Kenkyuu or literature review, (3) a written research proposal, (4) a live research lesson and discussion, (5) knowledgeable external observers, and (6) sharing of results. The difference between LS and CLR is that the main components in LS have been improved so that the outcomes obtained from CLR are more effective. The six components are essential in the CLR cycle to provide maximum impact on teaching and learning (Takahashi & McDougal, 2016). The details of the CLR components are as follows:

1. A clear research purpose: Before starting research, the purpose should be clearly stated referring to the solution of the problem encountered. The content should also be accurate and specific and not general in nature.

2. *Kyouzai Kenkyuu* or literature review: *Kyouzai Kenkyuu* refers to the clear and thorough study of literature about the topic or problem.

3. A written research proposal: The written proposal should be clear and relevant to content resulting from the *Kyouzai Kenkyuu* and helps build ideas about the research to be conducted.

4. A live research lesson and discussion: Teaching in the classroom is direct and requires views and comments from all members who are involved in the CLR.

5. Knowledgeable external observers: Experts who can provide independent views before and after the lesson is carried out.

6. Sharing of results: Sharing information obtained from the research lesson is important in ensuring its effectiveness can be achieved.

The CLR cycle begins with setting the overall teaching theme, content review and teaching, setting lesson plan objectives, lesson plan design, external observer review, live teaching and learning in the classroom, discussion of data and implications and the last is presentation and sharing of results. The six components mentioned above are important in ensuring that the main goals are achieved when CLR is carried out in solving the problems encountered especially in the learning of volume in this study.

Studies on CLR are still in the stage of infancy because it was introduced in 2016. Based on the research literature, only two empirical studies were conducted to date (Takahashi & McDougal, 2018; Watanabe et al., 2019). The studies by Takahashi and McDougal (2018) and Watanabe et al. (2019) in America and Qatar respectively have shown positive results. However, the literature review shows that research on CLR has yet been conducted in Malaysia so far. Hence, this study aimed to fill the research gap by implementing CLR in Malaysian primary school context.

Proficiency in Volume

Kilpatrick et al. (2001) have proposed the Mathematical Proficiency framework which includes five main components namely conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition. The National Research Council (2001) defines mathematical proficiency based on the framework of Kilpatrick et al. (2001) as comprising five interrelated strands:

1. Conceptual understanding: The understanding of the concept of operations and mathematical relationships.
2. Procedural fluency: Skills in carrying out procedures flexibly, accurately, efficiently and appropriately.
3. Strategic competence: The ability to design, represent and solve mathematical problems.
4. Adaptive reasoning: The ability for logical thinking, reflection, explanation and justification.
5. Productive disposition: The tendency to view mathematics as meaningful, useful and worthwhile, coupled with belief in perseverance and self-efficacy.

Pupils who are proficient in mathematics are pupils who have mastered all the five strands of mathematical proficiency.

In this study, proficiency in volume is defined based on the definition of mathematical proficiency by the National Research Council (2001). As such, year four pupils' proficiency in volume is defined as comprising five interrelated strands:

1. Conceptual understanding: The understanding of the concept of operations and mathematical relationships involving volume.
2. Procedural fluency: Skills in carrying out procedures flexibly, accurately, efficiently and appropriately involving volume.

3. Strategic competence: The ability to design, represent and solve mathematical problems involving volume.

4. Adaptive reasoning: The ability for logical thinking, reflection, explanation and justification involving volume.

5. Productive disposition: The tendency to view volume as meaningful, useful and worthwhile, coupled with belief in perseverance and self-efficacy.

Pupils who are proficient in volume are pupils who have mastered all the five strands of mathematical proficiency involving volume.

CPA Approach

Many studies (e.g., Isip, 2018; Putri, 2017; 2019; Putri et al., 2017; 2018; 2020; Purwadi et al., 2019; Rakhmawati, 2017; Salimi et al., 2020; Salingay & Tan, 2018; Saptini, 2016; Yuliyanto, Putri, et al., 2019; Yuliyanto, Turmudi, et al., 2019) had shown significant improvement in pupils' performance in mathematics when the CPA approach was implemented in the classrooms.

CPA approach comprises three main steps namely the concrete, pictorial and abstract steps and it is an adaptation of the three modes of representation proposed by Bruner (1966). Bruner (1966) states that the three modes of representation in mathematics are enactive, iconic and symbolic. Enactive representation means that learning is through motor responses, iconic representation is through perception of a picture while symbolic representation is something that is obscured or there is a meaning to something otherwise (Bruner, 1964). Based on the Bruner's (1966) three modes of representation, the CPA approach has been correspondingly represented by concrete steps in enactive representation, pictorial steps in iconic representation and abstract steps in symbolic representation.

The concrete step is an important step for teachers to make the mathematical learning meaningful to pupils. Learning in concrete step is something that pupils need to go through to strengthen their understanding of the mathematical concept. The benefits of pupils interacting with concrete materials are the opportunity to obtain important information and the higher likelihood of remembering the computational steps in solving mathematical problems. The use of concrete materials increases the percentage of pupils' ability to remember procedures in mathematical problem solving. The next step is the pictorial step or perception of the picture. The concrete material used and the mathematical problem solved in the concrete step are used again in the pictorial step. In other words, the iconic representation in the pictorial step acts as a bridge between problem solving using objects and problem solving using numbers (Flores, 2018). Having successfully gone through the concrete step, pupils will try to draw objects (such as cubes and cuboids that have been constructed in the concrete step) in the form of pictures. The relevance of the construction of cubes and cuboids at the concrete level will be translated on paper through drawings drawn by the pupils. Through translation on paper using drawings, the picture of the cubes and cuboids can be identified by the pupils. The most important thing is the translation process that the pupils have to do from the concrete form to the pictorial form. Pupils will imagine an object that has been constructed and then try to draw it on paper. If the pupil succeeds in drawing it, then the pictorial step is successful. The abstract step is the last step in which the pupils try to solve the given problems involving volume without using any concrete materials and pictures. The abstract step is solving problems using numbers and mathematical equations without using objects or pictures (Flores, 2018; Flores & Hinton, 2019; Flores et al., 2019; Hinton & Flores, 2019).

To date, most of the past studies on CPA approach in the research literature used the quasi-experimental research design involving two groups, and without CLR. However, the literature review shows that research on the CPA approach with CLR has yet been conducted in Malaysia so far. Thus, this study aimed to fill the research gaps by investigating the impact of the CPA approach with CLR on Year Four pupils' proficiency in volume of cube and cuboid in Malaysian primary school context by employing a different research design that is the counterbalanced design so that all the treatments for each group of participants would be tested equally.

Conceptual Framework of the Study

The conceptual framework of the study (see Figure 1) comprised Bruner's (1966) three modes of representation for the CPA approach, Takahashi and McDougal's (2016) CLR for the three CLR cycles, and Kilpatrick et al.'s (2001) Mathematical Proficiency framework for proficiency in volume. Figure 1 shows if the CPA approach with CLR could have a positive impact on Year Four pupils' proficiency in volume.

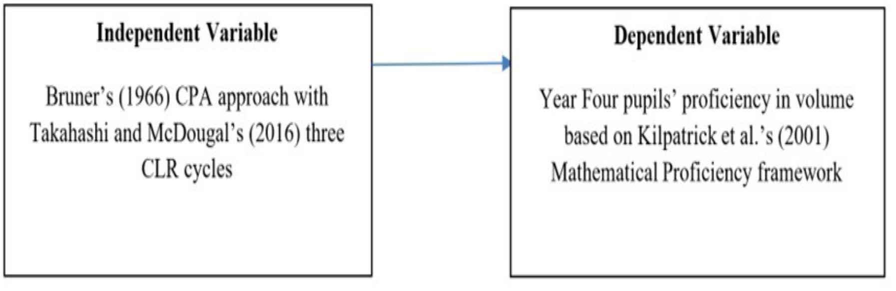

Figure 1. Conceptual framework of the study

Objectives of the Study

The objectives of the study are as follows:

1. To determine if there is a significant difference between the pre- and post-test mean score of proficiency in volume of cube and cuboid for the first, second and third cycles of the CPA approach with CLR, respectively.

2. To determine if there is a significant difference in the post-test mean score of proficiency in volume of cube and cuboid between the first, second and third cycles of the CPA approach with CLR.

METHODOLOGY

Research Design

The research design employed in this study was the counterbalanced design so that all the treatments for each group of participants were tested equally. The design consisted of three different groups of year four pupils with three treatments applied to each group. Each group went through the pre-test (0_1) followed by the treatment (X) and ended with the post-test (0_2). The paired-sample t test and one-way ANOVA were conducted using SPSS version 24 to achieve the first and second research objectives, respectively. The research design is as shown in Table 1. For the volume of cube, the first cycle of the CPA approach with CLR was Group 3, followed by Group 1 in the second cycle and Group 2 in the third cycle, while for the volume of cuboid, the first cycle of the CPA approach with CLR was Group 1, followed by Group 2 in the second cycle and Group 3 in the third cycle.

Table 1. Research design

Topic		Cube			Cuboid	
Cycle	C1	C2	C3	C1	C2	C3
Lesson plan		First			Second	
Group rotation	G3	G1	G2	G1	G2	G3
Teacher	T3	T1	T2	T1	T2	T3

Notes: C1 = First cycle; C2 = Second cycle; C3 = Third cycle; G1 = Group one; G2 = Group two; G3 = Group three; T1 = Group 1 teacher; T2 = Group 2 teacher; T3 = Group 3 teacher

Variables of the Study

The independent variable of this study was the CPA approach with CLR. Effects or outcomes (i.e., changes or differences in behaviour or characteristics) are known as dependent variables (Creswell, 2009; Gay et al., 2014). Thus, the dependent variable of this study was year four pupils' proficiency in volume.

Population and Sample

The target population of this study consisted of all year four pupils studying at the national schools in the state of Penang. Nevertheless, the accessible population of this study was all year four pupils studying at the national schools in one of the districts of Penang which consists of four national schools. Cluster sampling was used to select the sample of the study which consisted of three year four classes of 10-year-old pupils. Group 1 (class 1) consisted of 19 male pupils and 19 female pupils, Group 2 (class 2) consisted of 20 male pupils and 19 female pupils while Group 3 (class 3) consisted of 20 male pupils and 18 female pupils. The total number of pupils in Group 1 was 38 pupils, Group 2 was 39 pupils while Group 3 was 38 pupils. The selection of the three teachers from the three classes was based on similar gender, years of teaching experience and grade. The three teachers selected were female with at least 10 years of experience and had the same grade in service which was DG44. The three external observers who participated in this study are the Head of the Mathematics Committee, Mathematics Excellent Teacher and Mathematics School Improvement Specialist Coach (SISC+). The total number of pupils is 115 with 59 male and 56 female pupils. Three lesson plans were developed by the CLR group based on the CPA approach which focused on the volume for cube and cuboid. The learning standards of the lessons were to determine the volume of cube and cuboid, respectively. The time taken to carry out each lesson based on the lesson plans was 60 minutes.

Research Instrument

The Proficiency in Volume Test (PVT) was used in this study to assess year four pupils' proficiency in volume. PVT was constructed based on the Mathematical Proficiency framework of the National Research Council (2001). The test consisted of five questions based on the five strands of proficiency in volume: Q1 (conceptual understanding), Q2 (procedural fluency), Q3 (strategic competence), Q4 (adaptive reasoning), and Q5 (productive disposition). PVT has a total score of 15 and the indicators of proficiency in volume are low proficiency (0–4), average proficiency (5–10), and high proficiency (11–15). PVT was validated by a panel of three Mathematics teachers who had at least 10 years of teaching year four mathematics in national schools. The reliability of PVT was determined from the pilot test result with Cronbach's Alpha of 0.84 and 0.89 for proficiency in volume of cube and cuboid respectively.

Data Analysis

Paired-samples *t*-test was used to determine if there was a significant difference between the pre- and post-test mean score for the first, second and third cycles of CLR, respectively. The one-way ANOVA test was used to determine if there was a significant difference between the post-test mean score for the first, second and third CLR cycles. Both tests were conducted using the Statistical Package for the Social Sciences (SPSS) version 24.

RESULTS

Table 2 shows the mean and standard deviation of the pre- and post-test scores for the volume of cube. The difference in mean and standard deviation of pre- and post-test scores for the volume of cube in the first cycle (M = 2.42, SD = 0.97), second cycle (M = 5.66, SD = 0.98) and third cycle (M = 6.54, SD = 1.81) shows an increasing trend.

Table 2. Mean and standard deviation of pre- and post-test scores for volume of cube based on CLR cycle

CLR cycle	Test	Mean	*SD*
First cycle	Pre-test	2.79	0.94
(Group 3)	Post-test	5.21	1.91
Second cycle	Pre-test	2.68	0.70
(Group 1)	Post-test	8.34	1.68
Third cycle	Pre-test	2.77	1.04
(Group 2)	Post-test	9.31	2.85

Table 3 shows the mean and standard deviation of the pre- and post-test scores for the volume of cuboid. The difference in mean and standard deviation of pre- and post-test scores for the volume of cuboid in the first cycle (M = 1.00, SD = 0.66), second cycle (M = 3.18, SD = 0.88) and third cycle (M = 6.11, SD = 1.10) also shows an increasing trend.

Table 3. Mean and standard deviation of pre- and post-test scores for volume of cuboid based on CLR cycle

CLR cycle	Test	Mean	*SD*
First cycle	Pre-test	4.71	1.09
(Group one)	Post-test	5.71	1.75
Second cycle	Pre-test	4.97	1.11
(Group two)	Post-test	8.15	1.99
Third cycle	Pre-test	4.42	1.37
(Group three)	Post-test	10.53	2.47

Paired-Samples *t*-test

Table 4 shows the significant result of the paired-sample *t*-test for the volume of cube, $t = -6.74$, df = 37, $p < 0.05$ in the first cycle of CLR indicating that there was a significant difference between the pre- and post-test mean score for the first cycle of CLR.

Table 4. Paired-samples *t*-test for volume of cube in the first CLR cycle

Paired samples test									
		Paired differences					*t*	df	Sig. (2- tailed)
		Mean	SD	Std. error mean	95% confidence interval of the difference				
					Lower	Upper			
Pair	Pre-test –Post-test	–2.42	2.21	0.36	–3.15	–1.69	–6.74	37	0.00

Table 5 shows the significant result of the paired-sample *t*-test for the volume of cube, $t = -19.82$, df = 37, $p < 0.05$ in the second cycle of CLR indicating that there was a significant difference between the pre- and post-test mean score for the second cycle of CLR.

Table 5. Paired-samples *t*-test for volume of cube in the second CLR cycle

Paired samples test									
		Paired differences					*t*	df	Sig. (2- tailed)
		Mean	SD	Std. error mean	95% confidence interval of the difference				
					Lower	Upper			
Pair	Pre-test –Post-test	–5.66	1.76	0.29	–6.24	–5.08	–19.82	37	0.00

Table 6 shows the significant result of the paired-sample *t*-test for the volume of cube, $t = -22.10$, df = 38, $p < 0.05$ in the third cycle of CLR indicating that there was a significant difference between the pre- and post-test mean score for the third cycle of CLR.

Table 6. Paired-samples *t*-test for volume of cube in the third CLR cycle

Paired samples test									
		Paired differences					t	df	Sig. (2- tailed)
		Mean	SD	Std. error mean	95% confidence interval of the difference				
					Lower	Upper			
Pair	Pre-test –Post-test	–6.54	1.85	0.30	–7.14	–5.94	–22.10	38	0.00

Overall, the results of the significant paired-sample t-tests of the three CLR cycles for the volume of cube indicate that there was a significant difference between the pre- and post-test mean score for each CLR cycle with the post-test mean score higher than the pre-test mean score in every CLR cycle.

Table 7 shows the significant result of the paired-sample *t*-test for the volume of cuboid, $t = -3.15$, df = 37, $p < 0.05$ in the first cycle of CLR indicating that there was a significant difference between the pre- and post-test mean score for the first cycle of CLR.

Table 7. Paired-samples *t*-test for volume of cuboid in the first CLR cycle

Paired samples test									
		Paired differences					t	df	Sig. (2- tailed)
		Mean	SD	Std. error mean	95% confidence interval of the difference				
					Lower	Upper			
Pair	Pre-test –Post-test	–1.00	1.96	0.32	–1.64	–0.36	–3.15	37	0.00

Table 8 shows the significant result of the paired-sample *t*-test for the volume of cuboid, $t = -9.87$, df = 38, $p < 0.05$ in the second cycle of CLR indicating that there was a significant difference between the pre- and post-test mean score for the second cycle of CLR.

Table 8. Paired-samples *t*-test for volume of cuboid in the second CLR cycle

Paired samples test									
		Paired differences					t	df	Sig. (2- tailed)
		Mean	SD	Std. error mean	95% confidence interval of the difference				
					Lower	Upper			
Pair	Pre-test –Post-test	–3.18	2.01	0.32	–3.83	–2.53	–9.87	38	0.00

Table 9 shows the significant result of the paired-sample t-test for the volume of cuboid, $t = -20.76$, df = 37, $p < 0.05$ in the third cycle of CLR indicating that there was a significant difference between the pre- and post-test mean score for the third cycle of CLR.

Overall, the significant results of the paired-sample t-tests of the three CLR cycles for the volume of cuboids indicate that there was a significant difference between the pre- and post-test mean score for each CLR cycle with the post-test mean score higher than the pre-test mean score in every CLR cycle.

Table 9. Paired-samples t-test for volume of cuboid in the third CLR cycle

Paired samples test									
		Paired differences					t	df	Sig. (2- tailed)
		Mean	SD	Std. error mean	95% confidence interval of the difference				
					Lower	Upper			
Pair	Pre-test –Post-test	−6.11	1.81	0.29	−6.70	−5.51	−20.76	37	0.00

One-Way Analysis of Variance (ANOVA) Test

The one-way ANOVA test was used to determine if there was a significant difference between the post-test mean score for the first, second and third CLR cycles of the volume of cube and cuboid. Table 10 shows the non-significant result of the Shapiro-Wilk normality test for the post-test scores of the first, second and third CLR cyles for the volume of cube, indicating that they were normally distributed in the population with $p > 0.05$.

Table 10. Shapiro-Wilk normality test for first, second and third CLR cycles of volume of cube

Test of normality				
	1 = First cycle 2 = Second cycle 3 = Third cycle	Shapiro-Wilk		
		Statistic	df	Sig.
Post-test	First cycle (G3)	0.95	38	0.07
	Second cycle (G1)	0.95	38	0.07
	Third cycle (G2)	0.95	39	0.08

Notes; a. Lilliefors significance correction

Table 11 shows the non-significant result of the Levene's test for the post-test scores of the first, second and third CLR cyles for the volume of cube, indicating that they have the same variance in the population with $p > 0.05$.

Table 11. Levene's test for first, second and third CLR cycles of volume of cube

Test of homogeneity of variances			
Post-test			
Levene statistic	df1	df2	Sig.
0.60	2	112	0.55

Table 12 shows the significant result of the one-way ANOVA test for the volume of cube, F (2,112) = 53.32, $p < 0.05$, indicating that there was a significant difference between the post-test mean score of the first, second and third CLR cycles for the volume of cube.

Table 12. One-way ANOVA test for first, second and third CLR cycles of volume of cube

ANOVA					
Post-test					
	Sum of squares	df	Mean square	F	Sig.
Between groups	351.49	2	175.74	53.32	0.00
Within groups	369.18	112	3.30		
Total	720.66	114			

The Tukey Post Hoc test in Table 13 shows that the first CLR cycle post-test mean score differed significantly from the second and third CLR cycle post-test mean score and the second CLR cycle post-test mean score differed significantly from the third CLR cycle post-test mean score at the significance level of 0.05.

Table 13. Tukey Post Hoc test for first, second and third cycles of CLR for volume of cube

Multiple comparison						
Post-test Tukey HSD						
(I) 1 = First cycle 2 = Second cycle 3 = Third cycle	(J) 1 = First cycle 2 = Second cycle 3 = Third cycle	Mean difference (I–J)	Std. error	Sig.	95% confidence interval	
					Lower bound	Upper bound
First cycle (G3)	Second cycle (G1)	–3.13*	0.42	0.00	–4.12	–2.14
	Third cycle (G2)	–4.10*	0.41	0.00	–5.08	–3.11
Second cycle (G1)	First cycle (G3)	3.13*	0.42	0.00	2.14	4.12
	Third cycle (G2)	–0.97	0.41	0.06	–1.95	0.02
Third cycle (G2)	First Cycle (G3)	4.10*	0.41	0.00	3.11	5.08
	Second cycle (G1)	0.97	0.41	0.06	-0.02	1.95

Notes: *. The mean difference is significant at the 0.05 level.

Table 14 shows the non-significant result of the Shapiro-Wilk Normality Test for the post-test scores of the first, second and third CLR cyles for the volume of cuboid, indicating that they were normally distributed in the population with $p > 0.05$.

Table 14. Shapiro-Wilk normality test for first, second and third CLR cycles of volume of cuboid

Test of normality				
	1 = First cycle 2 = Second cycle 3 = Third cycle	Shapiro-Wilk		
		Statistic	df	Sig.
Post-test	First cycle (G1)	0.95	38	0.14
	Second cycle (G2)	0.95	39	0.11
	Third cycle (G3)	0.94	38	0.06

Notes: a. Lilliefors significance correction

Table 15 shows the non-significant result of the Levene's test for the post-test scores of the first, second and third CLR cyles for the volume of cuboid, indicating that they have the same variance in the population with $p > 0.05$.

Table 15. Levene's test for first, second and third CLR cycles of volume of cuboid

Test of homogeneity of variances			
Post-test			
Levene statistic	df1	df2	Sig.
1.58	2	112	0.21

Table 16 shows the significant result of the one-way ANOVA test for the volume of cuboid, F (2,112) = 71.16, $p < 0.05$, indicating that there was a significant difference between the post-test mean score of the first, second and third CLR cycles for the volume of cuboid.

Table 16. One-way ANOVA test for first, second and third CLR cycles of volume of cuboid

ANOVA					
Post-test					
	Sum of squares	df	Mean square	F	Sig.
Between groups	440.68	2	220.34	71.66	0.00
Within groups	344.37	112	3.08		
Total	785.04	114			

The Tukey Post Hoc test in Table 17 shows that the first CLR cycle post-test mean score differed significantly from the second and third CLR cycle post-test mean score and the second CLR cycle post-test mean score differed significantly from the third CLR cycle post-test mean score at the significance level of 0.05.

Table 17. Tukey Post Hoc test for first, second and third cycles of CLR for volume of cuboid

Multiple comparison						
Post-test Tukey HSD						
(I) 1 = First cycle 2 = Second cycle 3 = Third cycle	(J) 1 = First cycle 2 = Second cycle 3 = Third cycle	Mean difference (I–J)	Std. error	Sig.	95% confidence interval	
					Lower bound	Upper bound
First cycle (G1)	Second cycle (G1)	–2.44*	0.40	0.00	–3.39	–1.49
	Third cycle (G2)	–4.82*	0.40	0.00	–5.77	–3.86
Second cycle (G2)	First cycle (G1)	2.44*	0.40	0.00	1.49	3.39
	Third cycle (G3)	–2.37*	0.40	0.00	–3.32	–1.42
Third cycle (G3)	First cycle (G1)	4.82*	0.40	0.00	3.86	5.77
	Second cycle (G2)	2.37*	0.40	0.00	1.42	3.32

Notes: *. The mean difference is significant at the 0.05 level

A comparison of the mean differences showed that there was an increase between the first cycle of the CLR, the second cycle of the CLR and the third cycle of the CLR for the volume of cube and cuboid. The mean difference between pre- and post-test for volume of cube in the first cycle (M = 2.42, SD = 0.97), second cycle (M = 5.66, SD = 0.98) and third cycle (M = 6.54, SD = 1.81) showed a difference between 3.42 to 4.12. Group 2 obtained the highest mean difference because Group 2 learned the volume of cube in the third cycle of CLR while Group 3 obtained the lowest mean difference because Group 3 learned the volume of cube in the first cycle of CLR.

Likewise, a comparison of the mean difference between the pre- and post-test scores for the proficiency in volume of cuboid showed that Group 3 obtained the highest mean difference (M = 6.11, SD = 1.10) because Group 3 learned the volume of cuboid in the third cycle of the CLR while Group 1 obtained the lowest mean difference (M = 1.00, SD = 0.66) because Group 1 learned the volume of cuboid in the first cycle of the CLR. This was because the group that was in the third cycle of the CLR had used the lesson plan that had been revised three times starting from the first cycle of the CLR. The results were also significant with the first objective of determining whether there was a mean difference between pre- and post-test mean score for the first cycle of CLR, the second cycle of CLR and the third cycle of CLR.

DISCUSSION

The results of the significant paired-sample *t*-tests of the three CLR cycles for the volume of cube of cuboid revealed that there was a significant difference between the pre- and post-test mean scores for each CLR cycle with the post-test mean score higher than the pre-test mean score in every CLR cycle.

This might be attributed to the fact that the changes in each CLR cycle were based on the observations in the classrooms, discussions between the members of the CLR group before, during and after the lesson plans were carried out in the classrooms as well as the suggestions from the external observers. When changes were made, various aspects were considered especially involving the pupils' responses in the classrooms during the activities, teaching methods and the constraints that need to be overcome when the lesson plans were implemented. More importantly, the fourth step was the actual teaching in the classroom along with discussion based on its implementation in the classroom. Knowledgeable observers needed to be present in each session of the CLR cycle to ensure that the learning objectives were achieved. The final step which was the sharing of results together in which the final findings were presented based on the results of the PVT and the observations by the CLR group members. It is worthy to note that the six steps found in the CLR were repeated in each cycle with the last cycle being the best lesson plan for the CPA approach and can be used with CLR team members. These six CLR steps that incorporated the CPA approach are important processes that needed to be implemented correctly to improve year four pupils 'proficiency in the volume of cube and cuboid in this study.

These results were further supported by the results of the one-way ANOVA of the first, second and third cycles of CLR for proficiency in volume of cubes and cuboid which indicated that there was a significant difference in the proficiency in volume of cube and cuboids among the three cycles of CLR, respectively. In addition, the Tukey Post Hoc tests indicated that there was a significant difference in the proficiency in the volume of cube and cuboid between the first and the second cycles, the first and the third cycles, and the second and the third cycles of CLR as well. The results revealed that the lesson plan for the third cycle of the CLR produced the highest post-test mean score for proficiency in the volume of cube and cuboid, respectively.

The results obtained using the paired-sample t test and one-way ANOVA also supported the results of previous studies (Takahashi & McDougal, 2016; 2018; Watanabe et al., 2019) which stated that the effect of a change implemented in a CLR step would be demonstrated once it was completed. The results of the study also indicated that there are some similarities in the CPA approach with the results of previous studies. For example, Isip (2018) found that there was a significant difference in the algebra achievement between the CPA approach and conventional approach among college students, favouring the CPA approach. Salingay and Tan (2018) also found that the CPA approach had a positive effect on students' attitude and performance in mathematics. Putri et al. (2017) as well as Putri (2019) showed that there was a positive impact of the CPA approach on the elementary school students' spatial sense ability. In addition, Putri et al. (2018) as well as Putri et al. (2020) found that the CPA approach could improve the elementary school students' mathematical connection and mathematical reasoning abilities, respectively. Further, Purwadi et al. (2019) revealed that the CPA approach could enhance the students' mathematical conceptual understanding and mathematical representation of fractions. Moreover, Yuliyanto, Putri, et al. (2019) as well as Yuliyanto, Turmudi, et al. (2019) found that the CPA approach could enhance the students' learning of mathematics and there was an interaction effect of the CPA approach and self-efficacy on students' learning of mathematics, respectively. The results of the study also indicated that there is a similarity between the CPA approach with CLR and the result of previous study. Salimi et al. (2020) showed that the the CPA approach with CLR could improve students' learning of geometry.

In this study, the CPA approach with CLR helped improve the pupils' proficiency in volume of cube and cuboid. The CPA approach with CLR is not a quick method of learning volume of cube and cuboid. However, it was used in this study to improve year four pupils' understanding of the volume of cube and cuboid. The CPA approach with CLR was also not used to get answers quickly but to gradually help pupils use concrete materials to understand the volume of cube and cuboid better.

Besides, the five components of the PVT assessed the pupil's overall proficiency in the volume of cube and cuboid. For example, the conceptual understanding strand assessed pupils' understanding of the volume of cube and cuboid while the procedural fluency strand assessed pupils' method of answering a given question such as whether the strategy selection was correct or incorrect (strategic competence component). If a pupil chose the wrong strategy, then the teacher could identify that the pupil committed this mistake in the strategic competence strand and follow-up remedial teaching could be taken by the teacher.

PEDAGOGICAL IMPLICATIONS

Based on the results of the study, the CPA approach with CLR had a significant effect on Year Four pupils' proficiency in volume of cube and cuboid. These results have important pedagogical implications for primary school mathematics teachers in National Schools. In the CPA approach with CLR, teachers should begin by setting the overall teaching theme, reviewing the lesson contents, setting the lesson plan objectives, designing the lesson plans based on the CPA approach, reviewing the lesson plans by external observer, live teaching and learning in the classroom, discussion of the collected data and implications, and lastly, presentation and sharing of the results. These components of the CPA approach with CLR are essential in ensuring that the main objectives are achieved when the CPA approach with CLR is carried out in enhancing the primary school pupils' proficiency in volume of cube and cuboid.

In addition, during the design of the lesson plans based on the CPA approach in the CLR cycle, teachers should apply Bruner's (1966) three modes of representation in the teaching and learning of mathematics, namely enactive, iconic, and symbolic representations. Based on Bruner's (1966) three modes of representation, teachers should note that the CPA approach has been correspondingly represented by the concrete step in enactive representation, pictorial step in iconic representation and abstract step in symbolic representation. The concrete step is an important step for teachers to make the learning of volume of cube and cuboid meaningful to the primary school pupils. Learning in the concrete step is essential for strengthening the pupils'understanding of the volume of cube and cuboid. This is because learning with concrete materials in the concrete step provides the pupils with the opportunity to obtain important information and increases the likelihood of remembering the computational steps in solving the problems involving the volume of cube and cuboid later on. Further, the use of concrete materials increases the percentage of pupils' ability to remember the procedures in the problem-solving process. In the subsequent step, teachers should note that the concrete materials used and the problems solved in the concrete step are used again in the pictorial step. This is because the iconic representation in the pictorial step acts as a bridge between problem-solving using concrete materials and problem-solving using numbers (Flores, 2018). In the pictorial step, teachers should remember that the most important thing is the translation process from the concrete form to the pictorial form that the pupils have to perform successfully in order to progress to the abstract step of the CPA approach. This final step is essential in which the pupils try to solve the given problems involving volume of cube and cuboid without using any concrete materials or pictures. Teachers should take note that the abstract step provides the pupils with the opportunity to solve the problems using numbers and mathematical operations or equations without using concrete materials or pictures (Flores, 2018; Flores & Hinton, 2019; Flores et al., 2019; Hinton & Flores, 2019).

More importantly, the results of the study revealed that the lesson plans for the third cycle of the CLR produced the highest post-test mean score for proficiency in the volume of cube and cuboid, respectively. These results imply that the lesson plans for the third cycle of the CLR can be readily used by the Year Four primary school mathematics teachers in National Schools to teach the topic of volume of cube and cuboid for enhancing the Year Four pupils' proficiency in volume of cube and cuboid, respectively. The teachers can also carry out the CPA approach with CLR in their own school to further improve the lesson plans and share with teachers from other schools to enhance Year Four pupils' proficiency in volume of cube and cuboid.

THEORETICAL CONTRIBUTION OF THE STUDY

The development of CPA especially in combining it with CLR is something that is necessary in increasing the effectiveness of each CPA step. When each CPA step is examined by reviewing the previous class and developed based on the CLR steps that consist of a live research lesson and discussion, it can certainly look back at the reflection in the previous class. Through live research lesson and discussion, the CPA steps that are seen to have less effect will be revised to ensure that the CPA approach can be fully practiced. The importance of external observers who give relevant suggestions also allows CPA to be further improved. Although in general, the theory introduced by Bruner is something that has been practiced for a long time, the development in enhancing it has been improved by the CLR process.

Further, recommendations for the use of up-to-date and diverse tools in each step can also improve the CPA approach in each of the steps. CPA can also be said to be still relevant with many studies that used it to have a positive impact on pupils' proficiency in volume and other mathematical topics as well.

SUGGESTIONS FOR FUTURE STUDIES

There is a difference between the final results involving pupils of different genders even though the study did not focus on male and female pupils. Recommendations to study the differences in proficiency levels between male and female pupils in other mathematical topics can be carried out. Retention test and interview after two weeks of intervention study can be done to ensure whether there is still a reinforcement of the concept in the volume of cubes and cuboids. The use of simulation with the help of computer software through the CPA approach especially in the pictorial step can also be implemented in the future. Pupils can start by drawing cubes and cuboids using the software in the pictorial step before making calculations for volume in the abstract step.

CONCLUSION

In conclusion, the process of understanding concepts from concrete to pictorial to abstract is something that is very difficult to acquire in the classroom. The ability of a teacher in realising the concept is considered very difficult. Even so, teachers need to make connections between the concrete material and also the answers that have been given by pupils in the abstract. Pupils at the beginning may fail in understanding a concept if they do not understand the basics but continue to use formulas in solving mathematical problems. Some teachers assume that the process of pupils recognising a concept such as volume of cube and cuboid does not require a concrete understanding but only using a simple formula of length multiplied by width multiplied by height to obtain the answer. But for pupils, concrete objects are important for them to understand new concepts before gradually proceeding to the pictorial and abstract representation of the concepts. This is the real purpose of the CPA approach with CLR in teaching and learning of volume of cube and cuboid to enhance year four pupils' proficiency in volume of cube and cuboid in this study.

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