Caribbean Teaching Scholar
Vol. 5, No. 1, April 2015, 25–35

ERA
EDUCATIONAL RESEARCH ASSOCIATION

Pre-testing as an indicator of performance in final examinations among third year medical students

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This paper reports on the relationship between pre-testing and student performance in final examinations. Diagnostic pre-testing is a valuable tool that identifies gaps in knowledge among students; identifies teaching requirements, and helps direct teaching programmes to take corrective measures. Pre-test scores may also help to predict student performance in final examinations. A retrospective descriptive correlational analysis was conducted on third year medical students' performance in the total haematology components of selected multi-specialty final integrated examinations in four third year courses and one related first year course. These students had previously been given a diagnostic pre-test in haematology at the start of their third year programme. Of the 159 students eligible for the study, 130 passed and 29 failed the pre-test. Some students responded to the interventions instituted after the diagnostic pre-test and others did not. The pre-test proved to be a good predictor of final results. Correlation between the pre-test and the total haematology components of the different final integrated examinations ranged from r= .264 to r= .475) and between the pre-test and the final integrated examinations ranged from r= .375 to r= .467. It was concluded that the pre-testing grade is a reliable indicator of performance in the final examinations. However interventions need to be revised to encourage more individual, student engagement.

Key words: Academic performance, correlations, prediction, success

Introduction

Pre-testing stimulates and enhances student learning (Richland, Kornell & Kao, 2009). Simkins and Allen (2000) found that pre-test scores were a useful indicator of students' success in a course and helped to predict student performance in final examinations. This may be because pre-testing can direct or focus students' attention to information that is most explicitly relevant to them. Further, Beckman (2008) showed that pre-testing was an effective way of giving students the learning objectives of a course. Helle, Nivala, Kronqvist, Ericsson and Lehtinen (2010), in a pre-test/post-test study among undergraduate pathology students, found that the only factor that predicted performance on the post-test was performance in the pre-test. On the other hand, many other factors may predict end of course scores. In a third year internal medicine course, for example, Gupta et al (2007) showed that

in-course assessments correlated positively with end of semester assessments. This paper uses a diagnostic pre-test to assess the recall of material from a prerequisite course; evaluate student learning; identify teaching requirements and teaching methods that need to be changed, and highlight relevant changes that are needed in the curriculum. It also shows how an instructor-based pre-test can be used – not only as a diagnostic tool but also as a correlation tool.

In this undergraduate setting, haematology is taught as part of the Para-clinical Sciences course. Para-clinical Sciences bridge the gap between the pre-clinical and the clinical years of medical training. They integrate different sub-specialties such as anatomical pathology, chemical pathology, haematology, immunology, microbiology and pharmacology. In the current system, first-year students from medical, dental, and veterinary medicine take a six week introductory integrated course called Basic Para-clinical Sciences (BPS). Students are introduced to normal haematology and basic concepts in haematology (see Table 1). In the second year there is no haematology teaching (there is some teaching in the second year for the other sub-specialties). In the third year the medical students then examine the pathophysiological basis of disease applying the basic knowledge from first year. There is no time set to revisit the material covered in the first year. The first year course material is a pre-requisite for third year courses and students have to have passed the first year integrated BPS course.

Table 1. Courses in the Para-clinical Sciences and details of haematology component of these courses

Year	Course	Semester	Haemotology component: Course content	Course teaching/ delivery methods
1	Basic Para-clinical Sciences (BPS)	Semester 1	• Peripheral blood and blood components, haemopoiesis, introduction to haemostasis, introduction to basic laboratory procedures in haematology	• Problem based learning • Didactic lectures
3	Applied Para-clinical Sciences I (APS-I)	First half of Semester 1	• Anaemias	• Problem based learning • Didactic lectures
3	Applied Para-clinical Sciences II (APS-II)	Second half of Semester 1	• Haemostasis, thrombosis and transfusion medicine	• Problem based learning • Didactic lectures
3	Applied Para-clinical Sciences III (APS-III)	Semester 2	• Haematological malignancies and bone marow failure syndromes	• Problem based learning • Didactic lectures
3	Integrated Para-clinical Sciences (IPS)	Semester 1 & 2 (Rotations throught the year)	• Integrates APS-I, II and III	• Clerkships • Clinical and practical application and exposure

The various assessments undertaken across the first and third year courses are shown in Table 2. Each sub-specialty contributes equally to the integrated examinations.

Table 2. Assessments in first and third year courses in multi-specialty integrated course of Para-clinical Sciences

Year		Continuous assessment (CA)		End of course		Final score
1	Basic Para-clinical Sciences (BPS)	*Observed practical skills examination (OPSE)	Problem-based learning	Mulitple choice questions (MCQs)	Short answer questions (SAQ)	100%
3	Applied Para-clinical Sciences I (APS-I)	Progressive disclosure questions (PDQ) (20%)	Problem-based learning (5%)	MCQ (50%)	Extended matching questions (EMQ) (25%)	100%
3	Applied Para-clinical Sciences II (APS-II)	PDQ (20%)	Problem-based learning (5%)	MCQ (50%)	EMQ (25%)	100%
3	Applied Para-clinical Sciences III (APS-III)	PDQ (20%)	Problem-based learning (5%)	MCQ (50%)	EMQ (25%)	100%
3	Integrated Para-clinical Sciences (IPS)	Varies by sub-specialty (25%) [Includes different combinations of case presentation, case write-up, MCQs and **OSPE]		OSPE (45%)		70% Clinical skills assessed (30%)

** Not included in this analysis; ** Haematology component of CA*

The pre-test was given at the start of the third year to facilitate the recall of the material covered in the first year. According to constructivist learning theories, learning builds upon knowledge that the learner already has from previous experiences; however, knowledge cannot be built effectively without a firm foundation and it is important to identify and address fragile prior knowledge (Simkins & Allen, 2000). This study shows the correlations between the results of the pre-test and the results of final examinations. The research was conducted among third year medical students of the academic year 2010-2011. The authors could find few similar studies in the literature and no similar studies have been conducted in the faculty.

The research question

What is the association between the pre-testing results in haematology and student academic performance in the haematology components of the multi-specialty final integrated examinations in the first year course (BPS) and the various third year courses (APS-I, APS-II, APS-III and IPS)?

Methodology

Ethical approval was obtained from the Ethics Committee, and Office of the Dean, Faculty of Medical Sciences, The University of the West Indies, St. Augustine. This was a descriptive retrospective correlational, cross sectional analysis of medical students' examination results. Data was accessed from the Assessment Unit of the Faculty – maintaining the anonymity of the students. The data included results of the haematology components and the overall final integrated courses BPS, APS-I, APS-II, APS-III, IPS. Students who failed the first year course, BPS, and did not move on to third year with this class were excluded from the final analysis. Students who did not take all the third year final examinations were also excluded from the final analysis. At the start of the third year, students were given a diagnostic pre-test. They were given feedback within a week of the test. Using the pre-test results, the following interventions were introduced:

1. The instructor took time in each class to highlight the relevant pre-requisites, and their relevance, and paid particular attention to the failing students in class – whether it was in the large didactic class sizes (approx. 250 students) or in the smaller clerkship groups (20-25 students).
2. All students were encouraged to seek help from the lecturers – particularly the failing students.
3. The instructor chose the students with the lowest pre-test scores in their groups to be the group leaders during clerkships (clerkship groups are usually assigned alphabetically). The reason why students were chosen to be group leaders was not revealed to the class as students' tests scores are confidential. The responsibility meant that these students had to be in regular contact with the instructor concerning the group activities. The instructor took the opportunity to hold discussions with them whenever they made contact about the group activities.
4. The instructor increased students' interaction and engagement in both the didactic lectures in the large classes and the smaller clerkship group activities.

The results of the haematology pre-test, the continuous assessment (CA), the total haematology component (THC) and the multi-specialty final integrated examination (FIE) were analysed. The associations between the pre-test the THC and the FIE were analysed. A Chi square test (χ^2) of independence was performed between the pre-test and the THC of the third year courses, APS-1, II, III and IPS. Correlational analysis of the results of the pre-test, the CA and the FIE results was performed. Correlations were also performed between the pre-test and the first year BPS course (the CA results for BPS were not available for this analysis).

Correlational analysis was performed by using the Pearson product moment correlation method. Linear regression analysis was performed for the pre-test as an indicator or predictor of final performance. Linear regression analysis was also performed between the THC and the FIE.

Results

One hundred and ninety-four medical students took the first year integrated BPS examinations. Of these medical students, 33(17%) failed the integrated course (fail is defined by a score of less than 50%). One student did not take the pre-test and one did not take APS-III. Thus the final number of students eligible for analysis was 159. Table 3 shows the total possible scores and the group mean scores for the total haematology components of the first and third year courses. The best mean scores were in the third year courses APS-II and III and the worst was in the first year course, BPS.

Table 3. Results of the pre-test and the total haematology components in one first-year course and the third-year courses

	First year	Pre-test	Third year			
	Basic Para-clinical Sciences (BPS)		Applied Para-clinical Sciences-I (APS-I)	Applied Para-clinical Sciences-II (APS-II)	Applied Para-clinical Sciences-III (APS-III)	Integrated Para-clinical Sciences (IPS)
Total score possible	14	49	18	27	32	15
Mean	7.38 (52.7%)	32.16 (65.6%)	10.29 (57.2%)	18.36 (68.0%)	21.61 (67.5%)	8.69 (57.9%)
Std deviation	2.099	7.28	2.50	4.09	3.97	2.11

Table 4 shows χ^2 of independence for pre-test versus APS-I ($\chi^2 = 0.184$, $p>0.05$), APS-II ($\chi^2 = 3.020$, $p>0.05$), APS-III ($\chi^2 = 1.518$, $p>0.05$) and IPS ($\chi^2 = 3.064$, $p>0.05$) was found to be statistically insignificant. This shows that for the group, there was no significant difference between the results of the pre-test and the results of the third year courses. However the researchers did not perform further statistical analysis of the two groups that failed or passed the pre-test and then failed or passed the third year courses separately. Table 5 shows the number of students who passed and failed the pre-test and their results in the final examinations in the third year courses. Here we can see that 75.4% of students in IPS and 90% of students in APS-II who passed the pre-test, passed the final examinations. When it comes to the students who failed the pre-test, 93.1% passed APS-III compared to 58.6% in APS-I.

Table 4. Results of the pre-test and the total haematology components in the four third-year courses and χ^2 of independence

	No. of students who FAILED (Score <50%)	No. of students who PASSED (Score ≥50%)	TOTAL	χ^2 of independence
Pre-test	29 (18.2%)	130 (81.8%)	159	NA
Applied Para-clinical Sciences-I	32 (20.1%)	127 (79.9%)	159	*0.184
Applied Para-clinical Sciences-II	18 (11.3%)	141 (88.7%)	159	*3.020
Applied Para-clinical Sciences-III	21 (13.2%)	138 (86.8%)	159	*1.518
Integrated Para-clinical Sciences	42 (26.4%)	117 (73.6%)	159	*3.064

(p>0.05)

Table 5. Number of students who failed or passed the haematology pre-test and their subsequent results in the total haematology components of multispecialty final integrated examinations in four third-year courses

	FAIL		**PASS**		**Total**
Pre-test	29 (18.2%)		130 (81.8%)		159
	FAIL	**PASS**	**FAIL**	**PASS**	
Applied Para-clinical Sciences-I	12 (41.4% of fails) (7.5% of cohort)	17 (58.6% of fails) (10.7% of cohort)	20 (15.4% of passes) (12.6% of cohort)	110 (84.6% of passes) (69.2% of cohort)	159
Applied Para-clinical Sciences-II	5 (17.2% of fails) (3.1% of cohort)	24 (87.8% of fails) (15.1% of cohort)	13 (10% of passes) (8.2% of cohort)	117 (90% of passes) (73.6% of cohort)	159
Applied Para-clinical Sciences-III	2 (6.9% of fails) (1.3% of cohort)	27 (93.1% of fails) (17% of cohort)	19 (14.6% of passes) (11.9% of cohort)	111 (85.4% of passes) (69.8% of cohort)	159
Integrated Para-clinical Sciences	10 (34.5% of fails) (6.3% of cohort)	19 (65.5% of fails) (11.9% of cohort)	32 (24.6% of fails) (20.1% of cohort)	98 (75.4% of passes) (61.7% of cohort)	159

Linear regression analysis was performed and results are shown in Table 6. The pre-test predicted best the APS-I results followed by APS-II, then APS-III for both the THC and the FIE. For the practical examination, the observed structured practical examination, the pre-test was better at predicting the FIE than the THC results.

Table 6. Pre-test as indicator of performance in the total haematology component and the multi-specialty final integrated examinations

	Linear regression analysis *Total haematology component β*	**Linear regression analysis** *Final integrated examination β*
Applied Para-clinical Sciences-I	.48	.47
Applied Para-clinical Sciences-II	.37	.41
Applied Para-clinical Sciences-III	.30	.38
Integrated Para-clinical Sciences	.32	.46

(p=0.0001)*

Table 7 shows the correlations between the pre-test and the THC, the FIE and the CA-haematology component. In BPS, there was a weak positive correlation between the THC and the pre-test (r=.264) and a strong correlation between the final integrated examination and the pre-test (r=.434). In APS-I, there was a strong correlation (r=.475) between the THC and the pre-test and a strong correlation (r=.467) between the final integrated examination and the pre-test. In APS-II, there was a moderate correlation (r=.374) between the THC and the pre-test and a strong correlation (r=.409) between the final integrated examination and the pre-test. In APS-III there was a weak correlation (r=.295) between the THC and the pre-test and a moderate correlation (r=.375) between the final integrated examination and the pre-test. In IPS there was a moderate correlation between THC and pre-test (r=.322), a strong correlation between the final integrated examination and the pre-test (r=.457). Correlations between the pre-test and the CA for the individual courses ranged from r=.211 to r=.442.

Table 7. Correlations between the pre-test, and the total haematology component plus pre-test and the final integrated examination in five courses and the CA-haematology component

	Total haematology component	**Final integrated examination**	**CA-haematology component**
Basic Para-clinical Sciences (BPS)	.264**	.434**	NA
Applied Para-clinical sciences-I (APS-I)	.475**	.467**	.442**
Applied Para-clinical Sciences-II (APS-II)	.374**	.409**	.331**
Applied Para-clinical sciences-III (APS-III)	.295**	.375**	.283**
Integrated Para-clinical Sciences (IPS)	.322**	.457**	.211**

*** Correlation is significant at the 0.01 level (2-tailed). (Pearson product moment correlation method used)*

Discussion

Despite the fact that all students had been informed of the pre-test in advance, giving them the opportunity to review the material privately during their break at the end of second year and before the start of third year, 69 (43.4%) members of the study group (n=159) failed the haematology component of the integrated first-year course (BPS) and 29 (18.2%) failed the pre-test. It may be that the time during the break, when they had no other examinations to focus on, helped them revisit the prerequisite material with better focus. This is further emphasised by the fact that some of the students who passed the pre-test failed the total haematology component and the final integrated multispecialty examinations in the third year, when they had other sub-specialties to study for. It might also be that students who generally study for an examination 'short-term' do not retain knowledge 'long-term' and, therefore, do not have a firm foundation for the study of the subject. A number of factors are involved in final examination grades and correlations of the pre-test and this first year prerequisite course are weakly positive (r=.264).

The pre-test predicted best the APS-I results followed by APS-II and then APS-III for both the total haematology component and the multi-specialty final integrated examination. APS-I is the first course in the first semester, APS-II is in the latter half of the first semester and APS-III is in the second semester. The results may also be getting better through student maturation. This is echoed by the fact that the best mean scores are in the later courses. The students may also be getting more comfortable with the assessments. Furthermore, in APS-II, more students would have rotated through haematology clerkships at this point than in APS-I, and all students would have gone through all clerkships by the time APS-III examinations were held, hence have a better understanding of their course material after getting the practical and clinical applications, and learning in much smaller groups with closer contact with the instructor and other lecturers. This is similar to the findings of Beckman (2008) where students' scores were better in the later semesters and it was concluded that the students were becoming more accustomed to the tests. A recommendation for departments may then be to allocate more time to clerkships as this is where most learning seems to occur. Class sizes in the third year are between 200 and 250 students and clerkship groups are between 20-25 students – with clinical and practical exposure. Therefore, during clerkship, students see the relevance of their lecture content – something that is likely to improve the retention of knowledge.

In this paper, due to time constraints, it was not possible to create smaller groups for the failing students however the instructor took advantage of the existing smaller groups during clerkships (20-25 students) to pay closer attention to the failing students. All clerkship sessions required interaction and active participation of all students and the instructor. The instructor chose the students with the lowest pre-test scores in their groups to be the group leaders. This responsibility meant that these students had to be in regular contact with the instructor concerning the group activities. The instructor took the opportunity to hold discussions with

them whenever they made contact about the group activities. One such student, who had one of the lowest pre-test scores, after the first few discussions, voluntarily started to seek help from the instructor. In-fact, this student went on to have a final Honours Grade in APS-II and a distinction in APS-III, similar to some of the high attaining students. This student had never had such results before. The extra attention seemed to help him understand better and focus his studies better. The responsibility and accountability as group leader increased his self-confidence, self-esteem and motivation. He had never had the opportunity to be a leader at medical school. He did at some point enquire why he had been chosen as group leader and he actually guessed the reason. It may also be true that he was further motivated when he saw the dedication and willingness of the instructor to take time with him.

Other benefits of pre-testing exercise

Like Shepard (2001, in Beckman, 2008), the lead author felt that pre-testing improved their own teaching effectiveness. Firstly, it identified the objectives that needed to be re-visited in the pre-requisite course. The results of the analysis made the instructor more reflective in the teaching practice and identified teaching methods that needed to be changed and developed. It motivated the instructor to adopt and implement further innovative strategies, try a variety of techniques, and research other possible teaching techniques. While the pre-test did take time from the third year course slots, and initially the instructor was concerned that they wouldn't be able to 'cover all the material', in the end the instructor was better able to identify the most important learning objectives to be covered in class and the ones could be done by students at home.

Limitations

1. No similar analysis has been performed in the previous years, where no diagnostic pre-test was given by the researchers, for comparison.
2. The number of students in the study is small.
3. There may be a number of other reasons that may explain performance in final examinations besides the pre-test.
4. Statistical analysis in the two different groups that failed or passed the pre-test and then failed or passed the third year courses needs to be done (as shown in Table 5).
5. In this analysis, the effect of combining multiple sub-specialties in one big integrated examination was not analysed.
6. As this was a retrospective analysis, no formal analysis of the views and feelings of the students' about the pre-test.

Conclusion

No statistical difference between the pre-test and the third year course results was found. Some students seemed to respond to the intervention and others did not (Table 5). The pre-test identified students with low attainment, their baseline and their particular deficiencies. The interventions introduced were designed to increase student interaction and engagement. While all students, particularly those with low attainment, were encouraged to seek help from the lecturers, in actual fact the students who generally sought help voluntarily were usually the students who were high achievers already. This type of situation further confounds the challenge for the teacher, who has to be extra creative in cultivating an attitude that leads to better student engagement. In such a scenario where failing students are less likely to seek help voluntarily, the instructor could actively create extra sessions tailored to these students (as a smaller group), their particular weaknesses, at a pace that is comfortable for them, thus working to ensure their engagement. While this is time consuming, and requires dedication by both staff and students, it may well be valuable for these students. Warrier, Schiller, Frei, Haftel and Christner (2013) showed that short term and long term examination scores improved significantly after team-based learning and Johnson and Johnson (2009) showed that cooperative learning leads to higher achievement and greater productivity, as the teams become more caring, supportive, and committed to the group activities. As the groups get smaller students become more interactive, communicate more and are more accountable. In smaller groups, students encourage each other to achieve the goals as they challenge each other and give each other feedback, and the 'social-loafing' which happens in large classes decreases. Diagnostic pre-testing is a valuable tool to help in directing a teaching programme as well as stimulating student learning. Appropriate interventions can be implemented to help those in need. Some students responded to the intervention, others may require other strategies to motivate improved engagement. More class interaction in didactic lectures, no-matter how big the class sizes, should be encouraged and there is a need to explore new technologies in teaching to encourage more student engagement as some low attaining students are less comfortable approaching lecturers directly face-to-face. Small group activities may also help these students' engagement. Rahman, Khalil, Jumani, Ajmal, Malik and Sharif, (2011) after a pre-test/post-test exercise, concluded that the discussion method of teaching was more effective than the didactic lecture method. In a study by Gray, Fana, Campbell, Hakim, Borok and Aargaard (2014) they suggested that 'team-based learning' was a good tool that would stimulate learning and was useful in a setting with high ratios of students to teachers, as is the case in our setting.

In the case of the students who failed the pre-test but ended up with a passing grade in final examinations, this may be due to the fact that pre-testing stimulates future learning (Richland, Kornell & Kao, 2009). In this study, pre-testing may also have helped students to appreciate the relevance to the third year of the material covered in the first year. Interestingly Hudson and McIntire (1977)

showed that pre-testing was a better indicator of failure than it was of success and concluded that a highly motivated student can indeed overcome a deficiency in the prerequisite material. The motivation could be any number of things, including the pre-test itself, stimulating learning. When a student realises, right at the beginning, the gap between what they need to know and what the already know, they may be motivated by a form of panic. This is in keeping with Shepard (2001, in Beckman, 2008) who report that pre-testing encourages students to reflect upon what they currently know. This study was an attempt at highlighting the significance of learning foundations and it is recommended that others use pre-testing as a means of establishing the foundations for future learning.

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