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Impact of time between cognitive tasks on undergraduate mathematical performance in Rivers State, Nigeria

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Abstract
This study investigated the effects of temporal proximity of examinations on undergraduate mathematical performance in the department of mathematics and statistics, Ignatius Ajuru University of education. The ex-post facto design was adopted. A sample size of 44 level 300 trainee teachers of the department participated in the study. The 2012/2013 academic session first-semester examination results of the students in six (6) departmental courses were collected. The bar chart, mean, standard deviation, and Pearson Product Moment Correlation were used for data analysis. The findings indicated that the overall achievement of students in the first-semester mathematics courses was low. Massed examination time impacted negatively on student achievement in numerical methods and differential equation. There were positive and significant interrelationships between student performances in the first semester mathematical courses. It was recommended among others that faculty examination committee should ensure that mathematical courses are space-out for student optimal performance in cognitive tasks.

Keywords: Impact, time, cognitive tasks, undergraduate, mathematical performance

Introduction
The temporal proximity of examinations has been a source of concern to all students of Ignatius Ajuru University of Education (IAUE) Port Harcourt, Rivers State, Nigeria while other universities are not excused. Specifically, undergraduates in the department of mathematics, IAUE, often grumble about the propinquity of the spacing between examinations. The attention of the researchers was drawn to the subject when students on CGPA of 3.5 or above were found complaining over the nearness of two advanced mathematics examination papers written thirty minutes apart in the 2012/2013 first semester departmental examination period. Table 1 shows an extract from the 2013 first semester examination calendar for the department of mathematics showing the spacing between examinations. Experience also shows that when examinations are massed together, student achievement sometimes diminishes considerably.

There is the likelihood of the occurrence of cognitive fatigue and its consequent effect on performance when a rapid sequence of mental tasks is scheduled. Fillmore and Pope, (2012) [5] established that shorter amount of time between examination papers is associated with lower scores, particularly on the second examination. The study further indicated that students who take examinations with at least 10 days of separation are 8% more likely to pass both examinations than students who take the same examinations with only one-day separation. However, spacing effects are very robust and have vital implications for memory and education, people often misjudge the benefits of spaced repetition when learning, possibly due to the reliance on processing fluency during the study and attending to repetition, and not taking into account the helpful aspects of study schedule. Suitable temporal spacing of study can lead to enhanced memory and learning (Cepeda, Pashler, Vul, Wixted and Rohrer, 2006; Logan, Castel, Haber & Viehman, 2012) [2, 6].

Cognitive load theory is anchored on the idea that working memory is limited and that performance, reasoning, and learning retrogresses as the working memory becomes loaded (Fillmore and Pope, 2012) [5]. Therefore, every task in nature demands some specific energy which is propelled by intended outcome or result on performance.

The interval between successive task or events is a function of the applied energy on the task. When a task demand is prolonged more energy is required otherwise the outcome or expected results on performance will be reduced. To avert this, a good time lapse is required to cause a recovery for optimal performance. Every physical activity of man demands recovery after (during) rest in the mental task. This raises serious concern on the impact of time on task performance. Memory performance benefits from the repeated presentation of items, and long-term retention benefits when these items are spaced apart in time, rather than massed. This "spacing effect" has been demonstrated in a number of instances, with different populations, and is a highly robust phenomenon (Cepeda *et al*, 2006, Logan *et al*, 2012) [2, 6]

In the event of determining the impact of time on successive task performance, using mere observational data can be challenging especially when the time between tasks is likely endogenous (Fillmore & Pope, 2012) [5]. Ackerman and Kanfer (2009) [1] argue that the evidence is inconclusive regarding the impact of examination length on performance and produce empirical results that actually find out that performance can improve with examination length. Cepeda, *et al.* (2006) [2] suggests that proper temporal spacing of study can lead to enhanced learning and memory. Coviello, Ichino, and Persico (2010) [4] showed that Italian judges who were randomly assigned to work on several trials in parallel spent extra time as opposed to doing the trial one after the other.

In a bid to structure the learning effect in a proper manner, it becomes necessarily fundamental to understand how the gap between two exposures affects forgetting or forgetfulness. There are existing interactions on this study. Cepeda, *et al* (2006) [2] has it that spacing experiment should involve multiple periods of study devoted to the same material, separated by the same valuable time gap, with a final memory test administered after an additional retention interval (RI) measured along the second exposure. Fillmore and Pope (2012) [5] found that there exist an approximately linear relationship between 1 and 10 days between examinations. The study further stated that understanding how students handle multiple tasks that occur in close temporal proximity is an important but difficult issue to address empirically. Therefore, a study geared toward understanding the effect of the temporal proximity of examinations on student performance in mathematics at the university level is worthwhile and timely.

Table 1: An extract from the 2013 first semester examination calendar for the Department of Mathematics/Statistics IAUE PH showing the spacing between examinations.

Day/Date	Morning 8.30 - 11.30-am	Afternoon 12.00- 3.00pm	Evening 3.30–6.30pm
	Course	Course	Course
Wednesday, April 10	STA 311 Statistical Inference	MAT 214	MAT 311 Abstract Algebra II
Thursday, April 11		MAT 312 Classical Mechanics	
Friday, April 12		MAT 315 Teaching Mathematics in SSS	MAT 213 PHY 212
Wednesday, April 17	STA 211		MAT 211
Thursday, April 18		MAT 313 Numerical Methods	MAT 316 Differential Equation II

Problem specification

Student mathematical performance in both the secondary and the tertiary levels of education is questionable. It is agreed that mathematics require students to study hard to be successful in their studies. The ability to retain the learned materials and recall them under examination conditions is tasking for every student. This is made easier when the time between examinations give students time for the revision of the studied materials before confronting the examination.

Studies have indicated that time between cognitive tasks is impactful on student achievement. However, most of these studies were conducted outside of Nigeria. To the best of the researchers' knowledge, no study has been conducted in the Rivers State of Nigeria on the effects of temporal proximity of examinations on undergraduate student performance in mathematics. To plug this gap in knowledge, this study intended to investigate the effects of time between cognitive tasks of a mathematical variant on undergraduate mathematical performance in the department of mathematics/statistics at Ignatius Ajuru University of education. Specifically, the objectives of the study were:

1. To determine the effect of temporal proximity of examinations on the performance of undergraduates in the first-semester departmental courses
2. To determine interrelationships between the mathematics students' performance in first-semester departmental courses.

Research questions

The followed research questions guided the present study:

1. What was the effect of the temporal proximity of examination on the performance of undergraduates in the first-semester departmental courses?
2. How can we describe the interrelationships between the mathematics student performance in first-semester departmental courses?

Materials and Methods

This study investigated the effects of temporal proximity of examinations on student achievement in mathematics. The ex-post facto design was adopted. A sample size of 44 level 300 trainee teachers (B.Sc. Ed) of the department of mathematics and statistics, Ignatius Ajuru University of Education participated in the study. The 2012/2013 academic session first-semester examination percentage (%) grades result of the students in six (6) departmental courses were collected and served as the research data. Examination papers written less than 24 hours apart were assumed to be massed examination situation while examination papers written above 24 hours apart were considered as spaced examination situation. The researchers collected the data from the office of the head of the department for explorations. The line graph, mean, standard deviation and Pearson Product Moment Correlation were used for data analysis.

Results

Table 2: Effects of time between examinations (massed/spaced) on student mathematical performance

Course-Tags	Course score difference I-J	(I)	(J)	Mean diff. (I-J)	Time lag (days)	Exam situation
A	STA311-MAT311	49.57	52.93	-3.36	0	Massed
B	MAT311-MAT312	52.93	58.14	-5.21	1	Massed
C	MAT313-MAT316	40.48	40.80	-0.32	0	Massed
D	STA311-MAT312	49.57	58.14	-8.57	1	Massed
E	MAT311-MAT315	52.93	46.09	6.84	1	Massed
F	MAT312-MAT315	58.14	46.09	12.05	1	Massed
G	STA311-MAT315	49.57	46.09	3.48	2	Spaced
H	STA311-MAT313	49.57	40.48	9.09	8	Spaced
I	STA311-MAT316	49.57	40.8	8.77	8	Spaced
J	MAT311-MAT313	52.93	40.48	12.45	8	Spaced
K	MAT311-MAT316	52.93	40.80	12.13	8	Spaced
L	MAT312-MAT313	58.14	40.48	17.66	7	Spaced
M	MAT312-MAT316	58.14	40.8	17.34	7	Spaced
N	MAT315-MAT313	46.09	40.48	5.61	6	Spaced
O	MAT315-MAT316	46.09	40.80	5.29	6	Spaced

Table 2 further shows the mean difference in the scores of students between two courses each. Estimated time between each pair of the examination was initially quantified in hours and then converted into days. Time interval below 1 day when rounded off was regarded as zero-day. The time between two exams, less than or equal to 1 day was assumed to be massed exams while those up to 2 days or more were considered as spaced exams. The mean score and standard deviation (SD) of students in the six(6) departmental courses examined were MAT 311, Abstract Algebra II, (M=52.93, SD=13.83), MAT 312, Classical Mechanics, (M=58.14, SD=13.49), MAT 313, Numerical Methods, (M=40.48, SD=19.25), MAT 315, Teaching Mathematics in SSS, (M=46.09, SD=14.52), MAT 316, Differential Equation II,(M=40.8, SD=16.04), and STA 311, Statistical inference (M=49.57, SD=19.52) respectively. The overall performance of the students in the first-semester mathematics courses was generally low (M=48.00, SD=17.35).

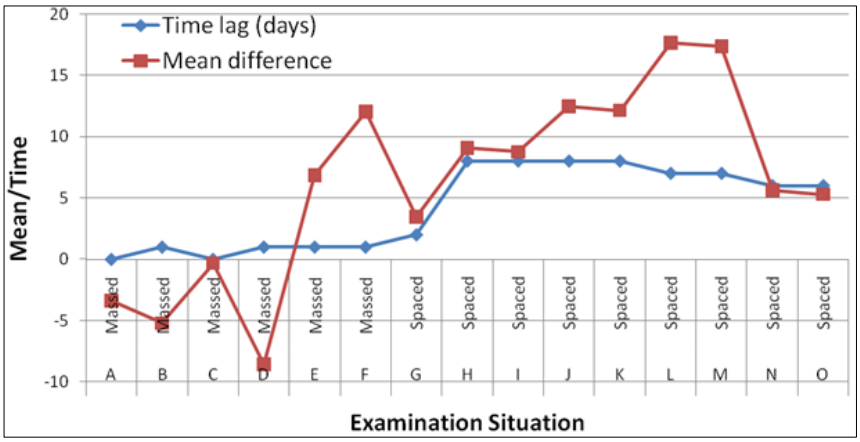

Fig 1: A chert showing the effect of spacing between examinations on student performance in the mathematics

Figure 1 shows that the difference between the scores of students on STA311 and MAT311 was -3.36 and MAT 311 was written less than a day after STA 311, the difference between the scores of students on MAT311 and MAT312 was -5.21 and MAT 312 was written just a day after MAT311 and the difference between the scores of students on MAT313 and MAT316 was -0.32 and MAT316 was written less than a day after MAT313. Mean grade difference seemed to increase with paper spacing.

Table 3: Correlation matrix of the interrelationships between students' performance in the first-semester mathematics courses (N=44).

		1	2	3	4	5	6
(1)MAT311	Pearson Correlation	1					
	Sig. (2-tailed)						
(2)MAT312	Pearson Correlation	.383*	1				
	Sig. (2-tailed)	.010					
(3)MAT313	Pearson Correlation	.705**	.468**	1			
	Sig. (2-tailed)	.000	.001				
(4)MAT315	Pearson Correlation	.593**	.540**	.694**	1		
	Sig. (2-tailed)	.000	.000	.000			
(5)MAT316	Pearson Correlation	.651**	.481**	.672**	.721**	1	
	Sig. (2-tailed)	.000	.001	.000	.000		

(6)STA311	Pearson Correlation	.635**	.486**	.746**	.727**	.709**	1
	Sig. (2-tailed)	.000	.001	.000	.000	.000	
*. Correlation is significant at the 0.05 level (2-tailed).							
**. Correlation is significant at the 0.01 level (2-tailed).							

Results in Table 3 shows the correlation matrix on the interrelationship between student performance in the first-semester mathematics courses. It further shows that the interrelationship between the first-semester mathematics courses were all positive and significant (p<.05). The strongest relationship was obtained between STA311 and MAT 313 (R=.746, p=0.00). This was closely followed by the relationship between STA 311 and MAT 315 (R=.727, p=0.00) and the least relationship was between MAT 311 and MAT 312(R=.383, p=.010). Specifically, the relationship between MAT 313 and MAT 316 (R=.672, p=.000) was also strong, positive and significant.

Discussion

The statistical results in Table 2 show that mathematical courses, numerical methods (MAT 313) and differential equation (MAT 316) where examinations were written on the same day (specifically, spacing 30 minutes apart), had the lowest mean scores when compared with those written on different days. The mean score of the students in numerical methods was almost equivalent to that of differential equations II. The difference between the student mean scores in the courses was -0.32 indicating that students performed poorly in the second exam. Similarly, Statistical Inference and Abstract Algebra II were written on the same day, but with about three (3) hours spacing between the two examinations, with a mean difference of -3.36. The longer hours of spacing may have accounted for better performance when compared with the former with only thirty (30) minutes spacing between examinations on numerical methods and differential equations II. Figure 1 shows that massed exams seem to decrease student mathematical performance. Specifically, the result established that when a mathematics examination is written less than 1 or two days apart, student performance in the second examination diminishes.

There seem to be double-barreled reasons for student poor performance in numerical methods and differential equation II. First, the students may have hurriedly worked through the morning paper (numerical methods) so as to have more time to prepare for the next examination. The time (duration) for preparation for the afternoon paper (differential equation II) might not have been adequate for sufficiently meaningful homework before the second examination. Secondly, the two courses were mathematical courses, requiring serious concentration and revision on the part of the students. There might not have been enough time to enable students to prepare adequately, to firmly grasp the numerous procedures required to successfully solve the lengthy tasks involved in advanced mathematical problem-solving. This suggests that the time between two or more examinations in mathematics may have adversely impacted the student performance in those courses at the university level. This finding is consistent with the earlier findings of Fillmore and Pope (2012) [5] who reported that there was strong evidence that a shorter amount of time between exams is associated with lower scores, particularly on the second examination. The study further indicated that students who take examinations with 10 days of separation were 8% more likely to pass both exams than students who took the same examinations with only one-day separation.

The results in Table 3 indicated positive and highly significant interrelationships (correlations) between student performances in the courses. This indicated performance consistency. Specifically, the proximity in the time between the examinations on numerical methods and differential equation II could not cause obvious variations in their performance, thus the strong relationship between their scores in the two courses (r=.672, p=.000). A similar result (r=.635, p=.000) was obtained on the relationship between Abstract algebra II and Statistical inference. This result is consistent with the findings of Fillmore and Pope (2012) [5] who found an approximately linear relationship between examinations spaced between 1 and 10 days. The study further stated that understanding how students handle multiple tasks that occur in close temporal proximity is an important but difficult issue to address empirically.

Conclusion

The overall achievement of students in the first-semester mathematical courses was low. Massed examinations might have impacted negatively on student achievement in numerical methods and differential equation. There were several positive and significant interrelationships across the students' performances in the first semester mathematical courses. The low grades obtained by students in these courses are an eye-opener to the fact that spacing between examinations has a significant impact on student performance in mathematics. The implication of the finding is that faculty examination committee, testing agencies, teachers and parents can all gain from understanding the effects of spacing between examinations on student performance in mathematics. This study provides coherent evidence that cognitive fatigue may be a vital factor in other related areas. Researches trying to replicate this present study should exploit other sources of effects of spacing between cognitive tasks on performance.

Recommendations

Based on the findings of the study, the following recommendations were made:

1. Students in the department of mathematics and statistics should work harder for improvement in their mean grade achievement in mathematics.
2. The faculty examination committee should ensure that mathematical courses are space-out to enable the students to prepare adequately for student optimal performance in cognitive tasks.

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