Conjoining Teaching Techniques to Enhance Learners' Multiplication Skills

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ABSTRACT

The study explored conjoining multiple teaching techniques (skip counting, drill, games, discussions, timed-test, flashcards and window cards) to enhance the multiplication skills of the students and their basic mathematics proficiency. An entire class of fifth graders (41 students) who obtained the lowest mean in their numeracy profile and pretest were the participants of the study. A validated researcher-made test (pretest and posttest) in mathematics assessed the academic performance of the pupils before and after the implementation of various strategies in teaching and learning of multiplication skills. Data collection also included interviews with the students. Results show that the pupils significantly improved their multiplication skills and basic mathematics proficiency. Based on the students' account, the intervention of various strategies in teaching mathematical skills and enhancing proficiency was effective. The students were also found motivated and were engaged in learning. Reflections on the results of the action research suggest that better learning experiences and student achievement may be subsidiary to mastering the basic skills, concepts and procedural proficiency which may be attained by combining and systematically implementing multiple teaching and learning strategies.

Keywords: mathematics fluency, multiplication skills, skip-counting, drill, games, timed-test, flashcards and window cards.

INTRODUCTION

Mathematics proficiency is believed to be vital in learned society. Ogena and Tan (2006) perceive Mathematics as a gateway for national progress. Thus, the Philippine education system advocated the enhanced basic education curriculum (K-12 program) to equip the learners with skills that will significantly contribute to the nation's progress. The new curriculum recognizes that being mathematically competent means more than having the ability to compute and perform basic algorithms and mathematical procedures. Skills exhibited by a mathematically competent student include how computing and performing basic algorithms. He or she can further display the following skills: being able to pose and solve mathematical problems and apply them and the reasoning ability in other subjects and everyday experience. Before developing such skills, foundational learners should attain a certain level of mathematical fluency and automaticity,

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as major components of mathematics proficiency, to be successful in higher and more complex mathematical experiences. Researchers (Baroody, Bajwa, & Eiland, 2009; Cumming & Elkins, 1999; Poncy, Skinner, & Jaspers, 2006; Verschaffel, Luwel, Torbeyns, & VanDooren, 2009; Woodward, 2006) define fluency as the rate of accurate recall of basic mathematics fact at an unconscious level. Connectedly, automaticity is the highest rate of fluency, in which the learner exhibits immediate, accurate recall at an unconscious level (DeMaioribus, 2011).

Consequently, though the new curriculum defines the track of the learner's mathematical development, many students still enter the fifth grade with low mathematics proficiency. These learners may not have adequately developed the level of fluency and automaticity needed to reduce the working memory overload and increase the amount of available energy for problem-solving in higher grade levels (Codding, Burns, & Lukito, 2011; Nelson, Burns, Kanive, & Ysseldyke, 2013). The struggle to address these problems at this late stage may restrict students from enjoying mathematics at all (Bystrom, 2010) and may consequently incur mathematics anxiety (Boaler, 2015). We also observed the same occurrence and phenomenon in our mathematics classes. In fact, Ismail and Sivasubramniam (2010) reported the same results in their most recent encounter with a class of grade 4 students who were unable to do long multiplication problems not because the algorithm was confusing, but because they could not recall their six, seven, eight, and nine multiplication tables. We observed that year after year, a significant number of fifth graders students incur difficulty in multiplication which is a crucial skill in performing other fifth grade concepts. Students find it hard to divide because they fail to master the basic multiplication principlesan indication of low mathematical fluency and automaticity in multiplication. Consequently, varied teaching strategies implemented in different class settings (Bystrom, 2010; Clarke & Holmes, 2011; D' Ettore, 2009; Edmiston, 2008; Steele, 2009) significantly developed mathematics proficiency of the participants. It must be noted, however, that only strategy intervention took place in the majority of literature. With the aim to place a premium in advancing the proficiency level in mathematics, and to add to the literature on the unique strategies for Filipino grade schoolers in developing the required ability, this action research sought to establish the combined effects of using and sequentially implementing multiple strategies in teaching mathematics to a group of grade schoolers particularly underscoring the principle of repetition (Steele, n.d.) and tiers (Grunke, 2016).

Mathematical Proficiency

The National Research Council (NRC, 2001) recognized the fact that no term can completely capture all aspects of competence, knowledge, and facility in mathematics. Accordingly, NRC reported that mathematical proficiency includes five strands, which approximate these areas of mathematics learning. Among these aspects are conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition. Seemingly, student's comprehension of mathematics defines the student's conceptual understanding. Also, a student who can carry out procedures flexibly, accurately, efficiently and appropriately, and can formulate, represent, and solve mathematical problems describe the student's procedural fluency and strategic competence. Finally, a mathematically able student known to possess adaptive reasoning and productive disposition can process logically, reflect, explain and justify, and views mathematics as sensible, useful, and worthwhile; he also believes in diligence and

efficacy. NRC believes that these strands are not only interdependent but also are intertwined in developing proficiency in mathematics. Groves (2012) used the same framework for identifying specific classroom practices that may attain mathematical ability among learners. Many other researchers used the same theory in building mathematics proficiency in their respective locale (Ally, 2011; Khairani & Nordin, 2011; Kilpatrick, 2011). Various research identified proficiency as vital to success in learning mathematics (Boaler, 2015; Cholmsy, 2011; Gojak; 2012; Russell, 2000; O'Connell & San Giovanni, 2011). However, NRC (2001) still goes for the five strands to concretely achieve success in learning mathematics.

Mathematical Fluency and Automaticity

Procedural proficiency, as a major component of mathematics proficiency, recognizes the learners' ability to apply methods and procedures appropriately, accurately, efficiently, and flexibly (National Council of Teachers of Mathematics [NCTM], 2017). Researchers (Baroody, Bajwa, & Eiland, 2009; Bystrom, 2010; Philipps, 2003) believe that mathematical fluency influenced by learners' automaticity builds through repetitive practice. In fact, Mason (2006) reported that a strong daily routing might increase student automaticity, defined as the ability to quickly, unconsciously, and accurately answer basic math facts (Crawford, 2003; Loewenberg-Ball et al., 2005). Cognitive psychologists confirmed that certain routine and overlearned components of tasks lead to automaticity (Whitehurst, 2003), and thus reduce working memory overload therefore leaving the learner with good amount of energy available for problem solving and more complex mathematics tasks (Codding, Burns, & Lukito, 2011; Nelson, Burns, Kanive, & Ysseldyke, 2013).

Interventions and Strategies

While other researchers identified other ways to attain proficiency. Frawley (2012) provided a compelling motivation to conduct action research to achieve mathematics proficiency with various interventions available to help students develop mathematical proficiency. In a meta-analysis (Burns et al. 2010; Codding et al. 2011), single group design action research specifically culled major interventions and strategies to achieve automaticity and mathematical fluency. Specific interventions and strategies found effective in attaining and improving automaticity and fluency include flashcards, timed-test, and drill. For example, teachers can use flashcards, songs, raps, games, worksheets, drills, or timed-tests to assist students to achieve accuracy and recall basic math facts and principles. In addition, several research successfully identified some interventions in attaining mathematics fluency: daily multiplication fact review (Bystrom, 2010); finger math (Edmiston, 2008); meaningful practice and drill for students (Clarke & Holmes, 2011); and the use of flashcards (D' Ettore, 2009; Steele, 2009). In the case of O'Connell and San Giovani (2011), they found out that a complete intervention program includes a practical guide for helping students master multiplication and division facts. These strategies as mentioned earlier need to include multiple instructional strategies, teacher tips, and effective classroom activities enhance students' mathematics proficiency.

In sum, mathematics proficiency highly depends on mathematics fluency influenced by automaticity. The literature above underscores the need for routine activities that may lessen the cognitive overload of learners and focus on the critical analysis in more complex mathematics. Numerous studies have been identified to establish routines to enhance fluency and automaticity. However, unique pairing and combination of these strategies coupled with the learning preferences of the students are not fully explored. Thus, this single-case design action research is focused on using integrated different materials to enhance the students' mathematics fluency.

Purpose of the Research

This single case action research was conducted to determine the effect of combined teaching strategies: skip counting, drill, games, discussions, timed-test, flashcards and window cards in enhancing students' skill and speed (mathematics proficiency) in basic multiplication. Its primary goal was to improve students' multiplication skills that could enable them to perform other fifth-grade mathematics concepts.

METHODOLOGY

This single case design action research used the pretest-posttest design to determine the effect of multiple strategies as an intervention to achieve mathematical proficiency of elementary schoolers. A low performing non-comparable class based on the school-wide numeracy profile test was purposely chosen to receive the identified interventions in their mathematics course. This low performing class designated as the participants of this action research included a whole class of fifth graders who obtained the lowest mean in their numeracy profile (a schoolwide test conducted to cluster students according to numeracy skill).

Data Sources

Several instruments deduced relevant data for this action research. We did a school-wide the numeracy profiling by administering the numeracy profiling test (a 100-item test on the four fundamental operations in Mathematics) in the first week of June, 2015 to assess students' speed in doing the four basic operations. Before the intervention, we administered the pretest, which included 25 items deduced from the 2014 district test, which assessed the participants' prior knowledge on multiplication (pretest) and to confirm their proficiency in basic multiplication skills (posttest). All items in the supply type of pretest and posttest assess the students' multiplication skills. Each correct answer merits a point. Implementation of action focused on the combined effect and sequential implementation of the following strategies (Table 1).

Table 1. Sequenced Strategies used as Intervention.

Strategy	Description
Skip counting	Sequential counting by a number higher than or larger than 1.
Games	These are common games but are set with simple rules and strategies, and are defined by clear mathemati- cal parameters.
Fact recall	This strategy is done during discus- sion or any part of the lesson in question and answer format.
Flashcards	These cards bear the numbers and the operation (multiplication) and are used in drills. They include single basic multiplication facts to enhance proficiency.
Activity Sheets, Work sheets, window cards	These are paper and pencil assessment format
Daily-timed test	These are sheets of paper contain- ing basic multiplication facts from 0 through 9 to monitor students' progress.

We followed the sequence as presented in the Table 1 in the implementation stage (action). We used Flashcards and window cards to enhance the proficiency of students in multiplication. To motivate students to enjoy while doing the activities that would improve their multiplication fluency, we utilized fact memory recall and games.

Preliminary Stage (Plan)

As part of this stage, we sought parental consent from all participants (fifth graders). This form stipulated the objectives of the action research, the action or intervention, the probable risks and benefits, and our contact information. We oriented the students on the sequence of events in a lesson as planned: skip counting, fact recall, alternating discussion and game, worksheets/ activity sheets/window cards, and timed-test twice a week. We also administered the pretest and the results of which confirmed the participants' low performance in multiplication.

Intervention (Act)

We followed the Plan-Act-Reflect (PAR) concept of action research in this single case research. We designed the lessons in a sequential format of different strategies to enhance mathematical fluency and to achieve the combined positive effects brought about by the different strategies. The sequential format of the different strategies took place in a period of 3 months or 120 contact hours. Initially, we let the students do skip counting as a gate pass to enter the classroom. Group leaders checked their members while doing the skip counting. When the student achieved the speed set by the group as monitored by the team leader, the student was allowed to enter the classroom for more activities. After everyone has entered the classroom and has settled down, discussion with the teacherresearcher started. This discussion was alternately done with games. Each day after the discussion, we asked the participants to answer the basic multiplication worksheets or window cards independently. We also gave the participants

timed-tests twice a week. We interviewed purposively selected students to determine their perception of the activities provided them and to have a peek on their classroom experiences with the sequenced action. We also kept a daily journal of the participants' activities and their improvement.

Post Intervention

After the intervention (action), we administered the posttest to the students to determine the extent of their mathematical skills and enhanced proficiency. These results were matched and combined with the results of the daily timed tests, numeracy profile and pretest. We used the t-test for dependent samples to statistically compare the students' pretest and posttest scores.

RESULTS

Action in this study is focused on the sequenced implementation of several strategies to enhance the multiplication skills of the low performing participants and to improve their mathematical fluency in the long run. We present three sets of data to showcase how the action has enhanced the mathematical skills of this low performing class.

Enhancing Multiplication Skill

We sectioned the presentation of the success of the low performing class in the intervention phase (act) as the gain in pretest and posttest, improvement in the numeracy profiling test, and the daily timed test in July and August.

Mean (N=41)		Standard Deviation		Mean Difference	P-Value
Pre-Test	Post-Test	Pre-Test	Post-Test	_	
.8	15	1.38	8.95	-14.2	<.0001

 Table 1. Comparing pretest and posttest results in multiplication.

Table 1 shows that this low performing class, who received the combined and sequential strategies in developing mathematical proficiency attained a very low mean score in the pretest (M=.8, SD=1.38). The .8 class mean score indicates that most students scored within the 0-3 points and most of them scoring zero. However, after the intervention (action), we observed that the class (M=15, SD=8.95) incurred a significant increase. These results suggest that sequentially implemented combined tools and strategies enhanced the fluency development of low-performing students. Gains projected and realized are comparable to developing fluency to high performing students using traditional lecture and memorization of multiplication tables. The t-test for dependent sample dictates that the mean difference deduced from both groups is comparatively significant (p < .0001). We infer that the sequentially implemented multiple strategies developed the skills in conceptual understanding, fluency, and computational strategy among the low performing pupils.

We also compared the performance of this low performing class to the achievement of the top performing class and considered objectivity in giving the lessons. We subjected the mean posttest scores of both class to t-test to determine if there are significant differences in their means. Table 2 shows this comparison.
 Table 2. Comparing the posttest scores of the low performing class and the top performing class.

Class	Posttest Mean	t-difference	p-value
N=44	17.2	0.677	.75
N=41	15.0		

*significant at the 0.05 level.

As gleaned from Table 2, the posttest means of the two classes do not pose a statistically significant difference. We infer that both classes were able to achieve the multiplication skills necessary at their level. They may have the same motivations and perseverance within this quarter that brought them to the same state of achievement. From these data, we infer and confirm our previous claim that the low performing class gained conceptual understanding, fluency, and computational strategy specifically in the multiplication domain comparable to the level of understanding, fluency, and computational strategies gained or achieved by the top performing class. We attribute this success to the sequenced implementation of the aforementioned multiple strategies.

Below are the sample transcripts of the responses in the interviews from students in the low performing class. They may provide additional information on the changes incurred in the cognitive development of the students, particularly in the aspect of mathematical fluency:

I enjoy games because we learn to multiply. Games motivate me to go to school.

"Dati bindi ako marunong mag-skip count by 7. Ngayon marunong na ako dabilsa mga pinapagawa ni Mam." (I don't actually know how to do skip counting by 7,but with the activities Mam asked us to do, I learned to do skip counting.)

"Pala-absent po ako pero pag alam kong may pagagawa si Mam gaya ng paglalaro ako po'y pumapasok po." (I usually dislike going to class, but if I know that Mam will give us activities, I get excited and I go to class often.)

Based on the interview with the participants, it was observed that they appreciated the activities and actions provided them. They claimed to be motivated in class and were also motivated to go to school (a rare case on the part of low performing students). They exhibited positive perception of the activities provided them by identifying which activities among the sequence they enjoyed. Additionally, their motivation seemed to propel their enthusiasm to learn multiplication and improve their skill. The figures below show how these students improved their numeracy profiling performance.

We observed that the numerical profiling results improved, with more students on the red

mark denoting scores within the 76-100 range in the supply type of test. Thus, we infer that the improvement in the numeracy profiling may be attributed to the sequential and combinatorial effect of multiple strategies employed in this action research.

The results match with the participants' performance in the timed-tests in July and August as presented in the chart below.





We observed that most students improved within the two-month duration. However, there were only 39 complete entries because two students were not able to complete the timed-test due to absences in school. From the July entries, students showed better performance in this assessment in August.



Figure 1. Numeracy Profiling (Pretest).



Figure 2. Numeracy Profiling (Posttest).

This action research aims to improve students' multiplication skills (mathematics proficiency) to help them move towards performing more complex tasks in mathematics in their next grade level. Improvement in mathematics proficiency through their mathematical fluency may be attained with the use of sequentially implemented multiple strategies. A wide range of literature dictates that enhancement in mathematical fluency may be derived from sequentially implemented multiple strategies such as skip counting, game, discussions, games, worksheets, flashcards and window cards, and timed-test. The majority of literature underscores the effect of one particular teaching strategy as intervention scheme to achieve mathematics proficiency, particularly fluency. However, there is little information on how combining and sequentially implementing the identified strategies may enhance grade schoolers' mathematics fluency.

Consequently, this single case design action research reports that combining the previously mentioned teaching strategies and sequentially implementing these strategies in teaching multiplication to low-performing grade schoolers developed the skills such as conceptual understanding, fluency, and computational strategy, comparable to developing fluency to high performing students using traditional lecture and memorization of multiplication tables. We infer that skip counting may have provided the students thinking strategy at the onset of their learning (Wright, Stanger, Stafford, & Martland, 2006), which familiarizes their thinking skills to patterns as the basis for understanding (Reyes et al., 2012). Furthermore, it may be that strategies such as games activated students' positive emotions, which, in brain-based learning research (Caine, 2000; Caine et al., 2006; Pessoa, 2013; Salvkin, 2004; Wagmeister & Shifrin, 2000; Wolfe, 2001), trigger the neurotransmitter dopamine (DA). Bromberg-Martin, Matsumoto, and Hikosaka (2010) identified this chemical content to deal with focus, motivation, and memory. Evanski (2009) even reported that music could improve conditions for optimal learning by enhancing blood flow to areas of the brain responsible for arousal, emotion, reward, and motivation. Furthermore, Caine, Caine, MacClintic, and Klimek (2009) reported that engaging students to focus students' attention on the work being undertaken involve fun and excitement. Thus, we can infer that their improved multiplication only skills not achieved through were memorization and algorithm-based techniques but by a cognitively-influenced understanding of numeracy, particularly multiplication.

Mathematics engagement as the thematic concept mentioned by the participants shows that students appreciate long but varied interventions. This idea confirms the claims of several researchers (e.g., Liao 1992; Sandy-Hanson, 2006) that sustained use of the same strategies and tools over a much longer period is usually less effective at improving achievement. Also, we affirm the belief of Frawley (2012) that intervention programs such as flashcards, games, worksheets, drills, and timed-tests assist students to achieve accuracy and recall of basic math competencies that help develop mathematics proficiency. Other research, which may confirm the claims above, successfully identified several interventions to achieve mathematics proficiency. These are daily multiplication fact review (Bystrom, 2010); finger math (Andres, DiLuca, & Pesenti, 2008a); meaningful practice and drill for students (Clarke & Holmes, 2011); and use of flashcards. O'Connell and San Giovani (2011) also reported that a complete intervention program that includes a practical guide for helping students master multiplication and division facts, a multitude of instructional strategies, teacher

tips, and classroom activities helped students develop better mathematics proficiency.

Additionally, it may be possible for others to replicate the process and identify other appropriate interventions suited to their learners. Online platforms may also be integrated to inject technology and a sense of 21st-century aura that may match the digital learning orientation of students in this era where immense benefits await stakeholders like us - teachers, researchers, students. administration and the Filipino nation. However, this action research found that intervention was successful to a group of lowperforming grade schoolers. Replication then may include the entire cognitive spectrum of students to determine the viability of the intervention or uniqueness of the intervention to a particular group within the spectrum.

CONCLUSION

The results we presented above show that the sequentially implemented multiple teaching strategies in the intervention phase (act) made a significant difference in the multiplication skills of pupils. The interventions provided drew the pupils' attention closer to doing daily activities, which made them more participative and confident in recitation and other oral activities. Aside from developing three of the five strands of mathematics proficiency - conceptual understanding, procedural fluency, and strategic competence - the intervention also visibly (through participants interview responses) improved a positive attitudinal outlook in learning mathematics and enhanced student engagement, which are core to Philippine K to 12 mathematics framework (SEI-MATHED, 2011). We also observed the pupils' more accurate responses and speed in computation. Their attitude towards long multiplication also changed consequently leading to better and faster recall of basic multiplication facts (Mata, Montiero, & Peixoto, 2012; Olatunde, 2009). The exhibited results in this action research are forerunners to achieving scientifically informed citizens and STEM (Science, Technology, Engineering, and Mathematics)-influenced learners who will be the future human capital of the country in their journey towards economic growth and development.

We, therefore, underscore that these positive results were achieved through teacher initiated activities derived from reflections-in-action and reflections-on-action at the onset of a mathematics class. While we can only share our findings in a class compared to another class, we value the fact that other mathematics teachers may walk the same path and plan, act, and reflect.

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