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## **Does Retention Interval Matters in Mathematics Performance?**

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### **Abstract**

This study describes and investigates if an association exist between the retention intervals of the three-grouped student respondents in high school and their performance in the basic algebra. The respondent's performances were categorized into different proficiency levels namely the far below basic, below basic, basic, above basic and proficient. Results revealed that a highly significant association was found between the retention intervals and the level of performance of the respondents. The level of performance of the respondents significantly increased with varying retention interval. An improved shift in the level of performances were observed from test to retest. The recall of information in the basic algebra was strengthened as retention interval increases particularly to high performing students. Respondents' exposure to related advance academic mathematics learnings, practice as well as maturity may have contributed to the mathematical performance across retention intervals of the respondents.

**Keywords:** Basic algebra; performance; proficiency; association; retention interval.

### **1. Introduction**

In the field of education and psychology many issues particularly on the individual's learning deteriorates over times.

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Is this true or not true? Perhaps it can be true to some specific field of study, however many studies have some conflicting results. Psychological theories were very beneficial for mathematics education since psychology has a strong influence in the field especially in learning numbers. On the other hand, mathematics education theories on the learning of numbers had been strongly influenced by the work of [1] that is for example that the assumption that children's ability to understand numbers is limited by their general cognitive maturation which perhaps involve time has certainly influence shaping educational approaches to teaching of mathematics in the classroom and the way teaching of mathematics particularly numbers was sequenced in the curricula [2]. In the aspect of retention, many researchers discussed many results on the studies on retention interval or sometimes called spacing over mathematics performance. For example, in the study of [3] on improving student's long term retention performance particularly in the personalized retention schedules, they suggested that personalized knowledge retrieval schedules are more effective than fixed schedules that is, in particular the students' long-term performance can be improved by giving them tests that are well spaced out and should be scheduled appropriately before gradually expanding the spacing between these tests. In their method, they were concerned with estimating the effects of personalized expanding intervals on improving students' long-term mastery level of skills. They developed a method called Personalized Adaptive Scheduling System (PASS) in ASSISTments' retention and relearning workflow. After applying the PASS, they conducted an investigation to the impact of personalized scheduling on long-term retention by comparing results from 97 classes in the summer of 2013 and 2014. They observed that students in PASS outperformed significantly students in traditional scheduling systems on long-term retention performance and that in particular, students with medium level of knowledge demonstrated significant reliable improvement with had a moderate effect size. In addition, the data we gathered from this study also helped to expose a few issues we have with the new system. These results suggested that personalized knowledge retrieval schedules were more effective than fixed schedules and suggested that more study should be made on examining approaches to optimize PASS. Reference [4] investigated the effect of distributed practice on the mathematical performance of eighty-one 7th graders. After a random lesson, one group of students worked three sets of exercises massed on one day, while the other group of students worked the same exercises distributed over three days. When they analyzed the data, they found out that performance for two weeks after the last practice revealed no evidence of an effect of practice condition. But, in a test given after six weeks, the result suggested a strong evidence for a positive effect of distributed practice came out. Further analysis indicated particularly for students in the medium performance range benefitted from distributed practice. This distributed practice in mathematics answered the questions of why and under which circumstances distributed practice proves a useful learning strategy in realistic learning contexts, even beyond learning of rather simple verbal content. They argued that while the effect of distributed practice emerges for roughly all learners if simple verbal content or mathematical routines are practiced, the effect of distributed practice on learning of more complex content for example on the acquisition and application of higher learning mathematical procedures is effective for students in the medium performance range. According to the authors, these assumptions were based on exploratory analyses and there is a need for further empirical confirmation. They concluded that that distributed practice remains a promising learning strategy and more studies on a broad range of content and learners could help to deepen the understanding of when and why it works which is quite related to our study. Reference [5] discussed issues regarding increasing retention without increasing study time which is quite interesting on our study with retention intervals. They argue that because people forget much

of what they learned, students could benefit from learning strategies that yield long-lasting knowledge. Yet surprisingly little was known about how long-term retention is most efficiently achieved. In their study, they examined how retention was affected by two variables: the duration of a study session and the temporal distribution of study time across multiple sessions. Their study resulted and suggested that a single session devoted to the study of some material should continue long enough ensuring that achievement of mastery but that immediate further study of the same material is an inefficient use of time. Their data showed that the benefit of distributing a fixed amount of study time across two study sessions called the spacing effect that depends jointly on the interval between study sessions and the interval between study and test. They said their findings showed some practical implications to mathematics learning. References [6,7] made contribution in the studies regarding effects of retention on the performance of Calculus. Reference [6], in their study on retention of concepts and skills in traditional and reformed applied calculus mentioned that a recent calculus reform initiatives have shifted emphasis from rote memorization and symbol manipulation to conceptual understanding and practical application to strive to make calculus more meaningful to students. A question they posed that said, is reform calculus making a difference? Their study compared outcomes of a traditional and reform calculus course in terms of students' retention of basic concepts and skills after the passage of time. Although in their result, traditional and reform students did not significantly differ on the overall performance however reformed students retained better conceptual knowledge and traditional students retained better procedural knowledge. Those reformed calculus students demonstrated that concepts and can be understood before computational competence will be achieved while [7] in their study among engineering students on the long-term retention of basic mathematical knowledge and skills, they focused on the long-term retention of basic mathematical techniques in a first-year calculus course, involving a sample group of engineering students at the University of Pretoria. They investigated which and how much of the basic mathematical knowledge and rote skills acquired in the first year of study were retained after a further two years of study. Their results showed that there was a significant decline in the performance over a two-year period. There were, however, areas in which students still performed reasonably well after the elapsed period or even showed improvement. The research was of diagnostic value since it assisted course designers in determining what basic mathematical skills and knowledge were retained after a period of two years in their teaching approach to and emphasis of different topics. This paper wanted to explore whether an association exist between the retention intervals and the performance of the spacing three retention interval groups of high school respondents particularly in their basic algebra subject. Some studies of similar objectives can be read in the work of [8] which studied relationship of time and learning retention, Reference [9] who investigated the relationship between retention in first grade and performance on high stakes tests in third grade, Reference [10] who were interested in a longitudinal study of mathematics and retention specifically on placement, retention and success and finally [11] who were interested in the length of the retention interval, forgetting and subject similarity. The results of this study would be helpful in providing teachers some perspective on how students learn and retain information about mathematical concepts and procedures in particular give them ideas on appropriate actions to facilitate better retention of information. As many centers and clients of educational endeavors, results can benefit students to have a better understanding on their mental processes and maturation, thereby, giving them ideas to what actions can be done to improve their performance and retain more information. Results also of this study may be used by school administrators in their decision-making concerning the arrangement of subjects in the school curriculum which

should always be designed for the improvement of human learning capacity particularly in mathematics education. This study also provides insights for further research investigations of similar nature and will give a new perspective and trends in educational researches.

### ***1.1. Scope and limitation of the Study***

The respondents of this study will only focus on the performance of 295 students comprising grade 8, grade 9, and grade 10 students respectively of the University Laboratory School in the University of Southern Mindanao, Kabacan, Cotabato, Philippines for academic year 2012-2013. These different groups determine the three-year levels which corresponds to their length of retention interval in their high school. The respondent's performance was only based in the result of the summed examination results that covers the first and second grading period in their elementary Algebra which covers topics on the Real Number System, Percentage, Ratio and Proportion, Measurement, Algebraic Expressions, and Polynomials. Other topics on the succeeding grading periods were not included in the study. We further assumed that the respondents received the same coverage and level of instruction in their grade 7, since the respondents were taught by the same teacher for the last three years. Further, we disregard those students who are transferees they will not satisfy the requirements of our respondents do not have data results in their grade 7. For further information about the data please refer to the work of [12].

## **2. Materials and Methods**

### ***2.1. Experimental Design***

This research employed a Test-Retest Comparative Design where the three year levels represented the different retention intervals. All the three different groups respondents totaling 295 students (118 students for 1-year retention, 90 students for 2 years' retention and 87 students for 3 years' retention groups) were given the same teacher validated test in their grade 7 by the same teacher who taught them the subject. Under the one-year retention interval, the grade 8 students received their test on October 2011. Those treated under two years' retention interval were the grade 9 students and received their test on October 2010 and lastly those treated under three years' retention interval were the grade 10 students and received their test on October 2009. For the retest, the same test instrument was administered to the same three groups on February 2013 by the same teacher who taught them in their grade 7 on their basic algebra. The performance of the respondents was determined by their scores in the first test and their re-test. The examination instrument used to get the performance of the students contained 125 multiple choice items. Only the retest was carried out by the researchers since test data were already available and the students took the test during their grade seven in high school as part of their quarterly examination. However, it is also customary to describe the events that took place between the test and the retest. Normally, in the Philippines, for high school, the academic year starts in June and ends in March in the following year but at present due to the COVID 19 pandemic there was an adjustment made by the department of education to refrain from doing face to face instruction but instead doing online and modular instruction.

### 3. Results and Discussions

In order to determine if an association exist between retention interval and the mathematical performance of the students, the data obtained during the experiment was analyzed using Chi-square test for association (dependence), this test is useful for categorical data in a contingency table. Prior to this, the performance level of students was divided into five categories according to the percentage of correct answers of the students in their 125 item test examination. The Categorization is shown in Table 1 below.

**Table 1:** Categorization of Performances. ULS-USM, Kabacan, Cotabato. A.Y. 2012-2013.

Performance level		Description	Percentage of Score Obtained (%)
Numerical Equivalent	Symbol		
1	FBB	Far Below Basic	0-34
2	BB	Below Basic	35-48
3	B	Basic	49-64
4	AB	Above Basic	65-83
5	Prof.	Proficient	84-100

Remark: Shaded cells represent merged categories on the following analyses

Adapted from Mathematics Performance Bands based on 2009 CST Results

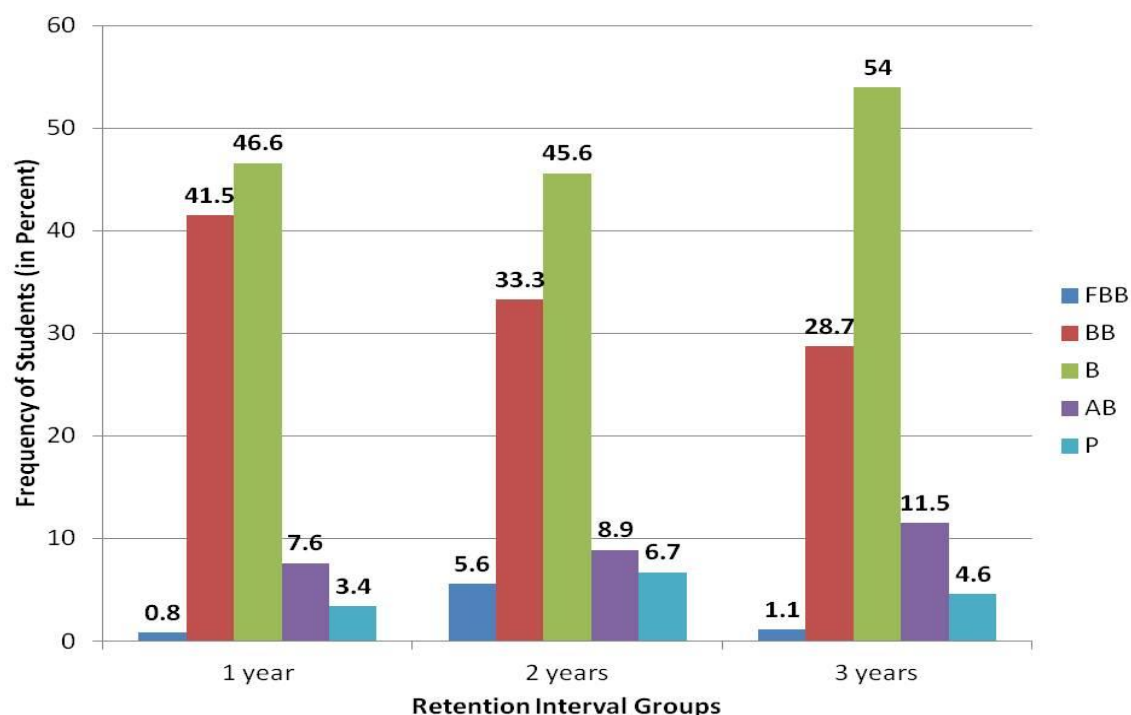
However, after running the preliminary analysis of the data, Results revealed that we need to divide the student's performance into three groups where the Far Below Basic group is merge with the Below Basic group and the Proficient Group merged with the Above Basic group. These merging is necessary to satisfy the assumption of the Chi-square test, that is each cell in the table should have at least five frequency counts. Frequencies of students who belong to different categories after the test and retest were tallied in Tables 2 and 3.

#### 3.1. Description of the Performance level of each Retention group in their Grade 7

Variations in the frequency in the different retention interval groups can be noted from Figure 1.

Apparently, all retention groups in their grade 7 test after they were given instruction were found to have more students who belonged to the basic group and below basic group and in the order above basic, proficient and the far below basic group. In details, 1 out of 118 students or 0.8 % from the 1 year retention interval group; 5 out of 90 students or 5.6% from the 2 years retention interval group and 1 out of 87 students or 0.8 % from the 3 years retention interval group belong to far below basic while 49 out of 118 students or 41 % from the 1 year retention interval group, 30 out of 90 students or 33.3% of the 2 years retention interval group and 25 out of 87 students 28.7 % from the 3 years retention interval group below basic category. The basic category, however, were composed of 55 out of 118 students or 46.6% from the 1-year retention interval group, 41out of 90 students or 45.6% from the 2 years' retention interval group and 47 out of 87 students or 54 % from the 3 years' retention interval group. The above basic category was composed of 9 out of 118 students or 7.6 % from the 1-

year retention interval group, 8 out of 90 students or 8.9 % from the 2 years' retention interval group and 10 out of 87 students or 11.5 % from the 3 years' retention interval group. Moreover, there were only 4 out of 118 students or 3.4 % from 1-year retention interval group, 6 out of 90 students or 6.7% from the 2 years' retention interval group and 4 out of 87 students or 4.6% from the 3 years' retention interval group who belonged to the above basic to Proficient category.



**Figure 1:** Frequency of Students (in percent) in Different Categories (Test). ULS-USM, Kabacan, Cotabato. A.Y. 2012-2013.

Generally, there were 7 out of 295 students or 2.4% under far below basic category, 104 out of 295 students or 35.3% under below basic category, 143 out of 295 student or 48.5 % fell under basic category, 27 out of 295 students or 9.2 % fell under above basic category, and only 14 out of 295 students or 4.7 % of all students reached the proficient level.

### 3.2. Analysis on the Association Between Performance and Retention Interval (Test)

The analysis of the categorical data in table 2 revealed that there was no significant association between the retention interval and the level of performance of the students ( $\chi^2=4.111$ ,  $p>0.05$ ). This means that we do not have sufficient evidence to conclude that a significant association exist after the learning instruction between with retention interval and the level of performance of the students. This held true since all the subjects of the experiment were tested when they were all first year student and no amount of retention interval were given to each group and their mathematical abilities perhaps were found to be equivalent and comparable with results from the literatures. Further, their exposure to learning is uniformly delivered since they have the same teacher who thought them during the period so retention is not a big issue yet.

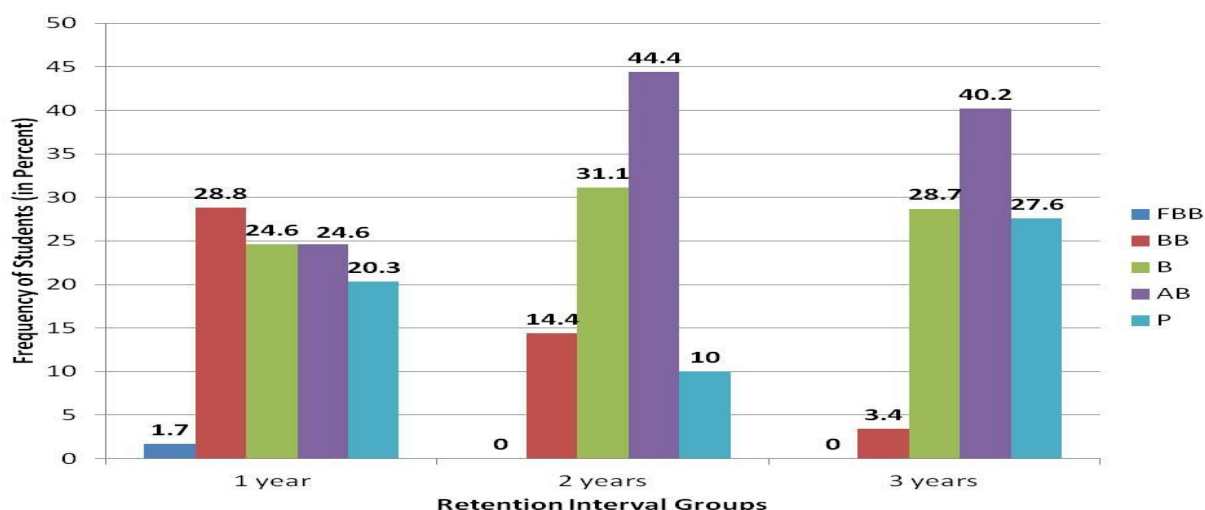
**Table 2:** Test of Significant Association between Retention interval and Performance level (Test) ULS-USM, Kabacan, Cotabato. A.Y. 2012-2013.

Retention Interval Group	Performance Level			Total
	FBB – BB	B	AB - Prof.	
	(1)	(2)	(3)	
1 year	50	55	13	118
2 years	35	41	14	90
3 years	26	47	14	87
Total	111	143	41	295

$X^2 = 4.111$ ,  $df = 4$ ,  $p\text{-value} = 0.391^{ns}$ , ns=not significant at 5% level of significance

### 3.3. Description of the Performance level of each Retention group during Retest

In contrast to the data presented in figure 1, figure 2, however presents a different pattern. After treating each group with the specified retention interval, it was found out that after a year, the frequency of students under below basic and basic categories dropped substantially which contributed to the large increase in the frequency of students who fell under above basic and proficient categories. Similar conclusion can also be deduced from the group treated with 2 and 3 years' retention interval. The frequency of students under far below basic fell down to none after 2 and 3 years' retention interval. Categorical analysis on each group revealed that after 1-year retention interval, far below basic category increased to 2 out of 118 students or 1.7%, below basic category decreased to 28.8 % or 34 out of 118 students, basic category decreased to 29 out of 118 students or 24.6%, above basic category increased to 24.6 % or 29 out of 118 students, and the proficient category increased to 20.3 % or 24 out of 118 students.

**Figure 2:** Frequency of Students (in percent) in Different Categories (Retest) ULS-USM, Kabacan, Cotabato. A.Y. 2012-2013.

However, after 2 years' retention interval, the group was 0 % or 0 out 90 students for far below basic performance level and 14.4 % or 13 out of 90 students from below basic performance level, 31.1 % or 28 out of 90 students from basic students and 14.4 % (40 out of 90 students) and 10 % or 9 out of 90 students from above basic and proficient performance levels respectively. On the other hand, after 3 years' retention interval, the group has 0 % or none of 87 students from far below basic performance level and 3.4 % or 3 out of 87 students from below basic, 28.7 % or 25 out of 87 students from the basic performance level and 40.2 % or 35 out of 87 students for above basic and 27.6 % or 24 out of 87 students from proficient performance level. Overall for all students regardless of the student's retention interval groups, there was 2 out of 295 student or, 0.7 % from far below basic, 150 out of 295 students or 6.9 % of students fell under below basic, 82 out of 295 students or 27.8% of students fell under basic category, 104 out of 295 students or 35.3 % fell under above basic category and 57 out of 295 students or 19.3% fell under proficient category with the treatment of retention intervals.

### 3.4. Analysis on the Association Between Performance and Retention Interval (Retest)

**Table 3:** Test of Significant Association between Retention interval and Performance (Retest) ULS-USM, Kabacan, Cotabato. A.Y. 2012-2013.

Retention Interval Group	Performance level			Total
	FBB – BB	B	AB - Prof.	
	(1)	(2)	(3)	
1 year	36	29	53	118
2 years	13	28	49	90
3 years	3	25	59	87
Total	52	82	161	295

$X^2 = 27.184$ , df= 4, p-value =0.000\*\*, \*\* highly significant at 0.01 level of significance

Using Chi-square test for independence or association on the preceding data as shown in Table 3, results revealed that there was a highly significant association between the retention intervals and the performance levels of the students ( $X^2 = 27.184$ , p-value < 0.01). We observed that there was a shifting of frequencies of students across each different category. One can see from the comparison of the categories in Figure 2 that any increase in retention interval causes a decline in the frequency of students who were under far below basic up to basic category. Even though there was no definite pattern, relative frequency of students in the above basic and proficient category generally continues to push upward as retention interval increases. It should be noted that far below basic category fell down to zero frequency when retention interval was increased. An important revelation that substantiated the claim that the properties of retention interval strengthens the students' prior mathematical knowledge. Thus, it would only mean that increasing retention interval tends to enhance students' expertise in mathematics as they are exposed to numerous academic trials and learning that provided avenues for practice of old and new knowledge as well as elaboration of newly learned materials with the already learned materials [12]. Further, [13] mentioned in their experiment that students assigned in the distributed rereading condition showed no forgetting from the short to the long retention interval and have beneficial effects on



learning. In relation to our study, more importantly in the retest, it was being observed that the frequency of students shifted towards higher level of achievement as a result of increasing retention interval and its properties like frequency of practice, exposure to related academic trials, and maturity entwined with time are possibilities to explain this phenomenon however our result is in contrast to the result of [11]. They argued that a long retention interval tends to result in the poor retention known as forgetting. A high subjective similarity between stimuli frequently produces their poor retention. Further, they said that a high subjective similarity between stimuli frequently produces their poor retention hence, a long retention interval may increase the subjective similarity between stimuli and this increase may produce forgetting and therefore may produce overall poor performance. Further, in the business field, Reference [8] in his focus of examining the importance of course sequencing in a curriculum, explored the degree to which students' understanding, or knowledge, may deteriorate over time. They measured the student performance in the quantitative business courses and found that over time, a correlation existed between students' performance in those courses but it declined significantly and these decline was nonlinear. Our study resulted in a direct association, where there was an increase in the overall performance as retention intervals increased. One explanation is due perhaps to maturation and exposure of the student respondents to more advanced mathematical concepts especially for those have more retention years. This is expected usually in mathematics education, where the curricula were arranged in such a manner that a student exposed first with basic course in mathematics then in an increasingly manner they were exposed to more advanced mathematics as retention interval increases as mentioned by [2] and their mathematical basic concept were retained [6]. The student as being taught and exposed gradually, leading to a more polished skills and expectedly and efficiently able to recall their basic mathematics because the procedural process which requires skill to solve advanced learning in mathematics is necessarily needed therefore there is a higher tendency basic mathematics were retained specifically in a particular subject like in our study the basic algebra as mentioned by [7].

#### **4. Conclusions**

As we observed in this study, the level of performance of the student respondents significantly increased with their varying retention interval. An improved shift in the level of performances among the three groups of students were observed from test to retest and a significant association existed between these performances and the retention years in the retest. Thus, with respect to this experiment, the recall of information in the content of the basic algebra that was in consideration in the test examination resulted to a better overall performance of the students. Perhaps this is strengthened due to the maturation and exposure of the students to more advance mathematics learning and practice in between the test and retest period in which greater advantage been seen on the overall performance to students with more retention years.

#### **5. Recommendations**

This study only considered in particular basic mathematics content in the experiment, the researchers recommend that this study might be replicated using other fields like in natural sciences or in languages, maybe a different scenario in turn may occur.

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