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Teaching with Frequent Tests and its Consequences on Students' Performance in Physics

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ABSTRACT : The intricacies of good teaching are known only to experienced teachers. Teaching is assessment and, learning and retention are functions of regular testing. This study theorises classroom assessments and links them with implicit theories of learning and retention of knowledge. The subjects of the study were motivated to maintain the momentum of learning through taking regular tests and subjected to counselling and regular feedback on the tests they took. The study analysed statistically semester results for five different year groups of students taught Quantum Mechanics by the same lecturer who adopted weekly testing. The results show substantial continuous improvements in students' academic achievement. The results may be indictments on lecturers who do not use classroom tests to motivate students' learning.

Keywords: Frequent tests, teaching and learning, academic performance, assessments, teacher-made tests.

1. INTRODUCTION

A number of educational systems today use standardised examinations to determine the quality of performance of their students. High grades may be influenced by factors such as student characteristics and teacher quality. There is no doubt that experienced teachers would combine teaching with assessments to produce high grade students. In that case assessments serve both formative and summative purposes but their planning and implementation should be done in such a way as to expose students' to continual learning (Harlen, 2005). Impliedly assessment is used to aid students to learn and retain what they learn. Also frequent tests imbue students with the confidence to eliminate the fear of failure. In the school system, teacher-made tests provide information to teachers for remediation and improving tuition. Also gaps, in students' knowledge about topics taught which manifest themselves in forms of misconceptions and mis-information, are revealed to teachers during feedback periods when teachers and students discuss the tests. Students' interests and courage to take frequent tests can be beefed up through feedback on tests and counselling. This study was set out to determine the impact of frequent teacher-made tests on students' learning and achievement while regular feedback and counselling are given to them. Dweck's self-theory has, therefore, been practicalised in this study.

Dweck's self-theory of fixed and growth mindsets

Dweck's theory is about individual student's perception of their own intelligence. In carrying out studies on how learners acquire and retain knowledge (Plaks, Grant, & Dweck, 2005; Dweck, 2000) a self-theory, which deals with how learners perceive themselves in the arena of learning has been propounded. The theory classifies learners into two groups of learning theorists. Dweck has termed the first group of learners as entity theorists and the second group of learners as incremental theorists. Learners who are entity theorists view intelligence as

being static and hardly changing. Students with this type of perception about learning are unwilling to volunteer to answer questions in class as they do not want to appear unintelligent before their colleagues. They get upset by comments on their wrong or inaccurate answers. Thus, they tend to think they have no control over their learning situations and avoid any challenges. The second group is the incremental theorists who view intelligence as expandable or malleable as they crave for improvement in their learning. They avail themselves of all opportunities that come their way and are not worried about comments on their wrong answers in class. They seek to use the comments for improvements in learning (Dweck, 2000). Thus, Dweck's theory is about intrinsic motivation as a factor that controls achievement and success. In effect, it is a theory that enables learners to develop self-efficacy, power and ability to wish to succeed through a series of struggles and failures. Dweck's theory may be summarised in points as shown in Table 1.

Table 1: The Dweck's theories of mindsets for learners' mindsets

Theory of Intelligence	Goal Orientation	Confidence in present ability	Behaviour Pattern
Entity theory (Intelligence is fixed)	Performance Goal To gain positive judgements	High	Mastery-oriented Seek challenges High persistence
	Avoid negative judgements of competence	Low	Helplessness Avoid challenges Low persistence
Incremental theory (Intelligence is malleable)	Learning goal Increase competence	High or Low	Mastery-oriented Seek challenges that foster learning High persistence

(Dweck, 2014)

From Table 1, the two theories of mindsets indicate contrasting characteristics of learners in each category. Learners disposed to entity theory are those with fixed mindsets and believe that their intelligence is fixed and does not grow while those disposed to incremental theory believe that their intelligence is malleable and will grow with the efforts they exert. Students espousing the entity theory may be classified into two groups – those with high confidence in their present ability to learn and those with low confidence in their ability to learn. The former may persist in the face of difficulties while the latter may appear helpless and avoid challenges or difficult situations. On the other hand learners disposed to incremental theory may hold high or low confidence in their present ability to achieve high academic outputs but would strive hard in the face of difficulties to foster learning.

In order to foster students learning while considering the Dweck's theories of the two mindsets, Wilson and Peterson (2006) have proposed benchmarks for modern day teaching and learning. They proposed that teaching should move from facts presentation by the teacher to learner engagement in activities. Teachers should, therefore, focus on the way students think about failure and success in learning as those with fixed mindsets may be unable to strive in the face of difficulties while those with growing mindsets may strive to improve. Teachers are, thus, to engage in growth mindset teaching strategies to move along all students to propel them to learn and gain from the efforts they make. In so doing, teachers should encourage their students, especially the academically weaker ones and convince them to strive more to achieve academic success. In order to promote growth mindset teaching the teachers should be the starting point. Teachers' mindset can be changed when they are coached on Dweck's dual mindsets theory (Table 1). The types of feedback teachers give to the students are the changing forces that drive progress and achievement of students. Research has shown that ego-oriented feedback encourages fixed mindset while task-oriented feedback encourages growth mindset (Boaler, 2015). This implies that praises heaped on students for the work they had done may encourage fixed mindsets while telling students about how they could correct the errors they commit on tasks would help them to develop growth mindset.

Experiences from elsewhere

In an experiment, Kang et al. (2007) found that regular short-answer quizzes with immediate feedback enabled students to learn better and retain what they had learnt than giving them multiple choice items on quizzes. The authors noted that short-answer items involved more demanding retrieval processes and so when students receive regular feedback on such items, they tend to learn how to retrieve stored information. Thus, using short-answer items as intervening quizzes rather than multiple choice items, before end of term final examination, provided training opportunities for students to perform better in the final examination. Teachers would, therefore, do well to use regular short answer quiz items to train their students towards the end of term examination.

Alkharusi (2008) examined determinants of achievement goals of ninth grade science students in public schools in Oman. The results indicated that teachers' teaching experience and assessment practices and, students' characteristics were the interacting determinant factors. In a study (Fina, Dunbar, & Welch, 2018), the authors matched high school students' assessment results in a national benchmarking examination with their performance in college courses. The outcome indicated that students who satisfied the college readiness benchmarks also obtained higher grade point averages in their first year college courses. This is an indication that the students have learnt well and retained a lot of materials needed for college courses. It might also imply that the students have learnt through high school tests and are used to examination conditions.

Wiliam et al. (2004) have noted that regular assessments done in the classroom are formative and hence aid learning and retention. The authors have observed, however, that due to pressure of completing the curriculum in anticipation of good performance of their students in external examinations many schools tend to preclude formative assessments. Khalaf and Hanna (1992) in an attempt to prove the formative nature of regular classroom testing have shown that students tested at least twice a month in a bid to give them regular positive feedback performed better in an end-of-term examination than their counterparts given less frequent class tests. Harlen (2005) has also observed from a series of literature reviews that some teachers hardly made use of assessment formatively as they wish to bask in the full glory of high grades of high-stakes summative examinations for their schools. Thus, some teachers resort to the use of past question papers, training students with marking schemes and limiting themselves to only syllabus-specific examples. The neglect of teaching through formative use of assessments leads to teaching by transmission, which currently is under heavy criticism by the teaching fraternity.

Impact of regular testing on students' motivation for learning

It may be that some educationists abhor regular testing of their students because of the workload involved. The workload may be a de-motivating factor for a number of teachers who feel time is needed for other equally important tasks. However, an aspect of teaching which teachers appear to ignore is to ask students what they use their time for while no quizzes are being organised throughout the school term and their understanding of learning. Harlen (2005) in a review of some literature has observed that since the 1990s a number of writings have discredited frequent testing as having a toll on students' enjoyment as they considered learning as only meant for passing examinations. The situation is different in the current century as authors like Kang et al. (2007) have found that test formats and appropriate feedback are the motivating influences for students' learning and enjoyment of school life. This is because the high marks that students obtain during the frequent tests motivate them to learn more while those obtaining low marks count on pieces of advice obtained from the task-oriented feedback in order to work towards the high-stakes examinations. Similarly, a controlled experiment of regular testing in a simulated classroom showed that frequent testing improved the long-term retention of students in a history class (Butler & Roediger III, 2007).

In an analysis of online regular tests data, Angus and Watson (2009) found that the exposure to frequent testing had significantly positive effect on students' learning. Regular testing has been noted as one of the five tools and techniques that enhanced learning and retention (Dunn, Saville, Baker, & Marek, 2013). The advantages of regular classroom testing do not accrue to students only. Teachers also accumulate a lot of questions and hence create question banks that would facilitate rapid composition of examination papers at later times. It is also common place knowledge that teachers who give regular tests gain experience of producing quality examination papers after several reviews of test papers in order to place them in better formats. Also in reporting on a review of articles that considered the impact of testing on students' motivation for learning, Harlen and Crick (2003) found that the authors they reviewed were not unanimous about their findings. While some of the findings were that testing had positive impact on students' motivation for learning, others noted that testing, particularly one-time high-stakes examination had negative impact on students' performance. The renowned American Educational Testing Centre has noted classroom testing as a catalyst for teachers to improve their competence as well as a way to determine their students' strengths and weaknesses (Educational Testing Service, 2003).

The current study, in the light of the advantages of regular testing for both teachers and students, analysed a five-year data for continuous assessments and end-of-semester examinations of third year students of the University of Education, Winneba in a physics course.

2. METHODOLOGY

The data set for this study was obtained from a five-year longitudinal study and an Action Research and, analyses of academic records of the intact classes that studied the physics course, PHY 361- Quantum Mechanics, while in the second semester of their third year. The records consisted of marks from regular weekly testing (continuous assessment), examinations marks and students' overall assessment marks for the semester. The analysis done is in line with one of the main objectives of the physics course, which has the thrust of providing an enabling environment for students to deepen their understanding of concepts in science, especially in physics.

Teaching with an approach of growing mindsets of students

In this study the researcher adopted the growing mindset approach to teach PHY 361 – Quantum Mechanics to level 300 students for the five academic years of 2013/2014, 2014/2015, 2015/2016, 2016/2017 and 2017/2018. Over the years, the researcher has observed that students considered the course as the most difficult among the physics courses. It is, however, noted that when teachers adopt the growing mindset theory of teaching, their students made great strides in learning (Dweck, 2014). In this study a Course Manual was developed for the course and each student given a copy. The Course Manual detailed the contents and objectives to be covered over the one-semester period, course regulations, assessment policies and grading system. The researcher, on the first day of meeting the students, explained all aspects of the course and the contents of the Course Manual to the students. Further, weekly encouragements such as advising students on how to acquire the habit of making effort, were given. Each week students were to be given quizzes based on materials learnt in the previous week so they were advised to revise seriously in groups or individually and also make library search. They were advised that the effort they put in to make good grades was important for retaining materials learned and for improving their learning outcomes. Thus, the students were advised at the beginning of each lesson to be mindful of Dweck's theories of mindsets and choose the growing mindset option, which is the incremental theory of mindset (Dweck, 2014). They were encouraged to accept challenges that learning comes with, persist in the face of difficulties and avoid helplessness. The short quizzes were made up of a combination of multiple choice items, fill-in the gaps, short-answer items and sketching and labelling of figures. The varied formats of tests as found by Kang, McDermott and Roediger III (2007) enabled each student to feel at ease and make choices. As the regular tests may have a toll on students' psyche and hence cause them to be pressurised to learn regularly they would feel anxious about their performance. Hence regular task-oriented feedback was used

to boost their morale and reduce stress during lectures. Each quiz was marked and returned with copious feedback written on them to direct students to what they did well, those issues that were not well done and how to correct the errors.

Purpose and objective of the study

The study, which is of a developmental design, examined the extent to which regular class assessments in the form of continuous assessment interlaced with academic motivation (feedback) during teaching influenced the academic outputs of students in their semester examinations. The objective of the study was to establish empirical evidence of the relationship between regular class tests (continuous assessments) interlaced with academic motivation and performance in semester examinations. The aggregate class performance for a semester was constructed for each year group as the mean marks on both continuous assessments and semester examinations.

Research Questions

The study addressed the research questions:

1. What effect does regular class tests have on the academic output of students?
2. What effect does academic motivation have on students' commitment to learn?

3. RESULTS

The results of the output of the study are analysed in terms of students' marks obtained from regular testing through short quizzes and students' behaviour change due to the influence of the theories of mindset on their psyche.

Students' outputs from regular testing

The results of a five-year data collected on the five independent groups of students are displayed in terms of the means marks for continuous assessment and the examination marks in Table 2.

Table 2: Performance of students over a five-year period in a Quantum Mechanics course

		Mean Marks (%)				Grades (%)				
Year	No.	CA	Exam	Total	SD	A	B	C	D	E
2013/2014	12	66.7	49.5	56.4	6.5	0	0	75.0	25.0	0
2014/2015	12	69.0	50.8	58.1	10.3	0	8.3	50.0	25.0	16.7
2015/2016	25	74.5	58.4	64.8	10.4	0	44.0	28.0	20.0	8.0
2016/2017	34	61.3	60.0	60.5	10.9	2.9	14.7	38.2	38.2	5.9
2017/2018	37	69.1	68.2	68.6	7.3	5.4	48.6	32.4	13.5	0

Note: Grades A= 100 - 80%; B = 79 – 70%; C = 69 – 60%; D = 59 – 50%; E = 49 – 0% (Failure)

From Table 2 it is observed that the mean marks in the continuous assessments were regularly above the pass mark of 50 % and the mean examination mark increased from year to year. The total mark is made up of 40 % of CA marks and 60 % of Examination marks. Also in the last two years the figures on the Table indicate the emergence of grade A, which increased from 2.9 % to 5.4 %. Similarly, the failure grade (E) decreased over the years. The figures displayed on Table 2 also show that majority of the students (over 80 %) passed the course which they had labelled as the most difficult. The good outputs of the students over the five-year period is not surprising considering the fact that the Dweck's incremental theory of mindset approach to teaching had been adopted by the researcher.

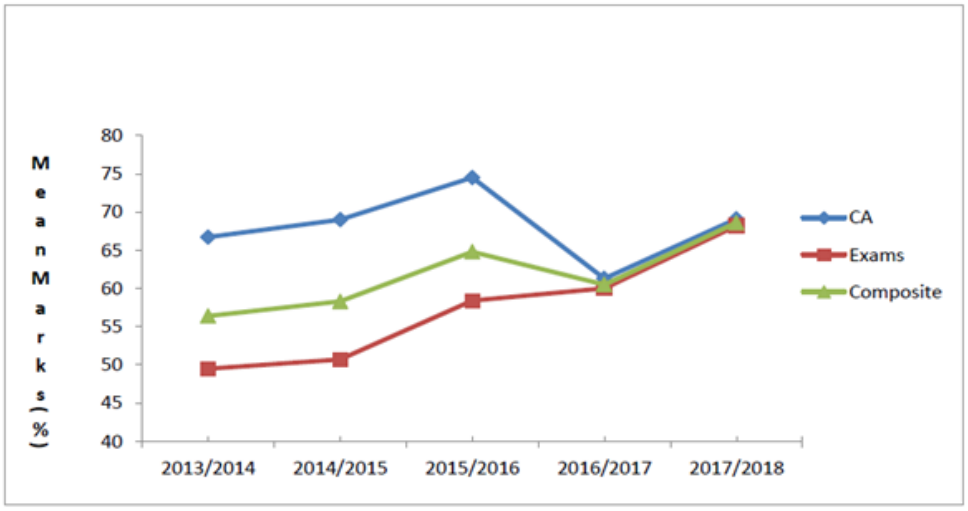

Figure 1: Comparison of students' performance over five years

A visual representation of the students' outputs is displayed graphically in Figure 1, using data from Table 2, to compare year-to-year performances in continuous assessments (CA), examinations and the composite (total mark) performance. The trends of the graphs show continuous improvement of examination marks over the period. The continuous assessment marks, however, showed a dip in the 2016/2017 academic year. This was due to absenteeism by some few students from some of the assessment quizzes hence their best three marks were not high enough to maintain the improving trend. This dip in trend for CA notwithstanding the average examination marks continued to increase from year to year.

Though the display in Figure 1 appears quite attractive, it is noted that the data set were not obtained from samples of the same population. However, a t-test, which is used in comparing the means of parametric data of two variables (or two groups), will not be suitable for comparing parametric data from five different year-groups. Cohen et al. (2012), therefore, suggest that when a researcher intends to investigate the differences between means of more than two groups then analysis of variance is the most suitable statistical tool to use. Analysis of variance (ANOVA) is based on the same assumptions as t-tests, which is that random sampling was used, parametric data collected and a normal distribution of data points is expected. So it might be insightful to do an ANOVA to ascertain whether there is a significant difference in performance between the five independent groups. Thus, a one-way analysis of variance (ANOVA) was done to determine whether there were any statistically significant differences between the total mean scores of the five independent groups. Specifically, the null hypothesis as shown in equation (1) was tested.

$$H_o = \mu_1 = \mu_2 = \ldots\ldots\ldots = \mu_5 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where μ = group mean and the subscripts represent the number of groups.

One-way ANOVA

The results of the one-way analysis of variance (ANOVA) are displayed in Table 3.

Table 3: One-way ANOVA calculations for treatment groups

Source of Variation	SS	Df	MS	F	p-value	Fcrit
Between Groups	283.2693	2	141.6347	3.92913	0.04869	3.885294
Within Groups	432.568	12	36.0473			
Total	715.8373	14				

Note: MS= Mean square; F statistic = ($F = MS_B/MS_W = 3.92913$); $p < 0.05$

It is noted from Table 3 that F = 3.9291, implies there is more variability between treatment groups than within treatment groups. Thus, we feel more confident in rejecting the null hypothesis, which was that all means were equal and there was no treatment effect. We are rather concerned about the p-value obtained from the F-distribution. The p-value (0.04869) means the probability of the between-treatments MS being >3.9 times the within-treatments MS, if the null hypothesis true, is p = 0.04869.

The p-value is, however, slightly less than the significance level of 0.05 at which the ANOVA was calculated. It would be quite unlikely to have F (MSB/MSW) as big as 3.9291. Let us for now reject the null hypothesis and accept the alternate hypothesis that there is significant difference between treatments. This also means accepting that all means of the treatments are not the same. This is also because the one-way ANOVA is an omnibus test statistic that does not tell us which specific groups were statistically significantly different from each other. It may only perhaps tell us that two groups are statistically significantly different from each other. We thus, resort post-hoc analyses to determine whether the group means are significantly different from each other. Though there are several post-hoc analyses we would depend on a commonly used post-hoc, which is Tukey Honest Significant Difference (Tukey HSD), since from our ANOVA the means are not all equal. So which means are different to the significance level of 0.05? Perhaps we may think of calculating a number of t-values but that would increase type I error within the calculated values so we adopt a more robust approach by using Tukey HSD.
To obtain the row of pairs in the Tukey HSD calculations, r = 5 for this study and number of pairs = r(r-1)/2 = 5(5-1)/2 = 10. Then critical q = (α, r, dfW) = (0.05, 5, 12) = 4.51 from Standard Tables.

Tukey HSD Calculations
The results of the Tukey HSD post-hoc calculations are shown in Table 4.

Table 4: Differences in means by the Tukey HSD

Year Groups	$x_i - x_j$	Critical q α, r, df_W	Standardised error (S. E.)	95 % Conf Interval for $\mu_i \pm \mu_j$	
1. Yr 1 vrs Yr 2	-1.9	4.51	3.47	- 17.55	+13.75
2. Yr 1 vrs Yr 3	-8.4	4.51	3.47	- 24.05	+7.25
3. Yr 1 vrs Yr 4	-4.1	4.51	3.47	- 19.75	+11.55
4. Yr 1 vrs Yr 5	-12.4	4.51	3.47	- 28.05	+3.25
5. Yr 2 vrs Yr 3	-6.5	4.51	3.47	- 22.15	+9.15
6. Yr 2 vrs Yr 4	-2.2	4.51	3.47	- 17.85	+13.45
7. Yr 2 vrs Yr 5	-10.3	4.51	3.47	- 25.95	+ 5.35
8. Yr 3 vrs Yr 4	+4.3	4.51	3.47	- 11.35	+ 19.95
9. Yr 3 vrs Yr 5	-3.8	4.51	3.47	- 19.45	+ 11.85
10. Yr 4 vrs Yr 5	-8.1	4.51	3.47	- 23.75	+ 7.55

$p < 0.05$; Yr 1 = 2013/2014; Yr 2 = 2014/2015; Yr 3 = 2015/2016; Yr 4 = 2016/2017; Yr 5 = 2017/2018

The calculations in Table 4 were obtained with the following formulae:
$\mu i - \mu j = q \times S.E. \pm (xi - xj)$ ..... (2)
$q \times S.E. = 4.51 \times 3.47 = 15.65$ ..... (3)
$S.E. = \sqrt{(MSW/2)(1/ni + 1/nj)}$ ..... (4)
where ni and nj are the data point for each treatment.
In this study each treatment has 3 data points, thus, Standardized error (S. E.)= $\sqrt{(36.0473/2)(1/3 + 1/3)} = 3.466$.

Interpretation of the results in Table 4

The results indicate that one can be 95 % confident that, on the average, a batch of 12 students in Yr 1 (2013/2014) performed between 17.55 % lower and 13.75% higher than 12 students in Yr 2 (2014/2015). So we cannot say there is a significant difference though literally speaking that is the case. The fact that the differences between the confidence interval lie between negative and positive values implies that there is a zero in the

middle. This means the pairs of treatments might have same or different performances. Thus, we cannot conclude with certainty that there is a difference in performance between each pair of treatment. Brown (2016) cautions that under the circumstances when the differences lie between negative and positive values one should refrain from concluding that there are significant differences, though this may be literally the case. However, when the endpoints of the confidence intervals are positive and positive then there is no zero in-between, so we can conclude that there is a significant difference between a pair of treatments.

Students' behaviour change

The researcher used a checklist to check students' attendance and behaviour toward the regular quizzes they had to take at the beginning of each lecture. It was observed that though the lesson was the first in the morning for each day on the time table lateness was reduced to the minimum as students came into the lecture hall early enough to discuss with colleagues what they termed last-minute issues before the start of the quizzes. They developed a slogan in the class – early morning cocoa drink - in reference to warming themselves up to start each day's lesson. It was also observed that the students developed cooperative learning strategies as they discussed and interacted to explain concepts to each other. The initial fears of failure gave way to confidence, especially as the feedback on receiving quiz papers back indicated improvement in marks obtained. Occasionally, some students were heard saying this practice will surely enable them to pass their end of semester examination easily as almost every topic taught is being examined well ahead of the semester examinations.

4. DISCUSSION

Involvement of students in the lesson and assuring them that they could develop a growing mindset (Dweck's incremental theory) if they strive to make greater efforts is essential for consistent performance of students. It is noted here that for the five years running that the lecturer in this study introduced students of a physics course to regular learning through weekly quizzes, the students have consistently passed a hitherto dreaded course. Further, the average performance in the semester examinations consistently increased over the years. This implies that the students had mastered the physics concepts that they had learnt and hence producing good learning outcomes rom year to year. The high learning output is supported by what some researchers (Brown, Roediger, & McDaniel, 2014) from Harvard University have found that assessments that are repeated enable students to reflect and induce in them great thinking skills.

The results of this study indicate that through frequent assessments students' average performance in examinations increased from year to year. This is an indication that in adopting the Dweck's growing mindset theory the students engaged in serious studies. This finding is consistent with the finding by other authors (Crosling, Heagney, & Thomas, 2009) that the teaching and learning strategy needed to keep students studying is to engage them. Also an improvement in the examinations results of the students can be attributed to the regular class quizzes which made them familiar with contents and contexts to be examined. In a similar research, Karpicke and Roediger III (2007) found that repeated testing during learning improved students' performance. Thus, the authors concluded that long term retention is linked to repeated retrieval of materials that students had learnt.

The results of this study also show that the high persistence developed by the students through regular academic motivation which was cued from the incremental theory of mindsets as propagated by Dweck (2014) helped them to maintain good academic output. The current results are in line with a study (Vanthournout, Gijbels, Gertjens, Donche, & Petegem, 2012) that compared students' learning strategies against academic motivation and found academic motivation as the sole predictor of persistence and academic achievement.

5. CONCLUSION

The effect of Dweck's incremental theory of intelligence (growing mindset) has been applied in teaching a course in physics which students perceived as very difficult. The learning outcomes have been consistently impressive

for the five-year period with five different groups of students. There were no significant differences in the composite mean scores between groups but mean output score increased from year to year. The results of this study have serious implications for teaching and learning. Teachers who do not use regular tests in their teaching would not develop question banks and hence stress themselves each time the semester is approaching an end and examination question are demanded. Also, teachers may not provide opportunities for their students to familiarise themselves with test format that may be used in semester examinations and hence cause students to be anxious and stressed in the examinations. It is, therefore, recommended that teachers adopt the Dweck's incremental theory of intelligence in teaching and hence develop in students the qualities of a growing mindset. There is paucity of literature on efforts by Ghanaian university lecturers to present assessments of their own teaching and their students' learning outcomes. The current study, thus, brings to the literature results of persistence of students due to academic motivation by their lecturer to sustain their academic performance. Thus, the findings of this study point to the consideration of appropriate academic motivations by university lecturers when contemplating solutions to their students' low academic performance.

Conflict of Interest

The author has no conflict of interest. The article was not sponsored by an organisation or an institution.

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