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Vanuatu's Typical Approach of Mathematics vs the TUAM Approach of Mathematics

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Abstract

There are multiple factors contributing to the low level of mathematics in basic education in the Republic of Vanuatu. Results through the Vanuatu Standard Test of Achievement (VANSTA) in 2017 and 2019 unveiled that there were gaps in the performance of mathematics which cause the overall achievement to stagnant which were below the expected minimum standard (Curriculum Development Unit, 2020). This study investigated the current situation of the teaching mathematics approach in the country recognised as the ‘I Do-We Do-You Do’ teaching model. In comparison, the study also examined the influence of the ‘Try-Understand-Apply-Master’ (TUAM) discovery learning process on students in Vanuatu. The study compared these two teaching approaches through pre and post-test interventions among the control and experimental group of two grade five classes. The findings of the study discovered a possibility that the TUAM discovery learning process could be effective in improving the mathematics level in the basic education in the Republic of Vanuatu.

Keywords: I do–We do–You do, Try-Understand-Apply-Master (TUAM).

Introduction

In this 21st century, students’ learning should be the core of learning and teaching processes in mathematics education. Teachers in the 21st century have to concern that students possess potential, and they require the suitable opportunity to develop. Thus, it is necessary to concentrate on the approaches of implementing a mathematics curriculum. One possibility is implemented for teachers to move away from procedural memorisation but move toward mathematical thinking processes, mathematical reasoning, and mathematical problem-solving skills which provides the best opportunities for students to explore and investigate their mathematical potentials (Cai & Howson, 2013). Concerning the nature of the current approach of teaching as an instructional strategy, through the ‘I Do-We Do-You Do’ strategy, learners are able to memorise mathematical ideas to acquire new knowledge instead of investigating the ideas to construct the new knowledge themselves. Hence, the TUAM strategy was employed for this comparison study as it is evident to be among teaching approaches which enhance stimulating children’s mathematical thinking processes through a discovery learning process. Takahashi (2006) elaborated that allowing students to learn through the discovery process is a method of encouraging them to utilise their minds in formulating new knowledge rather than depending on the teacher’s ideas in solving problems.

Cai and Howson (2013) asserted that the abilities to think independently, and critically, to learn, to be creative, and to learn how to learn, are the best qualities that teachers should achieve in encouraging their students to develop. Jaleniauskienė and Jucevičienė (2018) initially explained that in this 21st century, learners ought to be prepared with an extensive set of abilities rather than procuring a limit occupation-specific information. Considering such characteristics, the nature of the TUAM strategy corroborating the awareness of scrutinizing its' effectiveness in the Vanuatu context in comparison to the typical 'I Do-We Do-You Do' strategy which elevating memorisation through a typical lecturing lesson.

Literature review

The 'I Do-We Do-You Do' Approach

Mathematics is taught and learned through different approaches. In Vanuatu, mathematics is frequently taught by employing the 'I Do-We Do-You Do' model of teaching. According to Vanuatu's latest intended curriculum, this approach of teaching is defined as:

> "**I Do**- The teacher explains, models, and demonstrates the topic which will be learned and the way to think during this step. The student's duty is to pay attention and listen carefully to the teacher. **We Do** – Students work with the teacher as more examples are illustrated. It provides the students further opportunity to be encouraged until they demonstrate the skills and knowledge necessary to move to the final, independent step. **You Do** – It is the final step of the model in which students possess the opportunity to demonstrate mastery in the skill or knowledge by performing independently" (Vanuatu Ministry of Education and Training, 2018).

The approach reflects Vanuatu's traditional ideology of education. It is depicted from the country's cultural and traditional method of learning: the conviction that learning occurs by observing and copying from peers, parents, and adults or elderly people (Sanga, Niroa, Matai, & Crowel, 2004). It is vigorously believed that children learn best when they observe and copy what others conduct. The approach is considered to some extent as a scaffolding process of learning. In the first step, the 'I Do' stage, teachers in Vanuatu employed examples and demonstrations to navigate students' minds in learning new mathematical material. Based on Vygotsky's theory of constructivism, they considered providing examples during a lesson as a method of manipulating students to overcome problems on their own. Concerning that when instructions on the way to solve a problem is not displayed before allowing students to solve the problem themselves provides them with opportunities to entertain their exploratory hypothesis at the expense of encountering initial failures (Sinha et al., 2020).

The Try-Understand-Apply-Mastered (TUAM) Approach

Japan on the other hand is teaching mathematics through the TUAM discovery learning process in reverse of the 'I Do-We Do-You Do' teaching model. This problem-solving strategy is elaborated by Takahashi (2006) with the initials T-try, U-understand, A-apply, and M-master. Takahashi (2006) explained that the first step in this teaching approach which he called as Try with the initial 'T' is when a problem is portrayed and the first attempt is provided for students to explore and discover the solutions to the problem. The next step in this approach is Understand with the initial 'U'. In this stage, the students are guided through discussion to compare different solutions to the problem. After comparing the solutions, it is implemented the Apply stage with the initial 'A'. Students are provided other similar problems with the opportunity to implement the method they have confirmed during discussion. When students apply the skills that they attain from the first and second step, in this stage, they also master the skills and it is where the initial ‘M’ for Master occurs as the final step in the process.

Mayer (2004) asserted that this concept of the discovery learning process is well recognized as the constructivist approach of learning whereby learners are demanded to be active participants who identify to construct reasonable and structured knowledge themselves under the teacher’s guidance. Furthermore, Bakker (2018) did not intend to limit the term discovery to the action of investigating something unknown to mankind but rather was willing to incorporated all forms of acquiring knowledge for oneself by the utilisation of one’s mind. This approach provides the best opportunity for students to construct new knowledge by employing their minds. It is a process of training one’s mind to think critically and enhance speed, accuracy, and confidence in mathematical concepts. Trninic (2018) further demonstrated this approach as the notion of student-as-explorer. He emphasised that through this strategy, knowledge is obtained by the student rather than the teacher. He also highlighted that as an explorer, one is an active organiser of experiences who produces firm understandings by frequently constructing them anew. He elaborated more that students begin constructing knowledge of arithmetic principles through the discovery process. Ojose (2008) corroborated the previous idea that through discovery learning, children are able to enhance mathematical reasoning skills when there are investigating ideas.

This approach of teaching allows students to work freely in a learning environment (Mayer, 2004). The students are not restricted to construct learning processes. Developing mathematical reasoning skills through investigation is moreover encouraged for them (Ojose, 2008). The opportunities they possess here enhance their mathematical understanding when they extract relevant information from a problem statement (Ojose, 2008). Unlike the ‘I Do-We Do-You Do’ approach, the TUAM strategy corroborates the scaffolding theory by Vygotsky in its rightful manner. It exposed scaffolding as temporary instructional support which elevates cognitive reasoning (Byun, Lee, & Cerreto, 2013). Table 1 summarises the characteristics of the two teaching approaches based on the above discussion.

Table 1
Summary of Teaching Approaches

Characteristics	TUAM	I Do-We Do-You Do
Student Engagement	• Students are challenged and encouraged by the teacher to think deeply and explore variety of approaches to a solution. • Formal and informal discussions are structured and facilitated based on the learners’ ideas. • Teacher integrates the application of inquiry skills into learning experiences. • Inquiry skills are applied and refined collaboratively and individually by learners with accountability.	• Students are challenged and encouraged by the teacher through modelling of problem solutions. • Formal and informal discussions are structured through examples and demonstrations. • Examples are employed by students to implement and refine the inquiry skills.
Instructional Relevance	• The student communicates knowledge and understanding through interactions. • Complex and authentic problems are addressed by students collaboratively. • The teacher provides prompt feedback when students are attempting problems.	• Teacher turns classes into PowerPoint/lecture shows. • The teacher instructs and demonstrates on how to solve problems to students. • The teacher provides prompt feedback during the discussion

Characteristics	TUAM	I Do-We Do-You Do
Knowledge of Content	• Only essential support for students who are struggling with mathematical content is provided by the teacher. • The student explores content knowledge collaboratively and individually with accountability.	• Students who are struggling with mathematical content receives solutions from the teacher. The teacher demonstrates the understanding and in-dept knowledge of mathematics to students.
Learning Climate	• As learners, student accepts that their learning is their responsibility. • Active participation and authentic engagement are comprehended by students. • A sense of accomplishment and confidence is displayed by students. • Educational risk in learning is acknowledged by students. • Learning opportunities encourages students to participate and accept that learning is a process and mistake is a natural aspect of it. • Students' work is valued, appreciated and employed as a learning tool in the learning environment.	• Students depend on the teacher for learning. • Student avoids taking educational risks in learning. • Learning environment lacks the opportunity to allow students participating in contested activities and accepting that learning is a process and mistake is a natural aspect of it. • Teacher's work is valued, appreciated and employed as learning tool in the learning environment.

The objective of this study is to investigate the effectiveness of the TUAM discovery learning process in elementary schools in Vanuatu in comparison to the typical 'I Do-We Do-You Do' teaching approach. Specifically, the study concerns on how the approach to solve mathematical problems changes students' thinking processes. The investigation addressed the following research questions;

1. What is the current situation of the 'I Do-We Do-You Do' teaching model in elementary mathematical education in Vanuatu?
2. What influence does the TUAM discovery learning process possess on students?
3. Can the TUAM discovery learning process influence students' learning of mathematical concepts in elementary schools in Vanuatu?

Methods

Data Collection

The sample groups selected for the study were two grade 5 classes of which one grade was treated as an experimental group and the other grade as the control group. Even though the attendance was not consistent throughout the interventions, the enrolment of each grade ranged from 35 to 52 each day. The grades and the schools involved were randomly selected. There were five lessons of intervention in each grade similarly in both groups. All lessons were in accordance with multiplication which was the topic to be delivered during this period of interventions based on the curriculum document for this particular grade. The specific topics encompassed were new topics for students at this level, nevertheless, the concept of multiplication had been explained in their previous grades. Thus, the pre-test results obtained reflected students' prior knowledge of the multiplication concept studied in their previous grades, whereas the post-test mirrored students' performances during interventions. Table 2 demonstrates the topics included in these five lessons.

Table 2
Topics Covered during Interventions

#	Topics
1	Multiplication – Factors
2	Multiplication – Commutativity & Associativity
3	Multiplication – With and Without Trading
4	Multiplication – Converting Addition into Multiplication and vice versa
5	Multiplication – As the Inverse of Division

The interventions encompass pre-and post-performance tests, as well as interviews. This paper provides the findings through pre-and post-performance tests. All questions displayed in the test were merely word problems which required students to perform mathematical operations in solving each problem. Students' responses to the questions were evaluated as correct or incorrect responses, nevertheless, the responses were also analysed to evaluate students' thinking processes in each question. Table 3 illustrates the sample of the pre-and post-test administered for interventions.

Table 3
Sample Questions

	Pre and Post-Tests
1	Mum is earning 80 vt in 8 hours. How much is she earning in one hour?
2	There are 8 boxes of pencils on the table with 7 pencils in each box. How many pencils altogether are on the table?
3	There are 5 blue boxes of reading books on the teacher's table. In the blue box, there are 4 red small boxes with 6 reading books in each box. How many reading books are there altogether?
4	There are 421 ropes of fish. Each rope has 4 fish in it. How many fish are there altogether?
5	On a farm, Jim planted 465 rows of watermelon seeds. In one row, he planted 32 seeds. How many seeds altogether did Jim plant?
6	These students received the same number of awards at the end of the year. Adelpha 4 received awards, Jaylin 4 awards, Jeremy 4 awards, and Hendry 4 awards. How many awards altogether were awarded to these students?
7	A rope is 72 meters long. If you cut it equally into 8-meter pieces, how many pieces of rope will you get?

The interventions incorporated five lessons in each class of both groups. The same lessons applied in the experimental group were also utilised in the control group. However, the lesson structures were different. In the experimental group, the lessons were structured in accordance with the TUAM approach. Moreover, in the control group, the lessons were structured based on the 'I Do-We Do-You Do' approach. Figure 1 displays the summary of the lesson outlines.

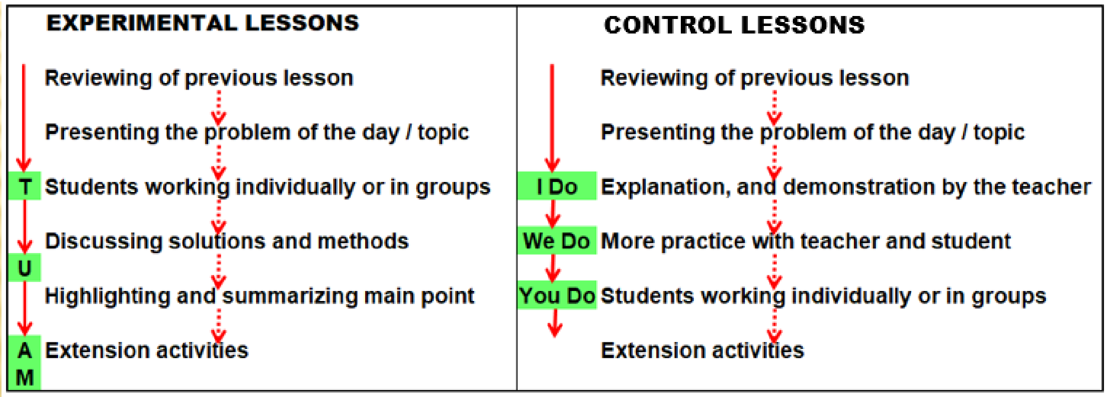

Figure 1. The summary outline of the lessons

Results

The primary data for this research paper was collected through pre-and post-performance tests. Observations of students' responses throughout the treatment were also investigated to identify the status of the current approach and the influence of the experimented approach. The data were evaluated based on the t-test normal distribution model utilising excel and r-software. The t-test model under normality distribution was selected for this analysis as the study compared two dependent variables represented by a control group and an experimental group. It was necessary to administer this model to examine if the sample size of the study was normally distributed or not. The t-test under normality was employed to assess the null and the alternative hypothesis defined for the study. Initially, the null hypothesis of the study was understood as 'the TUAM strategy will impact more positively on students' achievement than the typical 'I Do-We Do-You Do' strategy. On the other hand, the alternative hypothesis was elaborated as the control group performed better than the experimental group. The t-test under normality distribution was administered to discover if the null hypothesis can be rejected. The results of the testing are presented through tables, graphs, and images.

Generally, the mean results according to Figure 2 discovered that students of both groups possess naturally enhanced even though the experimental group performed much higher. Noticing that the mean result obtained increases from 1.073 to 1.694 in the experimental group, whereas the mean result increases a little from 0.861 to 1.029 in the control group. Such is an indication that both strategies are able to positively influence students' mathematical thinking processes. Particularly, it indicates that the current teaching approach can positively affect students' performances regardless of the limitation it owns. However, the difference in achievement deeply discovered that the TUAM strategy is much more effective than the current strategy regarding the trend in improvement. Understanding that the difference in outcome in the pre-test was 0.21 presenting the experimental group which accomplished higher than the control group. The results after the treatment revealed that the difference in outcome during the post-test accelerated to 0.67 which indicates that the experimental group still performed much higher than the control group. When analysing these results with respect to the counterfactual trend, the difference-in-difference of the outcome resulted to be 0.45 which illustrates that the experimental group performed higher than the control group with a big difference that caused the accelerated results. These results revealed that there is a more positive impact on the approach of teaching in the experimental group than that of the control group.

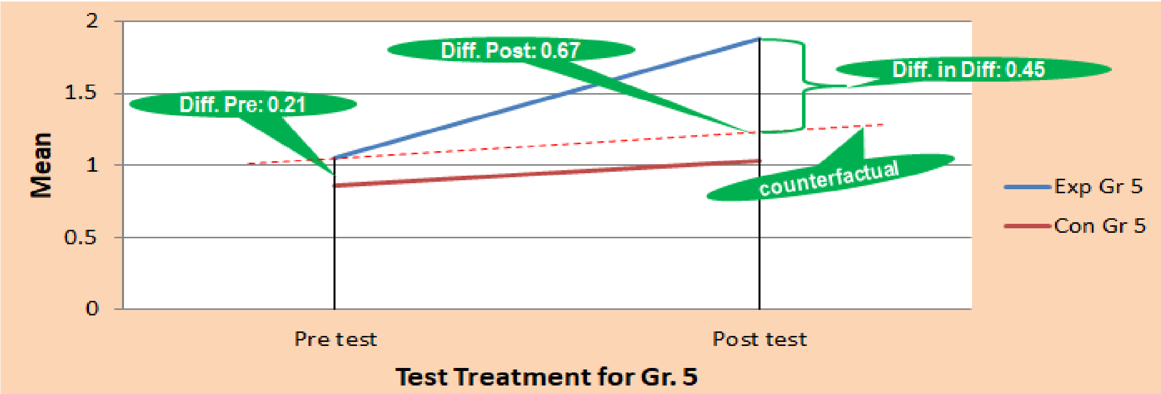

Figure 2. The difference-in-difference in the outcome

The results in Table 4 further highlighted that there was no significant difference in students' performances before the treatment, but changes occurred which presented the improvement in students' performances after the interventions. Understanding that in the pre-test, the p-value of 0.338>0.05 displays no statistically significant difference. It indicates that the performances in both groups were the same even though students from the experimental group accomplished much higher results. In the post-test, the p-value of 0.036<0.05 presents that there was a statistically significant difference. Changes in performance arose at different level as a result of the interventions. It indicates also that in the experimental group, the skewness of 1.157 was gained from the pre-test, and 0.88 was attained from the post-test, and the kurtosis of 0.752 was also acquired from the pre-test and -0.107 in the post-test. In the control group, the skewness of 0.032 was obtained from the pre-test and 1.033 was attained from the post-test, and the kurtosis of -0.069 was also acquired from the pre-test and 0.049 in the post-test. These sample characteristics signified that the test scores accomplished were approximately normally distributed. Generally, the findings unveiled that there was no significant difference in students' performances before the treatment, but after the treatment, there was a statistically significant difference. There was a more positive impact of teaching in the experimental group than that of the control group. However, the approach of intervention in the control group was also accepted to gain a positive impact on students' achievements as uncovered through these results.

Table 4

Basic Statistics Results

Pre-Performance Achievement									
	n	p-value	Mean	Standard Deviation	Skewness	Kurtosis	Variance	Min.	Max.
Exp. Gr. Pre-Test	43	0.338	1.073	1.27	1.157	0.752	1.62	0	5
Cont. Gr. Pre-Test	36		0.861	0.59	0.032	-0.069	0.352	0	2

Post-Performance Achievement									
	n	p-value	Mean	Standard Deviation	Skewness	Kurtosis	Variance	Min.	Max.
Exp. Gr. Post-Test	40	0.036	1.694	1.43	0.885	-0.107	2.05	0	7
Cont. Gr. Post-Test	34		1.029	1.17	1.033	0.049	1.363	0	4

Analysis of Students' Thinking Process

The questions that administered during the pre-and post-treatment for investigation in both groups were all about word problems. There were seven questions as illustrated in Table 3 above. The same questions employed in the pre-test were also applied in the post-test similarly in both groups. Table 5 displays the summary of individual questions. Generally, the result here revealed that there was an improvement in students' achievements for all questions in both groups. These results emphasised that the current teaching approach possessed positively impacted students' performances in such situations. However, when observing the difference-in-difference of these questions, the results unveiled that a significant difference in Q.3 and Q.7 whereby the experimental group performed better than the control group with a higher difference-in-difference in the outcome.

In Q.3 the difference-in-difference in outcome in the experimental group was 31.4% indicating that the experimental group performed better than the control group. Moreover, in Q.7 the difference-in-difference, the outcome was 44.7% which signifies that the experimental group still performed better than the control group. Table 5 displays the summary of these results. This finding implies that although both teaching approaches own a positive impact on students' mathematical performances, the experimental group possesses a more positive impact on students' thinking processes than that of the control group. Figure 4 further demonstrates students' thinking process in these questions.

Table 5
Summary of correct responses of individual questions by percentages (%)

#	Experimental Group			Control Group			Diff-in-diff
	Pre-test	Post-Test	Difference	Pre-test	Post-Test	Difference	
1	16.7	35	18.3	11.1	8.8	2.3	16
2	31	40	9	2.8	29.4	26.6	17.6
3	4.8	45	40.2	0	8.8	8.8	31.4
4	19	32.5	13.5	0	17.6	17.6	4.2
5	0	2.5	2.5	0	0	0	2.5
6	38.1	32.5	5.6	20	26.5	6.5	0.9
7	2.4	50	47.6	0	2.9	2.9	44.7

Based on the results in Table 5, below is a discussion of students' responses to Q.3 and Q.7 for both groups. Figure 3 presents the responses to Q.3 of student A from the control group and student B from the experimental group. The responses were received from the same student before and after treatment. This question was depicted from the topic

'Multiplication – Commutativity and Associativity'. It was displayed as: 'There are 5 blue boxes of reading books on the teacher's table. In the blue box, there are 4 red small boxes with 6 reading books in each. How many reading books are there altogether?' The question aimed to examine students' understanding of multiplication as Commutativity and Associativity. According to Figure 3, the pre-test result displayed a limited understanding of the mathematical content from both students before the intervention as usual. Even though the responses before the intervention were incorrect, it might be indicated that both students interpreted the situation as a multiplication problem by considering the operation they employed. It is also an implication of students' previous knowledge of multiplication in their previous grades. Initially, in previous grades, the 'I Do-We Do-You Do' strategy became a common teaching practice for mathematics course. Hence, there is a possibility to state that the student's previous knowledge reflected the typical common teaching practice at some point. However, during the post-test, both students performed better but at different levels of understanding, identifying that both students employed a diagram in demonstrating their thinking process by adding the number of books in the small boxes first and then adding the results to obtain the number of books in the big box which was correctly 120. They illustrated the meaning of multiplication as a repeated addition. However, Student B from the Experimental group moved further to express his understanding of multiplication as commutativity and associativity by switching the order of multiplier and multiplicand several times and still obtaining the same result. It indicates that the TUAM strategy was able to impact the child's mathematical thinking processes compared to the 'I Do-We Do-You Do' strategy. However, the current teaching approach was accepted to possess some positive impact on students' thinking processes even though the TUAM strategy initially owns a more positive impact, identifying that student A was able to perform the operation by employing a diagram to solve the problem. It can be implied that the typical 'I Do-We Do-You Do' strategy can cause changes in students' mathematical thinking processes to some extent.

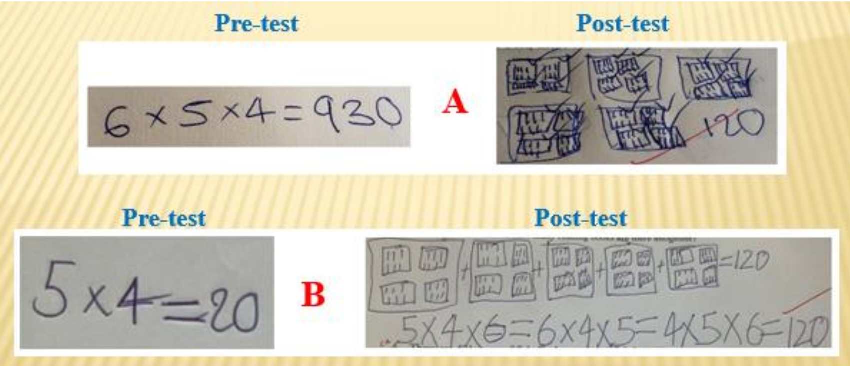

*Figure 3. S*tudents' way of thinking – Q.3 – Students A and B

Figure 4 demonstrates students' responses to Q.7 from both groups. The responses were acquired from the same student before and after treatment. This question was extracted from the topic 'Multiplication – the inverse of division'. It was illustrated as; 'A rope is 72 meters long. If you cut it equally into 8-meter pieces, how many pieces of rope will you get?' The rationale behind this question was to investigate students' understanding of multiplication as the inverse of division. Based on Figure 4, the pre-test results emphasised both students' limited understanding of this concept before treatment, understanding that student C from the control group understood the problem situation as an addition considering the operations which he preferred to apply. Student D from the experimental group on the other hand comprehended the problem as subtraction as he preferred to conduct the operation as subtraction. These results manifest students' understanding level of the situations in the problem before the treatment. After the interventions, Figure 4 demonstrated that students performed better but with different levels of understanding. Firstly, the results in Figure 4 revealed that both students interpreted the problem as a multiplication problem. They both assumed that multiplying the length of each piece of rope by the unknown number of pieces would be equal to the length of the long rope. As a result, even though the integer 9 was not displayed in the story problem, by multiplying the length of each piece of rope by the unknown number of pieces, the result would be equal to the length of the long rope that was 72 meters. After interpreting the problem situation, student C answered the question based on his memorisation of multiplication tables considering the provided response, understanding that no additional information apart from the answer was illustrated. It produces an assumption that since the student understands the situation as a multiplication problem, it is not necessary to investigate other possible interpretations of the solutions apart from retrieving the memorisation of the multiplication tables. However, student D from the experimental group moved further to confirm this assumption by switching the order of multiplier and multiplicand several times but still obtaining the same result. Hence, these results demonstrated how the TUAM strategy impacted students' mathematical thinking processes deeply compared to the 'I Do-We Do-You Do' strategy. Thus, it can be implied that the current teaching approach is able to encourage students in solving problems based on memorisation while the TUAM strategy encouraged students in investigating possible solutions to the problem.

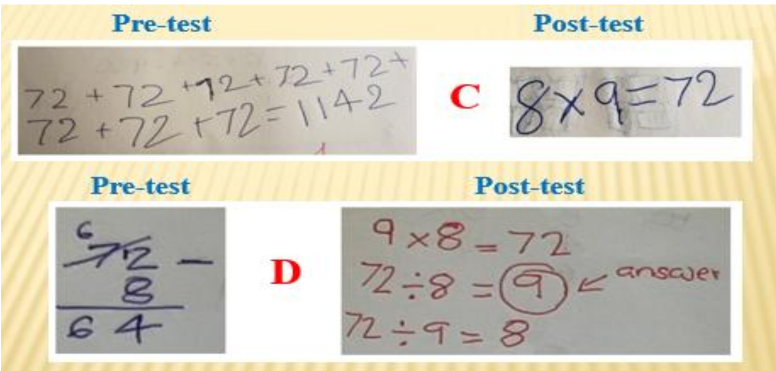

Figure 4. Students' way of thinking – Q.7 – Students C and D

Discussion

The results of this study revealed that students' mathematical understanding and thinking process in both groups enhanced over the course of interventions. The qualitative analysis of students' responses implied that the treatment provided during interventions provided a significant impact on students' thinking process which allowed them to produce various solutions to a particular problem. The findings discovered that there was a positive impact on students' achievements in both groups. Initially, the improvement in both groups portrayed that the current teaching approach influenced positively on students' mathematical thinking processes but to a certain level of understanding when compared with the experimented approach. Specifically, the quantitative analysis revealed that although there is a positive impact in both groups, the results display that the experimental group performed much higher than the control group, identifying that in the pre-test the p-value 0.338>0.05 demonstrates no statistically significant difference. However, in the post-test, the p-value of 0.036<0.05 displays that there was a statistically significant difference. These results uncovered that there was no significant difference in students' performances before the treatment, but after the treatment, a statistically significant difference was discovered which indicates the experimental group which performed much higher not by chance. Hence, the findings revealed corroborated that when allowing students to investigate mathematical ideas, the opportunities they possess will enhance their mathematical understanding when they extract relevant information from a problem statement (Ojose, 2008).

Unveiling that when observing the difference-in-difference in the outcome of students' achievements, Figure 2 presented that the experimental group performed better than the control group. It indicates that the students owned an opportunity to be an explorer of mathematical ideas during interventions (Trninic, 2018). The knowledge they obtained during self-discovery allowed them to practically demonstrate it during the post-performance test which produced the accelerated results as highlighted by Bakker (2018), Mayer (2004), and Trninic (2018). The difference in outcome in the pre-test was 0.21% illustrating the experimental group which performed higher than the control group and after the treatment, the difference in outcome during the post-test elevated to 0.67% which indicates that the experimental group still performed much higher than the control group with a difference-in-difference in the outcome of 0.45. The result unveiled that the experimental group performed higher than the control group with a big difference which made me the results accelerated. Based on Takahashi's (2006) illustration of the TUAM strategy, students presented that they were able to master the mathematical solutions well during their discovery processes and applied them later in the test which produced an accelerating result. It indicates that the TUAM strategy possesses the capacity of encouraging students to explore mathematical solutions and implement them in any situation necessary. On the other hand, the improvement of results in the control group implied that students can also learn through observation. Sanga et al. (2004) asserted that children learn best when they observe what others perform. However, these findings highlighted that learning through observation is less effective than learning through self-discovery.

Furthermore, the qualitative results in Figures 3 and 4 above uncovered that the TUAM strategy provided more significant impact to students' mathematical thinking process than the typical 'I Do-We Do-You Do' strategy. The results evidently revealed that where there was a limitation in understanding of multiplication content, the treatments provided through the interventions made students able to obtain the concepts accurately at different levels, understanding that both students in the control group demonstrated a correct response and so as the experimental group. However, reflecting on the nature of the 'I Do-We Do-You Do' strategy, there is a possibility that students' response was in accordance with their memorisation of the multiplication tables when considering the response of Student C. There is also a possibility that by implementing learning through observation (Sanga et al., 2004), students were not able to scrutinise deeply the situation of the problem as demonstrated in both responses of student A and C.

In response to research question 1, these findings discovered that there is a positive impact of the typical approach ‘I Do-We Do-You Do’ on students’ achievement in mathematics. To some extent, the ‘I Do-We Do-You Do’ typical approach is able to influence students positively in obtaining a correct understanding of mathematical content based on enlightenment by the teacher (Sanga et al., 2004). The results emphasised that students’ achievements in the control group were enhanced based on the imitation. The students were able to acquire mathematical knowledge based on the observation of the teachers’ demonstrated ideas. They learned and improved based on what the teacher demonstrated. In other words, if there was no explanation or example of a mathematical problem provided, it would be difficult for students to obtain a piece of new mathematical knowledge. On the other hand, concerning research questions 2 and 3, the findings unveiled a possibility that the TUAM approach was also able to influence students’ mathematical achievements. Most specifically, by providing students opportunities to attempt mathematical problems, they will be encouraged to explore possible solutions to the problem as asserted by Takahashi (2006), Ojose (2008), Bakker (2018), Mayer (2004), and Tminic (2018). Thus, the findings of the study corroborate that the TUAM strategy is able to positively influence students’ mathematical thinking process when allowing them to acquire a conceptual understanding of mathematical content.

Conclusion

Learning and Teaching Mathematics should not be based on a particular teaching approach. On the other hand, it is necessary to implement other learning approaches that involve students as the centre of learning which are evident to help stimulate students’ mathematical thinking. Although the typical ‘I Do-We Do-You Do’ teaching approach continuously impacts students’ mathematical thinking, this study revealed that the TUAM teaching approach is also able to positively impact students’ mathematical thinking. Conclusively, the findings through this research recommended that in this 21st century, the TUAM discovery learning strategy can be promising for mathematical education in Vanuatu on two bases. Firstly, it is a student-centred approach whereby students are able to construct freely their learning and develop their mathematical thinking. When the opportunity to solve a mathematical problem is initially provided for students, it allows them to develop their mathematical thinking process as they attempt and solve mathematical problems. Although they will encounter misconceptions, their mistakes can be a lesson for them in exploring better solutions to mathematical problems. Secondly, it encourages collaborative learning whereby students interact and learn from each other as well as from the teacher. It provides students the opportunity to discuss their mathematical reasoning and mathematical arguments, and justify their mathematical perspectives. As a result, even though both teaching pedagogies play crucial roles in children’s learning in different ways, in this 21st century, the TUAM discovery learning strategy is highly recommended for the Vanuatu mathematics education.

However, there were some limitations to these findings. Firstly, there were merely five lessons displayed for interventions in both groups. There may be further discovery if the number of lessons increases. Furthermore, the questions provided for pre-and post-treatment were all about word problems. The results might have changed if there were mathematical operations with direct integers. Finally, students' attendance during interventions was not consistent. Some students faithfully attended the lessons but did not attend the post-performance test while some students who took the tests were not attending the classes regularly. These limitations may produce some impact on the results.

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