SHUFFLED PRACTICE FORMAT OF MATHEMATICS PROBLEM SOLVING: ITS EFFECTS ON STUDENT PERFORMANCE AND MATHEMATICS TEST ANXIETY

Art Walden A. Dejoras*[1], Vima Socorro J. Tandog[2]
University of Science and Technology of Southern Philippines, Cagayan de Oro City, Philippines
*For Correspondence; Tel. No.: (+6388)8561738, Email: adejoras@gmail.com , Fax: (+6388)8564696

ABSTRACT: *The paper reports on a study about the blocked practice and shuffled practice formats in mathematics problem solving conducted at Xavier University High School during 2011. The independent variables are the two formats of practice: blocked practice, a method of practice involving problems from multiple lesson types that are arranged by lesson type, and shuffled practice, an unconventional method of practice, also involving problems from multiple lesson types but two problems of the same lesson types are not arranged consecutively. The dependent variables are mathematics achievement scores and mathematics test anxiety scores. The study was conducted at Xavier University High School, Cagayan de Oro City from June 28, 2011 to September 27, 2011 to eighty-eight second year students mixed boys and girls, each belonging to either of the two intact classes, with 44 students per class. The analyses yielded a significant difference on students' achievement scores and on mathematics test anxiety as influenced by the format of practice. Students who used shuffled practice outscored those who used blocked practice in mathematics achievement test (86.62% vs. 69.20%) and in mathematics test anxiety (8.99% vs. –0.90%). Therefore, shuffled practice should be used as reinforcer of mathematics learning, be adopted when conducting reviews for national assessments and be incorporated into the exercises portions of mathematics textbooks.*

Keywords: *Shuffled Practice, Blocked Practice, Achievement, Mathematics Test Anxiety*

1. INTRODUCTION

Most of mathematics students, especially the average and low-average performing students, spend most of their time in practicing mathematics problem solving for a test. Practice, according to [1], it is especially suited for them as it helps reinforce their mathematics learning and improve their achievement scores in mathematics by exposing them to concentrated skills learning. Secondly, practicing possible test content, questions, and conditions through practice tests can help students lessen their test anxiety level. According to [2], an estimate of 25% to 40% of students experience test anxiety or high levels of stress, nervousness, and apprehension during testing and evaluative situations which significantly interfere with their performance, emotional and behavioral well–being, and attitude toward school.

Recent studies, however, have focused on comparing shuffled practice and blocked practice to examine their effects in enhancing motor skills as demonstrated in [3-7] and in the few areas of mathematics education as demonstrated in [8,9,10,11]. In the blocked group, the same task was repeated over and over until all trials are repeated and then would start a different task while the shuffled group practiced all the tasks in an unpredictable order. Results showed poor performance during practice session. However, the results favored the use of shuffled practice in improving student achievement when tested at later time.

Shuffled practice, according to [12] is considered a performance paradox because the format/strategy leads to degraded performance during practice, but leads to enhanced learning as measured in retention and transfer tests. So, if the main goal is to maximize learning, one would conclude the shuffled practice condition is preferable over blocked practice condition. Moreover, [12] stressed that this positive benefit of shuffled practice is not found in all learning situations as various factors may affect its result which include ecological validity of the experiments (whether the experiment is done in a laboratory or in real world setting), age, gender, experience level of the learner, the type of skills, task difficulty, and the absence or presence of augmented feedback during the practice trials. In previous studies [8,9,10,11], they were all conducted only in very short span of time in a laboratory setting, problems of the same lesson type were knowledge problems (or problems that require simple recalling and/or solving only in order to arrive at a single answer) which are superficially similar (or problems that require the same method of answering).

The present study was conducted to find out if there is still positive effect of shuffled format over the blocked format of practice in enhancing learning where the treatment period is longer which was done in a real classroom setting, problems of the same type were composed of knowledge problems but which were superficially different (or problems that do not have the same method of answering). The present study investigated the effects of these two formats of practice on the student's achievement and mathematics test anxiety scores in selected topics in Intermediate Algebra at Xavier University High School during the first quarter of school year 2011 – 2012. Particularly, the researcher would like to address the following questions:

1. How do the achievement scores of students compare as influenced by two formats of practice?
2. How do the mathematics test anxiety scores of students compare as influenced by two formats of practice?

In the present study, the *shuffled practice* format contains different practice problems that are taken from the present lesson including previous lessons wherein the problems are arranged in such a way that no two problems belonging to the same topic or lesson appear consecutively. On the other hand, *blocked practice* format also contains different practice problems that are taken from the present lesson including previous lessons but unlike the shuffled practice, the problems are arranged in such a way that problems belonging to the same topic or lesson appear consecutively.

The present study is anchored on the theory of constructivism. The theory fosters the idea that all knowledge is a product of one's cognitive act by building on previous knowledge. In the present study, for every practice problem, the learner must construct and reconstruct a particular learned concept in the working memory before answering each practice problem. In the process, the learner analyzes, understands and reflects his answer whether it makes sense and finally establishes in his mind the new idea he has built. In the end, the learner produces a mental representation of the knowledge or skill that fosters long-term access to that knowledge and the ability to generalize.

The study is also anchored on theory of reinforcement. The theory states that if one wants to improve a behavior, then when the behavior is shown, consequence or reward must be provided. Practice of answering mathematics problem in an effective method can improve students test performance and lessen mathematics test anxiety because it provides them with retrieval practice in their working memory. By providing rewards in a form of more opportunities for such method of practice, there would be more opportunities for retrieval practice that can help reinforce and enhance their mathematics learning and lead them to higher mathematics achievement test scores and lesser mathematics test anxiety level.

2. METHODS

The study was conducted at Xavier University High School, Pueblo de Oro, and Cagayan de Oro City. In school year 2011 – 2012, the school has one honors class, two semi–honors classes and seven regular classes. The mathematics curriculum of Xavier University High School for the honors, semi-honors and regular classes differ in content, process and pace. Students in the honors and semi-honors classes have a QPI of at least 90 (or at least above average QPI) and final grade of at least 90 (or advanced learner) in English, Mathematics and Science subjects in the previous school year (SY 2010-2011) with no grade below 82 in any of the other subjects. Students who don't qualify in the honors and semi-honors classes are placed in the regular classes and their mathematics final grades in the previous school year varies significantly with many of them having low grades (grade below 80). Since at least 70% of the student population per year level are in the regular classes, and based from student interviews, a considerable number of problems from national assessments like the National Achievement Test (NAT), National Career Assessment Examination (NCAE), and College Scholastic Aptitude Test (CSAT) are usually taken from Intermediate Algebra in the second-year level, this study was designed for second-year level students in the general classes. The use of shuffled practice was introduced to them to see if there will be significant improvement in their mathematics grade and mathematics test anxiety level.

The teacher–made 30–item multiple choice mathematics achievement test was the first instrument used in the study. For content validity, the coverage of the test was based on the intermediate algebra syllabus prepared by the teachers of XUHS Mathematics Department in the school year 2011– 2012. The test covered the topics in the first quarter and half of the second quarter, namely: (1) Parallel and Perpendicular Lines, (2) System of Linear Equations in Two and Three Variables, (3) Systems of Linear Inequalities in Two Variables, (4) Factoring and (5) Rational Expressions. With reference to [15,16], the reliability index of the test using the Kuder–Richardson (K-R 20) formula is 0.85 (high reliability).

The teacher–made 15–item self–test for mathematics test anxiety is another instrument used in this study. Its references are the test anxiety scale by Nist and Diehl (1990) and the XUHS Study Skills Inventory. It was shown to some XUHS mathematics teachers for content validity. With reference to [15,16], the reliability index of the test using the Cronbach Coefficient Alpha formula is 0.91 (high reliability).

Scores of the two groups on teacher–made mathematics achievement test (pretest and posttest) and the self–test on mathematics test anxiety (pretest and posttest) were the only scores needed for the study. For the self–test for mathematics test anxiety, the score of each student is the mean of the values obtained from all 15 statements where each student was required to give 1 (for never), 2 (for rarely), 3 (for sometimes), 4 (for often) or 5 (for always) for each statement. The overall mean score of each group is the mean of all scores of all students in the group. Below are the range of scale, description and implication prepared by the teacher–researcher. See figure 1.

Figure 1: Mathematics Test Anxiety Self-Test Range of Scale, Description and Implication

Range	Description	Implication
1.00 – 1.55	Never	not anxious at all
1.56 – 2.55	Rarely	little anxiousness
2.56 – 3.55	Sometimes	uncertain of their feelings
3.56 – 4.55	Often	anxious
4.55 – 5.00	Always	more anxious

The present study employed a pretest/posttest quasi–experimental research design. The participants of the study were second year students of two intact regular classes of XUHS from June 28, 2011 to September 27, 2011, during the first quarter and part of the second quarter of school year 2011 – 2012. One section was randomly chosen as the experimental group and the other one, the control group. The experimental group used shuffled practice while the control group used the blocked practice as a method of reinforcement of mathematics learning. Eighty–eight students participated for the study, 44 from each class whose ages ranged 14 – 15 years old.

On the first session, a pretest which was the 30–item validated teacher–made mathematics achievement test was administered to both groups for 50 minutes. On the next session, another pretest which was a 15–item validated teacher–made self–test for mathematics test anxiety was administered for 15 minutes. Then the students were given orientation on what to do during the treatment period. In a classroom setting, the teacher–researcher met each group 50 minutes per session for 6 sessions a week. Thus, there was a day in a week when each of the two classes met twice. There were a total of 7 practice tests for the whole treatment period for each group. The schedule of when to have a practice test depends on the lessons covered and the need for it.

Before a practice test is to be given, however, the teacher–researcher made sure that the students have gained mastery over each lesson to be covered. Mastery is obtained if at least 75% of the class has scored perfect in all quizzes pertaining to each of the lessons covered. If mastery is not obtained, the lessons are taught again until mastery.

All problems in each practice test are routine, open-ended problems of unequal level of difficulty. Some problems were procedural, others were conceptual. Examples are shown in figures 2 to 5. All problems were like examples given during lesson development. Each set was to be answered individually for a given time allotment depending on the number and difficulty of problems but not beyond 35 minutes.

When answering each practice test, opening of book and notes and use of calculator were not allowed. After the end of the allotted time, students exchanged papers and answers were checked immediately. The teacher–researcher has also set consultation time after classes to welcome students for any clarifications or corrections. The teacher–researcher has also set extra time during the weekends for make–up classes to students who were absent during the week or for more consultation. The learning strategies, drills, seat works, board works, assignments, quizzes and long tests were all the same for both control and experimental groups in the entire course of the treatment period so that the only difference is in the format of the practice tests. After the specified treatment period, the posttest was given such as the teacher–made mathematics achievement test and the teacher–made self– test for mathematics test anxiety to the two sections.

Mean and standard deviation were used in the investigation to describe the performance of the two groups of participants in the mathematics achievement test and in the self–test for mathematics test anxiety.

The one–way analysis of covariance (ANCOVA) was applied with reference to [17] and [18] to test whether the format of practice influences the students' performance in the mathematics achievement test and whether the format of practice influences the students' self–test for mathematics test anxiety.

3. RESULTS

Table 1. Mean and Standard Deviation of Students' Pretest and Posttest Achievement Scores in Terms of Format Practice

Format of Practice	Pretest		Posttest	
	Mean	S.D.	Mean	S.D.
Control Group	8.80	2.19	14.89	4.04
Experimental Group	9.27	2.91	17.30	4.03

Table 1 show that students of both control and experimental groups have a poor background in intermediate algebra before the treatment period as revealed by their pretest mean scores. However, after the treatment period, the experimental group which used the shuffled format of practice outscored the control group which used the blocked format of practice (86.62% vs. 69.20%).

Table 1 further shows the homogeneity of the pretest scores of the students in both groups as revealed by their standard deviation. The slight increase in the standard deviation in the posttest of both groups implies that in the posttest, there are several students who got high scores and there are also several students who got low scores in both groups. From this result, it can be inferred that either of the two formats of practice tests can be an effective tool for separating high–achieving students and low–achieving students in intermediate algebra.

Table 2. Summary Table of One-Way ANCOVA for Mathematics Achievement by Format of Practice

Source of Variation	Adjusted Sum of Squares	df	Adjusted Mean Squares	Computed F-ratio	P
Format of Practice	120.64	1	120.64	7.36 *	.008
Error Within	1393.40	85	16.39		
Total	1514.04	86			

* Significant at $p < .05$

Table 2 shows computed *F*–ratio of 7.36 is significant at .05 level. This means that the posttest scores of students who used shuffled format of practice really differ from the posttest scores of students who used the blocked format of practice.

Table 3. Mean and Standard Deviation of Students' Pretest and Posttest on Self-Test for Mathematics Test Anxiety Scores in Terms of Format of Practice

Format of Practice	Pretest		Posttest	
	Mean	S.D.	Mean	S.D.
Control Group	3.34	.73	3.37	.80
Experimental Group	3.45	.75	3.14	.83

Table 3 shows that the students of both control and experimental groups have the same level of feeling of uncertainty about mathematics test anxiety before the treatment period as revealed by their pretest mean scores. After the treatment period, the posttest mean scores of both groups show that the students in control and experimental groups were still on the same level of feeling of uncertainty about mathematics tests anxiety. However, it can be noted that the mean score has slightly decreased in the control group by – 0.03 (or by –0.90%) and in the experimental group by 0.31 (or by 8.99%). This indicates that after the treatment period, the students in the control group became slightly more uncertain of their mathematics test anxiety feeling while the students in the experimental group became less slightly uncertain of their mathematics test anxiety feeling.

Table 3 further shows that the pretest standard deviations of the two groups have negligible difference but are quite high indicating that before the treatment period the student in both groups have dispersed feeling of mathematics test anxiety. After the treatment period, the standard deviations of the two groups still differ negligibly but both slightly increased as revealed by the posttest standard deviation. This means that students' feeling of mathematics test anxiety in the two groups became more dispersed. From this result, it can be inferred that either of the two formats of practice tests can be an effective tool for separating mathematics test anxious students and not mathematics test anxious students.

Table 4. Summary Table of One-Way ANCOVA for Self-Test for Mathematics Test Anxiety by Format of Practice

Source of Variation	Adjusted Sum of Squares	df	Adjusted Mean Squares	Computed F-ratio	P
Format of Practice	1.98	1	1.98	4.82*	.031
Error Within	34.97	85	.41		
Total	36.96	86			

*Significant at $p < .05$

Table 4 shows that computed *F*–ratio of 4.82 is significant at .05 level. This means that, however small is the difference, the self–test for mathematics test anxiety scores of students who used shuffled format of practice really differ from the posttest scores of students who used the blocked format of practice.

Table 5: Students' Self-Test for Mathematics Test Anxiety Pretest and Posttest Mean Scores and Percent Decrease per Math Test Anxiety Indicator in both Formats of Practice

No.	Mathematics Test Anxiety Indicator	Blocked Practice		Shuffled Practice	
		Pre	Post	Pre	Post
1	I worry so much before taking a math test.	3.77	3.73	3.70	3.39
2	I am afraid of taking a math test.	3.34	3.36	3.27	2.98
3	I get so worried when I have to take a surprise math test.	3.61	3.77	3.84	3.66
4	While taking a math test, I think a lot that I may fail the test.	3.45	3.48	3.72	3.41
5	After taking a math test, I feel I could have done it better than I actually did.	3.36	3.52	3.63	3.45
6	I usually forget some important facts while taking a math test.	3.57	3.68	4.07	3.32
7	I worry about a coming math test even if I already have studied well for it.	3.39	3.16	3.16	2.93
8	I feel very tense just before getting a math test paper back.	3.36	3.52	3.57	3.34
9	I get so nervous when my math teacher announces a test date.	2.55	2.61	2.52	2.48
10	I worry very much about how well I am doing in a math test much more than tests in other subjects.	3.48	3.43	3.43	3.30
11	If I miss a math test because I was absent, I worry very much that I will be behind my classmates when I come back to school.	3.52	3.18	3.61	3.52
12	I usually feel I need to be in a hurry every math test.	3	2.95	3.05	2.73
13	I lose focus in a time pressured math tests.	3.73	3.91	3.81	3.48
14	The more items a math test has, the more scared I feel.	3.09	3.41	3.32	2.98
15	As I answer every item in a math test, I usually get very worried thinking the next item is more difficult.	2.89	2.84	2.98	2.84

Table 5 shows how the students' self-test for mathematics test anxiety scores compare with respect to the two formats of practice per mathematics test anxiety indicator. In blocked practice, only mathematics anxiety indicator nos. 1, 7, 10, 11, 12 & 15 (or 33% of all the indicators) were lessened after the use of the blocked practice format where no. 11 indicator was the most lessened (about 9.68% decrease). In shuffled practice, impressively, all (or 100%) of the mathematics anxiety indicators were lessened after the use of the shuffled practice format where no. 6 indicator was the most lessened (about 18.44% decrease). Therefore, shuffled format of practice remarkably, lessen students' mathematics test anxiety compared to blocked format of practice.

4. DISCUSSIONS

In the present study, the higher mathematics achievement test posttest performance resulted from the use of shuffled practice than the use of blocked practice (about 86.62% vs. 69.20% increase respectively) showed that the benefit of shuffled practice in improving achievement test performance can hold not only for shuffled practice set that composed of superficially similar problems only but of superficially different problems as well. This means that the benefit of shuffled format of practice can also hold where problems require deeper comparisons of tasks in the working memory.

The positive benefit of shuffled practice compared to blocked practice of mathematics problem solving in selected topics in intermediate algebra may be attributed to the new theory of disuse as discussed in [13]. The theory states that memory of an item, without continued use, traces decay. In order to boost retrieval strength of the item, one has to retrieve the item himself through deeper and more effortful processing of the item. The more difficult the retrieval is, due to the presence of interference (that is, shuffling of different types of problems), the more beneficial it will be when one finally does come up with the item. This deeper processing is what forced the students in shuffled practice to do when answering problems so that after corrective feedback, the corrections made a bigger impact in their mind which resulted to better retention enough for them to obtain better posttest mean score. Thus, more students who used shuffled practice obtained lower practice performance because of their difficulty in answering the practice test but obtained higher score in the posttest. The positive benefit of using the shuffled format of practice may be due to the fact that the more they were exposed to the format of practice, the better their thinking ability functioned so that important concepts and procedure were somehow retained in their mind for a longer time.

Moreover, [13] and [14] proposed that the difficulty the students experienced in shuffled practice which caused them to obtain degraded performance during practice may be considered as a desirable difficulty which suggests that introducing certain difficulties into the learning process can greatly improve long-term retention of the learned material. These difficulties encourage deeper processing of materials which encourages long-term retention.

Another positive benefit of shuffled format is the discrimination ability training it provided. Shuffling of mathematics problems improves student's discrimination ability because it gives them the opportunity to recognize which features of a problem are relevant to the choice of concept or procedure. This opportunity to recognize which features of a problem are relevant to the choice of concept or procedure is a key element needed in problem-solving which is the heart of mathematics learning according to [1], which, sad to say, most mathematics students often struggle to develop. Thus, shuffled practice is suited as a reinforcer of mathematics learning.

The present study also showed that students who used shuffled practice lessen their mathematics test anxiety. This is good news since more than half of the students in the experimental group generally did not favor the shuffled practice format and said they felt more anxious when taking shuffled practice tests than when taking the achievement test posttest. On the other hand, students in the control group said they were comfortable with the blocked format of practice and felt less anxious when taking the blocked practice tests than when taking the achievement test posttest.

After the treatment period, generally, all students in both groups were still uncertain about their feeling of mathematics test anxiety. The students who used shuffled practice format, however, felt the lesser uncertainty. This result may be due to the fact that arrangement of problems in the achievement test posttest is the same as the shuffled format of practice which is just reasonable since in any mathematics achievement test, may it be at local, national or international setting, the problems are shuffled. Thus, aside from desirable difficulty and discrimination ability, the shuffled practice format may have provided them with more retrieval practice which provided them better study and test –taking skill and caused to lessen their feeling of mathematics test anxiety.

5. CONCLUSIONS AND RECOMMENDATIONS

Therefore, the findings in the present study ensures the benefits of shuffled practice in mathematics problems solving in terms of boosting achievement test performance and decreasing mathematics test anxiety in learning selected topics in Intermediate Algebra. This study hoped to shed some light on the nature of giving practice sets and on its ability to enhance mathematics learning and lessen mathematics test anxiety level. The extent of its use would offer useful information for organizing, facilitating and evaluating present mathematics instructions.

Based on the conclusions, the researcher has the following recommendations:

1. Shuffled format of practice should be introduced to students especially average and below-average performing students as a reinforcer of learning throughout high school and even college mathematics.
2. Shuffled practice sets can be incorporated when conducting reviews and mock tests for National Achievement Test (NAT), National Career Assessment Examination (NCAE), College Scholastic Aptitude Test (CSAT) and other national assessments.
3. Shuffled practice sets can also be incorporated into mathematics textbooks, which can be accomplished by transforming current editions of mathematics textbooks which require only a rearrangement of practice problems in a textbook.
4. Further study should be conducted to investigate whether the benefit of shuffled practice can still hold in practice sets involving process problems (or problems that has no single possible answer) or problems that require higher order thinking.

REFERENCES

[1] Rohrer, D. *The Effects of Spacing and Mixing Practice Problems - Research Commentary*, Journal for Research in Mathematics Education, Vol 40, Number 1, January 2009.

[2] Salend, S.J. *Addressing Test Anxiety - Teaching Exceptional Children*, 44, 2; ProQuest Education Journals pg. 58, November/December 2011.

[3] Kornell, N. & Bjork, R. A. *Learning Concepts and Categories: Is Spacing the "Enemy of Induction?"* Psychological Sciences, 19, 585-592, 2008.

[4] Kornell, N., Castel, A. D., Eich,, T.S. & Bjork, R. A., *Spacing as the Friend of Both Memory and Induction in Younger and Older Adults, Psychology and Aging, 25*, 498-503, 2010.

[5] Keller, Li, Weiss, and Relyea, *Contextual Interference Effect on Acquisition and Retention of Pistol–Shooting Skills*, Perceptual and Motor Skills, 103(1): 241 – 52, August 2006.

[6] Vera, Alvarez, and Medina, *Effects of Different Practice Conditions on Acquisition, Retention, and Transfer of Soccer Skills by 9 – Year – Old School Children*, Perception Motor Skills, 106(2): 447 – 60, April 2008.

[7] Menayo, Moreno, Sabido, Fuentes and Garcia, *Simultaneous Treatment Effects in Learning Four Tennis Shots in Contextual Interference Condition*. Perception Motor Skills, 661-73, April 2010.

[8] Taylor, K. & Rohrer, D., *The Shuffling of Mathematics Practice Problems Improves Learning*, Instructional Science, 35, 481-498, 2007.

[9] Taylor, K. *The Benefits of Interleaving Different Kinds of Mathematics Practice Problems*, Theses and Dissertations. Paper 529. http://scholarcommons.usf.edu/etd/529, 2008.

[10] Le Blanc, K. & Simon, D., *Mixed Practice Enhances Retention and JOL Accuracy for Mathematical Skills*, Paper presented at the 49th Annual Meeting of the Psychonomic Society, Chicago, IL. November, 2008.

[11] Taylor, K. and Rohrer, D. *The Effects of Interleaved Practice*, Applied Cognitive Psychology, 2009.

[12] Mazzardo Jr., O. *Contextual Interference: Is it Supported Across Studies?*, A Master's Thesis, University of Pittsburgh, 2004

[13] Bjork, E. L. & Bjork, R. A. *Making Things Hard on Yourself, but in a Good Way: Creating Desirable Difficulties to Enhance Learning*, In M. A. Gernsbacher, R. W. Pew, L. M. Hough, & J. R. Pomerantz (Eds.), Psychology and the Real World: Essays Illustrating Fundamental Contributions to Society (pp. 56-64). New York, Worth Publishers, 2011.

[14] Bye, J. *Desirable Difficulties in the Classroom*, http://www.psychologytoday.com/blog/all-about-addiction/201105/desirable-difficulties-in-the-classroom, 2011.

[15] Raagas, E. L. *Assessment & Evaluation of Student Learning: Concepts & Applications (4th edition)*, Cagayan de Oro City, Philippines, ***E λ r*** DATStaT Analysis Center, 2015

[16] Raagas, E. L. & Sinco, A. *Operation Manual For Data Analysis. 2nd ed.*, Cagayan de Oro City, Philippines, ***E λ r*** DATStaT Analysis Center, 2015

[17] Lund, A. & Lund M. *One-Way ANCOVA in SPSS Statistics*, Laerd Statistics, http://statistics.laerd.com/spss-tutorials/ancova-using-spss-statistics.php

[18] Rothwell, J. *ANCOVA in SPSS* http://www.sheffield.ac.uk/polopoly_fs/1.531299!/.../MASH_ANCOVA_SPSS.pdf