Does the Proportion of Marks for Wet Laboratories Affect the Overall Mark, Grade, and Failure Rates?

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Abstract

Students have higher marks in programs with a higher proportion of marks allocated to ongoing assessment (tutorials, assignments) than exams. However, there has been little attention to how the allocation of marks to wet laboratories affects the academic performance of students in university courses. The aim of this study was to analyse how the allocation of marks to examination and wet-laboratory-related assessment affected the performance of students in a biochemistry course. The students were from four programs: pharmacy, biomedical science, medical laboratory science, and nutrition. The methods were (i) comparing the marks for the exam and laboratories, (ii) determining any association between these marks and academic outcomes by regression line analysis, and (iii) undertaking modelling to determine the effects of changing the allocation of marks on passing and failing rates. Overall, and for each cohort of students, the results were similar. Students who completed the course had much lower marks in the exam than in the laboratories. Regression line analysis of the marks in the exam versus laboratories showed (a) a poor line fit and (b) the correlation coefficient was moderate. A high percentage of students passed the course (90%). Modelling showed that increasing the marks for the exam decreased the number of students passing the course to as few as 51%. Thus, the allocation of marks to wet laboratories can have a major effect on the percentage of students who pass courses. The question of whether students who fails exams should pass courses/programs needs to be given further consideration.

Introduction

Historically, exams, where students have no prior access, were the most common way to determine academic performance for students. However, over the last 40 years ongoing assessment (coursework) has been introduced into many degrees and most courses have become a mixture of exams and ongoing assessment. Presently, exams are often used to test the assimilation of knowledge and ensure that the students complete the work themselves. Due to time pressures, exams do not allow academic excellence whereas ongoing assessment is used to teach as well as test (Richardson, 2015).

There are no rules about the proportional allocation of marks for ongoing assessment and exams, and the allocation is often made on a seemingly arbitrary basis and not justified. I undertook a search of the websites of Australian universities for (i) second year "Biochemistry" stand-alone courses i.e., not clinical, or medical biochemistry, that gave (ii) details of the allocation of marks; and found that the marks for exams varied between 45% and 80%. The lowest was 45% for midsemester and final tests, 35% for practical worksheets, and 20% for an assignment with presentation (Deakin University), followed by 50% for exam with 50% laboratory-related (University of the Sunshine Coast), 50% exam with 40% laboratory-related, and 10% tutorials (The University of Sydney). Other universities had higher marks for exams; 55% exam, 45% laboratory-related (The University of Queensland); 70% exam and in-semester tests, 30% laboratory-related (Monash University, Australian Catholic University);

70% exams and quizzes, 30% laboratory-related (Murdoch University), 80% exams, 20% laboratory-related (The University of Adelaide), 80% exam and tutorial tests, 20% laboratory-related (Australian National University).

There is evidence that the marks for coursework are higher than for exams, and this has various consequences. Across UK universities, in the programs with higher proportions of coursework, students had higher overall marks, and consequently better degrees, than those with a lower proportion of coursework (Chansarkar & Raut-Roy, 1987; Gibbs & Lucas, 1997; Bridges et al., 2002). This also applies to students in biology/molecular sciences having higher marks in courses with 100% assessment, compared to courses with mixed assessment (Simonite, 2003).

There are few studies of the consequences of proportioning marks between exams and coursework in individual courses. In allied health programs, coursework marks are higher than exam marks in individual courses, and there is only a weak-to-moderate correlation between the marks for coursework and exams, e.g. pharmacy students (Murdan, 2005), students in nursing, paramedicine, and optometry in a pharmacology course, (Doggrell, 2020, 2021), nursing students in a bioscience course (Doggrell, 2023). There are many types of coursework e.g., regular quizzes, homework, games, tutorials, oral or poster presentations, essays/assignments, and laboratories. In addition, laboratories can be either be wet, where testing and analyses are performed using physical samples or dry where analyses use data, coding, and computer systems. In addition, coursework can be either individual or group activities. It is not known whether the relationship between coursework and exams is similar for all types of coursework, or whether it applies to other cohorts of students.

In a second-year biochemistry course with students from pharmacy, biomedical science, medical laboratory science, and nutrition programs, the coursework is wet laboratories. In this course, the following questions, hypothesese, and objectives were addressed:
(i) Do students have higher marks in wet laboratories than exams? The hypothesis was that they would. The objective was to compare the academic performance of students in the laboratories and the exams.
(ii) Do marks in wet laboratories predict marks in the exam? The hypothesis was that they would. The objective was to determine whether performance in the laboratories was a predictor of performance in the exam.
(iii) Does allocating higher proportions of marks to the exam decrease pass rates? The hypothesis was that allocating higher proportions of marks to the exam was associated with lower marks and pass rates. The objective was to consider how proportioning marks, between wet laboratories and the exams, affected the overall marks and pass rates for the completing students.

Methods

In the second-year biochemistry course at Queensland University of Technology, 45% of the total marks were allocated to ongoing assessment of a laboratory portfolio and 55% was allocated between a mid-semester exam (20%) and final examination (35%). The laboratory portfolio was a combination of reporting of practical tests in laboratory books and scientific data analysis tasks. These tasks were marked by the laboratory demonstrators under the guidance of the course co-ordinator. The examinations were predominantly of lecture material with the mid-semester exam being multiple choice questions (MCQs) and the final exam was divided between short answer questions and MCQs. In 2018, there were 326 students enrolled initially, and 306 completed with 20 of those enrolled either not having undertaken one of the exams or the laboratories. Data analysis was for the completing students.

Ethical approval was obtained for this project from the Human Research Ethics Committee at Queensland University of Technology; Ethics Approval Number 1900000541. Student anonymity was achieved by removing names and students' IDs from the marks data prior to the study. The author was not involved in the teaching of the course. The coordinator of the course gave their permission for the author to undertake the study and provided the author with a copy of the Microsoft Excel sheets of the marks associated with the course.

Data analysis for objective 1: comparing academic performance in wet laboratories and for the exams.

The marks for the laboratories and for the exams (mid-semester, final, and combined) were totalled. The totals were expressed as a percentage, and then the percentages were averaged. The percentages for individuals in the exams and laboratories were compared by Students paired t-test. Mean values ± SD were also determined. Students who received < 50% for a component were considered to have failed that component and failure rates for exams and laboratories were compared by Odds-ratio using the online Odds ratio calculator; https://www.medcalc.org/calc/odds_ratio.php.

Data analysis for objective 2: regression line analysis to determine whether performance in wet laboratories was a predictor of performance in the exam.

To determine Pearson's correlation and significance, regression line analysis was undertaken using the data analysis function in Microsoft Excel. Coefficients of 0 - 0.19 were considered very weak, 0.2 – 0.39 weak, 0.4 – 0.59 moderate, 0.6 - 0.79 strong, 0.8 – 1.0 very strong: http://www.statstutor.ac.uk/resources/uploaded/pearsons.pdf. The marks for individual students in the exams were also plotted against their marks in the laboratories. The equation for the regression line ($y = ax + b$), where 'a' is the slope of the line, and the R^2 values are also given. In regression, the R^2 coefficient of determination is a statistical measure of how well the regression line approximates the real data points, with an R^2 of 1 indicating the regression line perfectly fits the data.

Data analysis for objective 3: how proportioning marks, between wet laboratories and the exam, affected the overall marks and pass rates for the passing and failing students.

For all the students who completed the course (i.e., successful and failing students), modelling was undertaken to determine the effect of changing the marking proportions from 45% laboratories/55% exam had on the pass/failure rates and overall grades. The proportions modelled were changed to (i) 60% for laboratories and 40% for exam, (ii) 80% laboratories/20% exam, (iii) 100% ongoing/0% examination (iv) 30% laboratories/70% exam, (v) 15% laboratories/85% exam, and (vi) 0% laboratories/100% examination. Mean values ± SD were determined. Students who achieved less than 50% in the laboratories or the exam were considered to have failed that component for both the actual and modelled data.

Results

Comparison of marks for examinations and wet laboratories for completing students.

Students obtained significantly lower marks, 31%-point difference, in the combined examinations than the laboratories (Table 1). Dividing the examinations into mid- and final exam showed that students obtained lower marks, 18%- and 38%-points, respectively, in these examinations than in the laboratories (Table 1). Students also obtained lower marks in the mid- than final examination (Table 1).

For completing students, the passing rate was 89.5% (274 students) and the failure rate was 10.5% (32 students). Some of the students failed the individual components, by obtaining < 50%. The failure rates for the combined, mid-, and final examinations were much higher than for the laboratories (Table 1). Also, the failure rate for the final examination was higher than for the mid-semester examination (Table 1).

Table 1. Percentage marks and failure rates for examinations and wet laboratories.

Academic outcome	% Mark	Paired t-test	Failure number/rate	P value from Odds-ratio
Combined examinations	51 ± 16 (306)	P < 0.0001	157 (51.3%)	P < 0.0001
Laboratories	82 ± 13 (306)		5 (0.02%)	
Mid-semester examination	64 ± 16 (306)	P < 0.0001	68 (22.2%)	P < 0.0001
Laboratories	82 ± 13 (306)		5 (0.02%)	
Final examination	44 ± 19 (306)	P < 0.0001	201 (65.7%)	P < 0.0001
Laboratories	82 ± 13 (306)		5 (0.02%)	
Mid-semester examination	64 ± 16 (306)	P < 0.0001	68 (22.2%)	P < 0.0001
Final examination	44 ± 19 (306)		201 (65.7%)	

Each % Mark value is the mean ± SD (number of students)
Failure rates were number of student with less than 50%/total number of students who completed the course (percentages)

The findings of higher marks and higher failure rates in examinations and laboratories were similar for students in each of the programs (pharmacy, biomedical science, medical laboratory science and nutrition); Table 2.

Table 2. For individual cohorts, marks and failure rates for examinations vs wet laboratories.

Cohort	Academic outcome	% Mark	Paired t-test	Failure number/rate	P value from Odds-ratio
Pharmacy	Examinations	52 ± 13 (83)	P < 0.0001	42 (50.6%)	P < 0.0001
	Laboratories	79 ± 13 (83)		0 (0%)	
Biomedical Science	Examinations	51 ± 16 (67)	P < 0.0001	33 (49.3%)	P < 0.0001
	Laboratories	83 ± 13 (67)		0 (0%)	
Medical Laboratory Science	Examinations	45 ± 12 (88)	P < 0.0001	59 (67.1%)	P < 0.0001
	Laboratories	84 ± 12 (88)		1 (1.1%)	
Nutrition	Examinations	57 ± 14 (68)	P < 0.0001	27 (39.7%)	P < 0.0001
	Laboratories	81 ± 19 (68)		1 (1.5%)	

Each % Mark value is the mean ± SD (number of students)
Failure rates were number of student with less than 50%/total number of students who completed the course (percentages)

Regression line analysis and Pearson's correlation coefficients.

Regression line analysis was undertaken to determine whether performance in laboratories was a good predictor of performance in the exam. A good correlation would be indicated by both a slope of ~1 and R^2 values of ~1. For the analysis of exam mark vs laboratories, slopes indicated a poor fit, as the slope and R^2 value were not close to 1 (Figure 1), presumably because the marks for the laboratories were much higher than for the exam. However, Pearson's correlation coefficients did show a moderate correlation (r = 0.442) between the marks for the examinations and the laboratories. The findings were similar for students in each of the programs (data not shown).

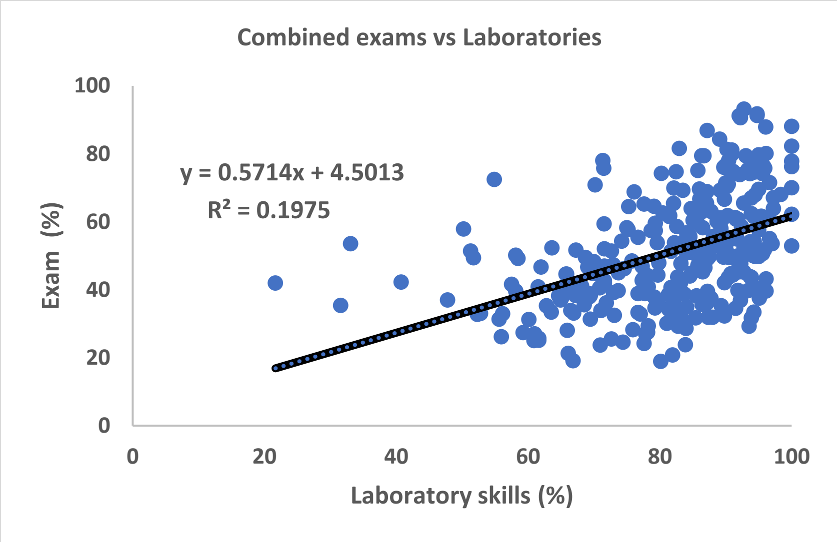

Figure 1. Combined exam marks vs laboratory skills marks, as percentages, for students of biochemistry.

Modelling changing the proportional allocation of marks between wet laboratories and the exams.

Decreasing the allocation of marks to the exams increased the number of students who would have passed the course (Table 3). As the passing rates in the course were relatively high (89.5%), and the modelling only resulted in a maximum of about 8 percentage points to 97.7% (Table 3). Conversely, increasing the allocation of marks to the exams would have dramatically increased the number of students who failed the course (Table 3). The failure rate was 10.5% and was increased up to a maximum of 49.0% in the modelling (Table 3).

Table 3. Actual and modelled data of overall marks, grades, and passing/failing percentages.

Data type	% wet laboratories/% exams	Overall mark N = 306	Grade N = 306	Additional students passing[1] (% passing)	Additional students failing[2] (% failing)
Modelled	100%/0%	82 ± 13	6.1 ± 1.1	7/13 (97.7%)	
Modelled	80%/20%	76 ± 12	5.6 ± 1.2	4/17 (95.8%)	
Modelled	60%/40%	70 ± 12	5.0 ± 1.1	14/32 (94.1%)	
Actual	45%/55%	65 ± 13	4.7 ± 1.1	(89.5%)	(10.5%)
Modelled	30%/70%	60 ± 13	4.3 ± 1.3		32/306 (23.5%)
Modelled	15%/85%	56 ± 15	4.0 ± 1.2		72/306 (36.6%)
Modelled	0%/100%	51 ± 16	3.8 ± 1.3		150/306 (49.0%)

N = number of students

Mark and grade values are the mean ± SD.

1. Additional students passing of the completing students who had failed (% passing of completing students)
2. Addition students failing of the completing students (% failing of completing students)

Discussion

The three major findings of this study of students in a biochemistry course are that for the completing students (i) marks are higher for wet laboratories than the exams (combined exams, mid-semester and final exam) for all students and for the students in different programs;

pharmacy, biomedical science, medical laboratory science, nutrition, (ii) there was a moderate association between marks obtained in the exams and wet laboratories, and (iii) increasing the marks allocated to the exams decreased the number of students who passed the course, whereas decreasing the allocated exam marks increased the number of students passing.

Marks are higher for wet laboratories than for exams, and for the mid-semester than final exam.

This is the first study to show that marks for ongoing assessment (laboratories) are higher than for the exams for students in a biochemistry course. Similar findings have been made previously for pharmacy students undertaking a bioscience course (Murdan, 2005) and for allied health students undertaking a pharmacology course (Doggrell, 2020, 2021) and confirms previous findings of higher marks for ongoing assessment at the program level (Chansarkar & Raut-Roy, 1987; Gibbs & Lucas, 1997; Bridges et al., 2002).

In the present study, the marks for the mid-semester exam were higher than for the final exam. One possible reason for this is that the final exam contained SAQs in addition to MCQs, whereas the mid-semester exam was solely MCQs. A recent study has shown that medical students perform better in MCQs than SAQs in examinations (van Wijk et al., 2023). As a follow-on, the difference between the marks for the exams and wet laboratories in the present study could have been even greater if SAQs had been included in the mid-semester exam.

Performance in wet laboratories as a predictor of performance in the exam

The present study showed for students in biochemistry, marks in laboratory-related ongoing assessment were a moderate predictor of academic performance in the exam. This was in line with previous studies of allied health students (using Pearson's coefficients) showing assessment and its components (tutorials and assignment) to be weak-to-moderate predictors of performance in exams in pharmacology (Doggrell, 2020, 2021), or in exams when laboratory and communication skills are used as the ongoing assessment in a bioscience course (Doggrell, 2023). Marks in ongoing assessment to be a moderate predictor of performance in examinations in a pharmacy program (Murdan, 2005).

Altering the marks allocated to the examination changed the number of students who failed or passed.

Increasing the marks allocated to examinations increased the number of students who failed the course and decreased the number who passed. With the allocation of marks of 45% to examinations and 55% to wet laboratories, in the present study, the number of students who failed the biochemistry course was low (10.5%). With this failure rate, the likelihood of increasing the passing rate by changing the allocation of marks to laboratories was low, and our modelling confirmed this by showing that the passing rate could be increased by 10.2% points. With this allocation, the passing rate was high, 97.7%, and this occurred despite 48.7% of students failing the examination component of the course.

The major finding of the modelling part of our study was to show that increasing the marks allocated to the examinations would have decreased the number of students who passed the course in biochemistry, with 49% failing overall if all the marks had been allocated to the examination. In Australia, the allocation of marks for examination in 2nd-year biochemistry courses varies from 45% to 80% (see Introduction). Thus, if there had been more marks allocated to examination in any of these courses, more students would have failed.

Implications and recommendations from these results

We have previously shown that first year nursing students rapidly lose their recall of bioscience, and less than half consider they have enough recall to handle further bioscience or pharmacology courses (Doggrell & Schaffer, 2016). This situation may have partly arisen from the allocation of marks. Thus, the concern is that the students in the biochemistry course, who pass the course based on marks from ongoing assessment/laboratory-related, but not the examination components, may not have assimilated the necessary knowledge to continue their study of biochemistry. Thus, the disparity between marks in examinations and laboratories needs to be considered, and methods introduced to overcome this. One possible practical solution to this dilemma of whether students who pass laboratories but fail examinations, should be allowed to pass courses and progress in their studies, would be to make it compulsory for the students to pass the examination component of the course. This is already mandatory for second-year biochemistry courses at some universities in Australia e.g., The University of New England, where the examination is worth 40-50%, and the University of Newcastle.

Under the presiding rules at QUT, 51% failed the combined examinations in the biochemistry course but passed the course. It is unlikely that there would have been such a high failure rate, if students were aware of having to pass the exam component at the start of the course, as they would have adjusted their learning and approach to the exams. To avoid any dramatic changes in the pass/fail rates for courses, my recommendation is that there be a stepwise change to requiring the students to pass the exam. For instance, in the first year, the requirement could be a 40% requirement in the exam, followed the next year by 45%, to finally reach 50% in the exam to pass the course.

Another possible solution would be to limit how many marks could be proportioned to ongoing assessment to 20-30%, as is presently done at the Monash University, Murdoch University, and the University of Adelaide, to limit the impact of the allocation of marks to ongoing assessment. By increasing the marks allocated to exams, this measure may improve the underlying knowledge of students, but even this would not guarantee that students have the recall of introductory courses necessary for higher-level courses later in their program.

The downside to decreasing the marks allocated to wet laboratories, is that it may decrease student attendance/engagement in wet laboratories. To avoid this, my recommendation is that attendance/engagement at laboratories could be monitored during a stepwise decrease in marks allocated to laboratories, from 45% to 30% over three years. Should the attendance/engagement drop during this process, consideration should be given to stopping the stepdown.

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