The effectiveness of separating theory and practicum as a conduit to learning physiology

Johannes A. Schuijers,1 Stuart J. McDonald,1 Brianna L. Julien,1 Louise A. Lexis,1 Colleen J. Thomas,1 Siew Chan,2 and T. Samiric1

1Department of Human Biosciences, La Trobe University, Bundoora, Victoria, Australia; and 2School of Allied Health, La Trobe University, Bundoora, Victoria, Australia

Submitted 3 December 2012; accepted in final form 18 January 2013

Schuijers JA, McDonald SJ, Julien BL, Lexis LA, Thomas CJ, Chan S, Samiric T. The effectiveness of separating theory and practicum as a conduit to learning physiology. Adv Physiol Educ 37: 153–156, 2013; doi:10.1152/advan.00161.2012.—Many conventional science courses contain subjects embedded with laboratory-based activities. However, research on the benefits of positioning the practicals within the theory subject or developing them distinctly from the theory is largely absent. This report compared results in a physiology theory subject among three different cohorts of students: those taking the theory subject alone, those taking it concurrent with a physiology practicum subject, and those who previously took the subject when it had practicums embedded within the one subject. The path model shows that students taking both physiology theory and physiology practicum attained a significantly higher result in online tests compared with those who took the theory subject alone (P < 0.05) and that this translated to a significantly higher result in the end-of-semester examination. Similarly, students taking both physiology theory and the physiology practicum attained a significantly higher end-examination result compared with those who took the physiology subject in previous years when the practicums were embedded within the theory subject (P < 0.05). In both cases, this increase was largely attained in components that tested critical thinking and deep learning (short theory application questions and extended written questions). We conclude that students undertaking both physiology theory and the physiology practicum most likely performed better in the theory subject due to better problem-solving skills and a more developed understanding of theoretical content. We suggest that consideration be given in all science curricula to the separation of theory and practicum by developing two subjects with clearly defined different learning outcomes.

physiology theory; physiology practicum; physiology teaching

Address for reprint requests and other correspondence: J. A. Schuijers, Dept. of Human Biosciences, La Trobe Univ., Bundoora, Victoria 3086, Australia (e-mail: J.Schuijers@latrobe.edu.au).
were previously enrolled in the old iteration of physiology (i.e., theory embedded with the practicum). The present study examined student census data from 2011, the first year of implementation of the two new redesigned subjects. As a comparison, student census data from 2009 when the physiology theory subject contained the embedded practicums were compared with both the 2011 cohorts.

The content of the physiology theory subject remained essentially the same: systems-based general physiology. However, the physiology practicum subject underwent substantial revision that aimed to have fewer practical activities requiring students to follow a “recipe” in a laboratory manual and more activities requiring students to identify the problem, explore strategies for solving it, and finally evaluate the solution. Interspersed with these practical activities, a series of skill development activities were also designed to explore the concepts of scientific writing (particularly the development of an abstract), methodology evaluation, and reporting of results. Furthermore, a series of prelaboratory hurdle requirements was developed consisting of prereading tasks and predictions on the to-be-conducted laboratory activity outcomes. Results from a previous study (11) have indicated that practical class activities are more effective when students are prepared before they conduct their experiments. Indeed, activities such as hypothesis testing and predictions have been widely used to promote active learning and improve student performance (2). As such, we hypothesized that the development of a new stand-alone physiology practicum subject would not only meet the stated objectives of the subject but would also enhance the physiology theory grades of those students who undertook both subjects within the one teaching period.

METHODS

Ethics. Publication of the material presented in this report was approved by the Faculty Human Ethics Committee (FHEC 12/147 and FHEC 12/170).

Students. In the year that this study was undertaken (2011), 208 students were enrolled in the physiology theory subject. Enrollment was 103 students in the physiology practicum subject. All students enrolled in the physiology practicum were also concurrently enrolled in physiology theory. Hence, 105 students were enrolled in the physiology theory subject but not the physiology practicum subject. The year that the one subject contained both physiology theory and practicums, the subject had an enrollment of 196 students. Students who did not attempt all assessments were not included in this study.

Students undertaking the subject were enrolled in three principal courses whose prerequisite scores before entry into the university were not substantially different. It is important to note that the group of students who were required to take both the physiology theory and practicum subjects had no difference in first-year grade point average than the other groups. The groups that were able to elect to take the practicum subject in addition to the theory subject also had no difference in their previous year grade point average. Thus, it was not simply the brighter students of year 1 who took both physiology subjects.

Assessment tasks in human physiology theory. The three assessment types in physiology theory were as follows: first, three online tests (OLTs; open book) based on the lecture material. Each test had a set duration, could be attempted only once, and consisted of five short answer questions requiring the application of core knowledge. The three tests collectively contributed 20% toward the total subject grade. Second, there were three group tests (closed book) based on tutorial/workshop case studies. Groups were self-selected and comprised up to five students. Each test consisted of one recall question, one related applied knowledge question, and one further related critical thinking question. The three tests collectively contributed 30% toward the total subject grade. Finally, there was an end-of-semester examination. The examination was based on lecture material and consisted of 40 multiple-choice questions (MCQs) and 5 essay-type questions (extended response (ER) questions). The examination was worth 50% of the total subject grade.

The end-of-semester examination in 2009, when the theory subject contained embedded practicals, was essentially in the same format as that currently used.

Statistical analysis. A path model constructed in the form of a structural equation model was applied to ascertain the difference in end-of-semester examination results among the following three cohorts: the theory subject alone (cohort 1), theory and practicum (cohort 2), and theory embedded with practicals (cohort 3). As shown in generic form in Fig. 1 (8), the model could explicitly measure a cohort’s direct and indirect effects on the end-of-semester examination. The indirect effect of cohort on the examination was through the three intrasemester OLTs. Both the OLTs and examination are known as endogenous variables, whereas cohort is exogenous. The more familiar regression models are unable to cope with such a data structure where there are multiple endogenous variables in a model. A similar model, as shown in Fig. 2, was constructed to analyze the individual components of the examination results, namely, the MCQ component and the ER component. As analyzed with Stata 12.0 (Stata), all statistical tests were performed with 95% confidence intervals (equivalent to setting the level of significance at 5%).

RESULTS

Assessable components of the theory subject. The path model showed that students enrolled in both theory and practicum subjects performed significantly better in the individual OLTs, achieving a higher average mark of 1.02 (out of 20) compared with those who enrolled in the theory alone. Moreover, a better result in OLTs were significantly associated with a better examination result. When analyzed individually, the results for both components (MCQ and ER) were also significantly associated with the OLT results. However, a greater effect was seen with the ER component of the exam than with

![Fig. 1. Generic path model in the structural equation modeling framework. Cohort, cohorts 1–3 (see METHODS); Exam, the end-of-semester examination; OLT, intrasemester online tests; ε, endogenous variable.](http://advan.physiology.org)
the MCQ component (see Table 1). Students did not perform better in the group case study tests.

When students enrolled in both subjects were compared with those who previously enrolled in the single theory/practicum-embedded subject, we found that they performed significantly better in the exam (3.77 marks better of 50 marks total, P < 0.05). This was primarily achieved by a significant improvement in the ER section of the exam (and not the MCQ), achieving a 5.83 better mark of 50 marks total (see Table 1).

In contrast, there were no significant differences in the exam results (or its MCQ or ER components) between those who enrolled in the theory alone and those who were previously enrolled in the theory/practicum-embedded subject (see Table 1).

DISCUSSION

There is a relative paucity of scholarly research from science educators regarding the effects of specific university laboratory experiences on student learning. A recurring concern of practicums is how one can encourage students to apply effective learning strategies to improve their performance in all the components of multiple-choice examinations. This study explored the impact of separating theory and practicum content on student performance, and whether this separation had a significant effect on the ER section of the exam.

In the present study, when we teased out the differences in performance among the three cohorts in both of the two components of the end-of-semester examination, we found that students taking both theory and practical subjects concurrently performed significantly better in both the MCQ and ER components of the exam but, importantly, much more so in the ER component than students enrolled in the theory subject only. When students taking both theory and practical subjects were compared with those previously enrolled in the single theory/practicum-embedded subject, we found that those taking both subjects performed significantly better in the ER component of the exam but not in the MCQ component. Finally, when we compared those students who took the theory subject only with those who were previously enrolled in the single theory/practicum-embedded subject, we found no significant differ-

Table 1. Combined path analyses of examination, MCQ, and ER results

<table>
<thead>
<tr>
<th>Path Analysis</th>
<th>Coefficient</th>
<th>95% Confidence Intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohort → OLT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Theory subject alone* vs. theory and practical subject</td>
<td>1.0240†</td>
<td>0.1381–1.9099</td>
</tr>
<tr>
<td>OLT → exam</td>
<td>1.6823†</td>
<td>1.3101–2.0545</td>
</tr>
<tr>
<td>OLT → MCQ</td>
<td>1.0454†</td>
<td>0.7533–1.3374</td>
</tr>
<tr>
<td>OLT → ER</td>
<td>2.0581†</td>
<td>1.5990–2.5172</td>
</tr>
<tr>
<td>Cohort → exam</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Theory and practical subject* vs. theory with embedded practicals</td>
<td>−3.7707†</td>
<td>−5.8622 to −1.6792</td>
</tr>
<tr>
<td>Theory subject alone* vs. theory with embedded practicals</td>
<td>−0.5893</td>
<td>−1.6824 to 0.5039</td>
</tr>
<tr>
<td>Cohort → MCQ</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Theory and practical subject* vs. theory with embedded practicals</td>
<td>−1.3664</td>
<td>−2.8328 to 0.1000</td>
</tr>
<tr>
<td>Theory subject alone* vs. theory with embedded practicals</td>
<td>0.0783</td>
<td>−0.6894 to 0.8461</td>
</tr>
<tr>
<td>Cohort → ER</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Theory and practical subject* vs. theory with embedded practicals</td>
<td>−5.8334†</td>
<td>−8.5466 to −3.1202</td>
</tr>
<tr>
<td>Theory subject alone* vs. theory with embedded practicals</td>
<td>−1.2764</td>
<td>−2.6748 to 0.1219</td>
</tr>
</tbody>
</table>

MCQ, multiple-choice question; ER, extended response; OLT, intrasemester online test. *Reference point for coefficient analysis. †Statistically significant at 5%.
The difference in results between the cohort currently undertaking both physiology theory and practicum subjects and those that previously undertook the single embedded theory/practicum subject as well as the lack of difference between the cohort currently undertaking the theory subject only and those who previously undertook the single embedded theory/practicum subject might also be explained by different depth of learning. The practicals contained in the “old” physiology subject did not contain many of the skill-based practical classes that were introduced to develop deep learning skills. Also, the weighting of the assessment of the practical tasks was only a small proportion (25%) of the total assessment. Research clearly demonstrates that the importance a student places on a subject when assessment tasks are clearly dictated by their overall weighting (9). In our case, it can be argued that when the combined sum of all the assessments tasks associated with the practical activities contributed only 25% toward the total subject grade, less importance by students was given to the assessment tasks than when the assessment tasks associated with the practicals cover all 100% of the total assessment. Students may be divided into three main groups with regard to learning and studying: surface (memorizing details), deep (understanding material), and strategic (motivated by assessment) (3, 9, 10). The separation of physiology into theory and practicum components, thus allowing the implementation of highly weighted assessment tasks based on skill development, encourages the last two of the aforementioned learning strategies.

Conclusions. In 2010, a physiology theory and embedded practical subject (20 credit points) was divided into separate theory and practicum subjects (15 credit points each) after a change in university policy to reweight all second-year subjects at 15 credit points. This decision to increase rather than decrease the physiology presence in a science degree has resulted in better student learning for those students undertaking both subjects concurrently. Even though the practicum subject was constructed to develop a different set of intended learning outcomes compared with the theory subject, it is interesting to note that not only do students undertaking the practical subject develop these learning outcomes, but they are also able to perform better in assessments designed to test deep learning of the physiology theory and hence obtain, on average, a significantly higher mark in their physiology theory subject. The intrasemester OLTs are an accurate indicator of those students who attain these deep learning skills. Those who do so not only perform better in the OLTs but are able to translate that improvement to the end-of-semester examination and, in particular, the ER component of that exam. Therefore, our model of intrasemester OLTs assessing physiology theory requiring deeper learning provides educators with the opportunity to identify students who are at risk of performing below expectations in the end-of-semester examination. Our experience demonstrates that requiring students to undertake a significant stand-alone practicum subject with highly weighted skill-based assessment tasks alongside the same discipline theory subject should be considered in all science curricula as it provides not only the attributes attainable by undertaking appropriately constructed practical tasks but also provides and encourages the skills and opportunity to develop a deeper learning of the theory underpinning the practical tasks.

DISCLOSURES

No conflicts of interest, financial or otherwise, are declared by the author(s).

AUTHOR CONTRIBUTIONS


REFERENCES