Promoting student engagement and academic achievement in first-year anatomy and physiology courses

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Reinke NB. Promoting student engagement and academic achievement in first-year anatomy and physiology courses. Adv Physiol Educ 43: 443–450, 2019; doi:10.1152/advan.00205.2018.—Students from three undergraduate programs at James Cook University, Queensland, Australia, studying combined first-year anatomy and physiology courses, showed different academic achievement in physiology. Physiotherapy students were more active and social when completing learning tasks and achieved significantly higher grades in physiology compared with students enrolled in Sport and Exercise Science and Occupational Therapy programs. To promote academic engagement and achievement by all three groups, discussion questions, case studies, and study guides were included. The aim of this study was to investigate the effectiveness of using these modified resources to promote active learning, enhance academic social interactions, and provide a supportive learning environment. The occupational therapy students showed increased academic achievement (from 57.9 to 66.5%) following implementation of the new resources, but there was no change in the already high-performing physiotherapy students (73.1%) and, more concerning, the sport and exercise science students (from 54.6 to 56.7%). Fewer sport and exercise science students had prior learning in chemistry (30.4% of participants) and also spent little time outside class studying (8 h/wk), compared with the physiotherapy cohort (70.0% chemistry; 13 h/wk studying). Findings of this research demonstrate that creating a supportive and active learning environment are important factors in promoting the learning of physiology for some cohorts. Background knowledge, academic self-regulatory skills, and the experience of teaching staff are factors that must be considered when endeavoring to increase student academic achievement. Future studies should examine the effect of students’ academic self-regulation and the use of remedial chemistry classes when learning physiology.

active learning; first-year; learning environment; physiology; student engagement

INTRODUCTION

Physiology is the study of the normal functioning of a living organism and its component parts, including all of the internal biological processes (50). It is essential that curricula in health science programs provide a solid foundation in physiology to promote understanding of the interplay between cells, organs, and organ systems during both health and disease. In addition, basic knowledge of cell biology, chemistry, and physics are necessary to develop a thorough understanding of physiology (21, 38, 44). Physiology is perceived by students as being difficult to learn (12, 16, 38, 44, 51, 52). Researchers have identified many factors that contribute to this difficulty, including students’ prior knowledge (38), the required level of reading skills, classroom methodology (24), as well as the terminology and the complex nature of the discipline (44). Consequently, failure rates in first-year university physiology courses are consistently high (21–23).

The engagement of first-year students in educationally purposeful activities is positively related to academic outcomes (31). According to constructivist theories, learners construct new knowledge with their own activities to build on what they already know (6). Thus academic achievement may be promoted by a learning environment based on constructivist theory, which affords opportunities that enhance students’ ability to regulate their learning (13), support the construction of knowledge, and promote engagement (27). Astin (4) proposed that student involvement (engagement) is one of the most important predictors of student success.

The term “engagement” describes a range of behaviors exhibited by learners. Coates (10) identified several elements of engagement, including active learning, a supportive learning environment, and student/staff interactions. Active learning refers to students’ efforts to purposefully increase their knowledge. A supportive learning environment promotes students’ feelings of legitimation within the learning community (10). Additionally, a supportive learning environment and positive learning experiences promote students’ self-efficacy, which, in turn, is associated with increased academic performance and successful progression to graduation (39). Student/staff interactions are important, because support by both teaching staff and peers has been shown to promote student academic engagement and achievement (45). The educator must, therefore, create a teaching-learning environment that provides quality instructional materials and experiences to enhance active learning and facilitate social interaction (27).

Many aspects of university study have been investigated, including teaching and learning techniques, learning environments, and methods that can promote student learning. The ultimate goal has been to identify factors that promote students’ academic success and persistence to graduation. Freeman et al. (17) conducted a meta-analysis of 225 studies that had examined active learning in lectures in science, education, and mathematics. Results indicated that active learning increased the examination performance of students by improving
their conceptual understanding (26). However, Jensen et al. (25) found that the use of learning resources outside the classroom (for example, those that require the application of knowledge to novel situations and problem solving) also increased student learning. In addition, student perceptions of their learning environment, such as the classroom ambiance and inclusivity in the learning community, can influence their learning behaviors and whether or not they succeed in their studies (47, 57). For example, a classroom environment that promotes student feelings of security and well-being with regard to their peers, teaching staff, and the curriculum, that is, their comfort, will also support active learning and the understanding of challenging concepts (28).

The present study investigated students enrolled in combined first-year human anatomy and physiology courses at James Cook University (JCU), Queensland, Australia, in three different programs: Bachelor of Occupational Therapy, Bachelor of Physiotherapy, and Bachelor of Sport and Exercise Science. The anatomy and physiology components each constituted 50% of the final grade. The physiology component of these courses consisted of six modules: core physiological concepts, neurophysiology, muscle physiology, blood and immunity, respiratory physiology, and cardiovascular physiology. A consistent team of faculty taught the physiology component of these courses for several years, including the duration of this study. In previous years, students from the three courses had been found to engage with the learning resources in different ways, and, despite the similar delivery of classes and assessment tasks, the groups achieved different levels of academic success. Specifically, physiotherapy students were more actively involved in completing learning tasks and participated more frequently in discussions during practical classes than did the other two cohorts. The physiotherapy students also achieved higher grades in physiology (73.1%) compared with the other two cohorts. The physiotherapy students also achieved higher grades in physiology (73.1%) compared with occupational therapy (57.9%) and sport and exercise science students (54.6%).

The aim of this study was to investigate the impact of using modified learning resources on student engagement and academic achievement in physiology. The resource modifications addressed three key elements of student engagement: promoting active learning, providing a supportive environment for learning, and creating opportunities to encourage interactions between staff and students. The study addressed the following research questions:

1. Will the new learning resources and activities provided to first-year physiology students support active learning, create a supportive learning environment, and encourage student-staff and student-student interactions?
2. Will these new learning resources and activities promote academic achievement?

**METHOD**

The study used action research methodology (40). One cycle of action research was conducted, starting with problem identification, defined as the differences in classroom engagement and academic performance of physiology students in three health science programs. Intervention (i.e., modification to learning resources) was designed to address the problem and then implemented. An assessment of the effectiveness of intervention was subsequently conducted by examining students’ reported engagement with the resources, their interactions with staff and peers, their perceptions of the learning environment, and their academic achievement. This assessment was undertaken by examining student feedback (provided using an online questionnaire) and student academic records.

**Ethics**

This research project was approved by the Human Research Ethics Committee at JCU (approval no. H4486). Ethical principles, such as informed consent, confidentiality, and security of information complied with the JCU code of ethical conduct for teaching and research involving human subjects.

**Participants**

Student volunteers were recruited from three first-level courses at JCU:
- BM1031 – Anatomy and Physiology for Occupational Therapy 1
- BM1041 – Anatomy and Physiology for Physiotherapy 1
- BM1061 – Anatomy and Physiology for Sport and Exercise Science 1

Toward the end of semester 1, 2012, students enrolled in these courses were invited to participate in the study. Of the 232 students enrolled in the courses, 82 responded to the survey. Participants completed an online questionnaire administered through Survey Monkey, and the responses were divided into three groups, according to their program (Table 1). Participants in all three cohorts were of similar age and were enrolled in a similar number of courses. Sport and exercise science had a higher proportion of men compared with the other two cohorts.

**Physiology Learning Resources**

Some years before the present study, the physiology lectures for these courses had been modified from traditional didactic lecture delivery to a format encouraging student interaction and activity. Brief intervals during lectures were introduced to provide time for effective note taking, and for students to reflect, question, and critically think about the information provided. Small-group discussions and summarizing tasks were also included in each lecture session. Students could confirm or explore facts and assimilate information without delay, thereby making the lectures more physically and cognitively active events compared with the traditional format. Lecture slides were provided before the lecture to support note taking, and audio recordings were available after the lecture to facilitate review of facts and concepts.

For the present study, several additional physiology learning resources were produced, and some of the existing resources were modified to encourage active engagement and social interactions. The

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**Table 1. Demographic information of participants studying physiology in three university courses**

| Characteristic            | n   | Occupational Therapy | n   | Physiotherapy | n   | Sport and Exercise Science |
|---------------------------|-----|----------------------|-----|---------------|-----|---------------------------|
| Age, yr                   | 32  | 19.6 (2.8)           | 19  | 20.2 (2.7)    | 23  | 19.7 (2.2)                |
| Sex, male/female          | 34  | 8/26                 | 20  | 8/12          | 23  | 11/12                     |
| Study load, no. courses/semester | 34  | 3.7 (0.8)           | 19  | 3.6 (1.0)     | 23  | 3.5 (1.0)                 |

Values are means (SD); n, no. of participants.
four new resources provided before the lectures for each module are listed below.

1. Study guides were developed to specify and discuss important concepts and outline suggested reading materials for these concepts. Concept checks and problem-solving questions were included in the guides.

2. Discussion questions [e.g., Identify a partner who has a different Spirogram to yours (either resting or exercise). You should describe the traces to each other, make notes, and sketch the traces. Together, discuss the differences between the two traces] were added to the practical workbooks and included a combination of short-answer questions, case studies, and other activities requiring knowledge synthesis and problem solving. To further encourage peer interactions, many of the physical resources (e.g., ECG traces, puzzle pieces) were provided to groups of students.

3. Weekly formative quizzes of lecture content were introduced and immediate feedback provided, which could be accessed by students through the online learning management system.

4. Weekly online animations, quizzes, and puzzles (Mastering A&P, Pearson) accompanying the prescribed anatomy and physiology textbook, Human Anatomy and Physiology (34), were incorporated into the course assessment. These activities were hurdle tasks that students were required to complete each week but did not contribute to the final grade.

Data Collection

The online questionnaire consisted of two parts. Part 1 collected information about student demographics (age, sex, study load) and academic history [overall position (OP) score on entry, courses completed at high school, hours/week spent studying physiology]. The OP score is used in Queensland to provide a rank order from 1 (highest) to 25 (lowest) based on the overall achievement at high school. This score is used to rank students for entrance to programs at tertiary institutions (43). Part 2 requested responses to 18 statements about how students interacted with the learning resources and their perceptions about learning physiology. Students were asked to indicate their response to each statement using a 10-point Likert scale.

Active engagement was measured by students rating (from 1 = never to 10 = always) how often they engaged in physical and cognitive episodes when using/engaging with seven learning resources. This approach was modified from that used by Van Amburgh et al. (58), who defined “doing” and “processing” elements of active learning when developing a measurement tool. In the present study, physical (doing) activities included note taking, drawing, and highlighting; cognitive (processing) activities involved thinking about concepts, pondering, problem solving, and recalling and applying facts. The self-assessment of learning activity was applied to students’ interactions with seven learning resources (including in-class and private study time), rather than to learning activities (tasks) occurring solely within lectures. Each statement focused on student engagement, either physical or cognitive, when they were “using” each of the following resources: lectures, podcasts, lecture slides, practical classes, prescribed textbook, online activities (including Mastering A&P and online practice quizzes), and study guides. For example:

When engaging with the prescribed textbook to study physiology, how often are you physically active (for example, writing notes, drawing, or highlighting)?, where 10 = always (whenever I use this learning resource I am always physically active) and 1 = never (whenever I use this learning resource I am never physically active).

The scores for all seven resources were summed to give physical and cognitive active scores, each ranging from 7 to 70. Student comfort, defined as feelings of well-being with their peers, staff, and the curriculum, when studying physiology was measured when the semester commenced and again toward the end of the semester (from 1 = not comfortable at all to 10 = very comfortable). Students also indicated how often they engaged in physiology-related social interactions with teaching staff and their peers during practical classes; for example:

During the physiology practical classes in this course, on average, how often did you interact with other students to discuss a physiology related topic?, where 10 = at least 10 times during a practical class, and 1 = not at all during a practical class.

Face validity of the statements was evaluated by a panel of colleagues working independently (9).

Student academic records included academic achievement in the physiology components of the courses, which were assessed by four examinations comprising 120 multiple-choice questions. Using Bloom’s taxonomy (7) as a guide, 54 questions were at the knowledge level, 48 questions were at the comprehension level, and 18 questions were at the application level. These examinations were identical for all three courses, and there were only minor variations in questions between 2011 and 2012.

Data Analyses

All data were analyzed using IBM SPSS Statistics software (version 24). Demographics data were analyzed using descriptive statistics. Inferential statistics were used to analyze data relating to academic achievement. Independent group t-tests were performed to assess differences in mean scores for academic achievement for students in each of the three cohorts between 2011 and 2012. An ANOVA was conducted to examine differences in mean responses among cohorts in 2011. Further analysis was conducted using post-hoc Games-Howell tests, because sample sizes were not equal. In part 2 of the questionnaire, students rated their physical engagement, cognitive engagement, level of comfort with physiology, and their social interactions on a Likert scale from 1 to 10. Responses to statements were presented as percentages and averaged to provide an overall composite measure out of a possible score of 10, with higher scores indicating higher agreement. χ² tests for goodness of fit were performed to explore the relationships among categorical variables. Kruskal-Wallis tests were used to examine differences among cohorts. Mann-Whitney U-tests were performed between pairs of groups, and a Bonferroni adjustment was applied to the α-values to control for type I errors. Wilcoxon signed-rank tests were used to investigate changes in scores between two time periods (beginning of semester 1 and end of semester 1, 2012). The strength of the relationship between the statement responses was analyzed using Spearman’s rank-order correlation (p) and interpreted using Cohen’s (11) guidelines. The significance of test results was based on the probability convention of \( P < 0.05 \).

RESULTS

Engagement

Active learning. Students’ active involvement with seven learning resources were investigated for each cohort (Table 2). There was a significant difference in cognitive activity among the three cohorts: \( \chi^2 \) [degrees of freedom (df) 2; \( n = 76 \)] = 6.71, \( P = 0.035 \). Post hoc Mann-Whitney U comparisons indicated significant difference between the physiotherapy and sport and exercise science students in the number of episodes of cognitive activity \( (U = 122, z = -2.47, P = 0.013, r = 0.29) \). There was no difference in cognitive activity when using the learning resources between physiotherapy and occupational therapy students \( (U = 236, z = -1.87, P = 0.062, r = 0.25) \) or between occupational therapy and sport and exercise science students \( (U = 311, z = -1.06, P = \)...
A large, positive relationship between total cognitive activity when learning and academic achievement in physiology for the physiotherapy group (\( r = 0.654, n = 17, P = 0.004 \)). However, no relationship in total cognitive activity when learning and academic achievement was found for the occupational therapy (\( r = 0.016, n = 34, P = 0.927 \)) or sport and exercise science students (\( r = 0.314, n = 21, P = 0.166 \)).

**Learning environment.** The change in student comfort when learning physiology over the course of the semester was used as a measure of the nature of the learning environment (Table 3). There was a statistically significant increase in comfort as the semester progressed for all participants (\( z = 4.94, P < 0.001 \)), with a medium effect size (\( r = 0.40 \)). There was no difference among the courses in the change in students’ comfort (comfort scores) when learning physiology [\( \chi^2 (df = 2; n = 77) = 0.370, P = 0.831 \)].

**Social interactions.** Social interactions during physiology practical classes were recorded by students according to the number of physiology-related exchanges they had with teaching staff and peers (Table 3). There was no difference in the number of either student-teacher [\( \chi^2 (df = 2; n = 75) = 0.001, P = 1.000 \)] or student-student interactions [\( \chi^2 (df = 2, n = 76) = 0.462, P = 0.794 \)] among cohorts.

**Academic Achievement and History**

Academic achievement in the physiology components of the three courses completed in 2011 (prestudy) and 2012 were expressed as percentages and compared (Table 4). There was a statistically significant difference in academic achievement among the cohorts in 2011 [\( F(2,207) = 28.8, P < 0.001 \)], with a large effect size (\( \eta^2 = 0.22 \)). Post hoc comparisons using Games-Howell tests indicated that the mean percentage for the physiotherapy students was significantly greater than for either the occupational therapy (\( P < 0.001 \)) or sport and exercise science (\( P < 0.001 \)) cohorts.

Following implementation of the changes to the learning resources in 2012, achievement in physiology was significantly higher for the occupational therapy students compared with 2011 [\( t(136) = -3.19, P = 0.010 \)]. There was no change in achievement in physiology from 2011 to 2012 in either the physiotherapy [\( t(132) = -0.01, P = 0.380 \)] or sport and exercise science [\( t(156) = -0.77, P = 0.440 \)] groups.

Several characteristics of the participants’ academic history were investigated (Table 5). There was a significant difference in OP scores among the three cohorts [\( r^2 (df = 2; n = 74) = 9.19, P = 0.010 \)]. Post hoc comparisons using Mann-Whitney U-tests indicated that physiotherapy participants had a higher OP score compared with both occupational therapy participants (\( U = 29.5, z = -2.67, P = 0.008 \)) or sport and exercise science participants (\( U = 26.0, z = -2.36, P = 0.018 \)). There was a strong negative relationship between OP score and academic achievement in physiology (\( r = -0.57, n = 39, P < 0.001 \)), indicating that participants who performed well academically at high school also performed well in first-year physiology. Approximately 67% of all participants had completed high school biology. There was a significant difference in the proportion of students who completed high school chemistry among the three cohorts [\( r^2 (df = 2; n = 77) = 6.90, P = 0.032 \)]. Post hoc comparisons indicated that more physiotherapy participants completed high school chemistry compared with the sport and exercise science students (\( U = 139, z = -2.56, P = 0.011 \)). However, there was no difference in the number of participants who completed high school chemistry between physiotherapy and occupational therapy cohorts (\( U = 338, z = -1.03, P = 0.302 \)) or between occupational therapy and sport and exercise science cohorts (\( U = 252, z = -1.83, P = 0.068 \)).

The number of private study hours per week dedicated to learning physiology was examined for each cohort (Table 5). There was a significant difference in the number of study hours completed by the three cohorts [\( r^2 (df = 2; n = 74) = 9.19, P = 0.010 \)]. Post hoc Mann-Whitney U-tests indicated that the physiotherapy participants completed more hours of study per week compared with the sport and exercise science participants (\( U = 92.5, z = -2.98, P = 0.003 \)). However, there was no difference between the number of hours of study for physiotherapy and occupational therapy participants (\( U = 242, z = -1.8, P = 0.072 \)) or occupational therapy and

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### Table 2. Active learning scores of students studying physiology in three university courses

| Type of Active Learning | n | Occupational Therapy | n | Physiotherapy | n | Sport and Exercise Science |
|------------------------|---|----------------------|---|---------------|---|-----------------------------|
| Physical               | 34| 54.5 (15/70)         | 19| 55.0 (31/63)  | 20| 53.0 (30/65)                |
| Cognitive              | 34| 51.0 (34/70)         | 20| 55.5 (40/70)* | 22| 47.0 (26/60)*               |

Values are median scores (minimum/maximum) out of a possible total of 70; \( n \), total no. of participants. *Significant difference between cohorts: \( P = 0.013 \).

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### Table 3. Participant comfort scores and number of in-class social interactions when studying physiology

| Measure                           | n | Occupational Therapy | n | Physiotherapy | n | Sport and Exercise Science |
|-----------------------------------|---|----------------------|---|---------------|---|-----------------------------|
| Comfort when learning physiology  |   |                      |   |               |   |                            |
| Start of semester                 | 34| 5.0 (1/10)           | 20| 6.0 (2/10)    | 23| 6.0 (2/10)                 |
| End of semester                   | 34| 7.5 (1/10)           | 20| 9.0 (5/10)    | 23| 8.0 (2/10)                 |
| Change in comfort score*          | 34| 2.0 (−9/9)           | 20| 2.0 (−2/6)    | 23| 2.0 (−6/7)                 |
| Social interactions/practical class |   |                      |   |               |   |                            |
| Student and teaching staff        | 32| 9.0 (4/10)           | 20| 9.0 (4/10)    | 23| 9.0 (3/10)                 |
| Student and peers                 | 33| 7.0 (3/10)           | 22| 7.0 (2/9)     | 23| 8.0 (2/10)                 |

Values are median scores (minimum/maximum); \( n \), total no. of participants. *Change in comfort scores refers to change in rating from beginning to end of semester.
sport and exercise science participants ($U = 252.5$, $z = -1.6$, $P = 0.101$, $r = 0.22$). There was a strong, positive correlation between study hours per week and academic achievement ($r = 0.55$, $n = 17$, $P = 0.022$) for the physiotherapy cohort. Physiotherapy participants who spent more hours studying physiology per week also performed well in physiology. However, there was no correlation between these two variables for the occupational therapy ($r = -0.04$, $n = 34$, $P = 0.833$) or sport and exercise science students ($r = -0.11$, $n = 19$, $P = 0.667$).

**DISCUSSION**

In 2011, academic achievement in the physiology component of the first-year combined anatomy and physiology course was greater for physiotherapy students than for occupational therapy and sport and exercise students. In addition, physiotherapy students were found to engage more actively and socially in class compared with the other two groups. In 2012, modifications were made to the teaching and learning resources used for all cohorts. This change was made in an attempt to encourage more active engagement, foster more social learning opportunities, and provide a supportive environment for physiology students in the occupational therapy and sport and exercise science courses.

Using the modified resources, all three cohorts of students engaged in physical and cognitive active episodes when learning physiology. Physiotherapy participants were more cognitively active when studying physiology compared with those enrolled in sport and exercise science. Additionally, the more cognitively active the physiotherapy participants were, the higher their academic achievement in physiology. These results support the findings of Rodenbaugh et al. (46), who reported that the use of active learning activities in anatomy and physiology courses was associated with positive outcomes, such as enhanced student performance. Additionally, according to Mayer (36), thinking behaviors (cognitive activities) are better able to support learning compared with “learning by doing” (physical activities). However, the inclusion of active learning activities does not guarantee an increase in learning and academic achievement (2). Andrews et al. (2) also argued that, to effectively use active learning resources to promote learning, instructors must have a high level of teaching expertise and an understanding of how to use these resources to encourage the construction of knowledge by students. Many educational research studies, including the present research, rely on self-report scales, yet it must be acknowledged that the validity of the data collected varies with the students’ abilities to accurately assess their own responses (3). Social desirability bias and memory inaccuracies can influence data collected as student’s overall feelings about the course, teaching, teachers, and support staff, or their conscious or unconscious desire to appear other than they are (8).

Pollock and Finkelstein (42) stressed the importance of two factors in creating an effective learning environment: the situation (physical features of the rooms, learning resources, social setting) and the culture (rules, accepted norms and ambience in which these situations are set, purposes of tutorials). Thus the role of an experienced and skilled educator is vital in creating an environment that supports student learning. In the present study, there was some variation in how the learning resources were modified and implemented in the classroom. This highlights a significant challenge for a team-teaching and learning environment in that students will need to adjust to the pedagogical approaches of several different teachers within a single course.

In the present study, the positive change in comfort over the course of the semester across all three health science cohorts suggests that students were actively committed to learning physiology in what they regarded as a supportive environment. Students’ perceptions of the classroom environment have been shown to influence their learning behaviors and the learning outcomes. Lizzio et al. (33) argued that student perceptions of a good learning environment can encourage them to adopt deep approaches to learning. A supportive and nonjudgmental environment allows students to make mistakes without fear of humiliation (5), but requires staff to be available and approachable. Students who feel supported by their teaching staff and peers are more engaged with their studies (45).

Student interactions with teaching staff are important for promoting learning (32, 41). Staff-student interactions in the classroom are useful for the discussion of course content, but may also help students to develop problem-solving abilities and have a positive impact on their approach to study and life in general (15). In addition, interactions of students with their peers in academic activities make a valuable contribution to

### Table 4. Academic achievement for the physiology component of three combined anatomy/physiology courses in 2011 and 2012

| Year | Occupational Therapy | Physiotherapy | Sport and Exercise Science |
|------|----------------------|---------------|----------------------------|
| 2011 | 67 (57.9)            | 73.1 (10.7)   | 54.6 (16.5)                |
| 2012 | 71 (66.5)            | 73.1 (12.7)   | 56.7 (16.3)                |

Values are means (SD) in percentage of possible marks; $n$, total no. of participants. *Significant difference between cohorts with matching symbols: $P < 0.001$. †Significant difference from the same cohort from the previous year: $P = 0.01$.

### Table 5. Academic history of participants studying physiology in three university courses in 2012

| Characteristic                                 | Occupational Therapy | Physiotherapy | Sport and Exercise Science |
|------------------------------------------------|----------------------|---------------|----------------------------|
| OP score*, median (minimum/maximum)            | 9.0 (3/14)           | 5.0 (3/6)     | 10.5 (4/18)                |
| Private physiology study, median (minimum/maximum), h/wk | 8.0 (1/9)           | 13.0 (1/18)   | 8.0 (1/9)                  |
| Participants who completed high school biology, % | 61.8                 | 75.0          | 65.2                       |
| Participants who completed high school chemistry, % | 44.1                 | 70.0          | 30.4                       |

Values are median (minimum/maximum) or percentage; $n$, total no. of participants. *OP score denotes the overall position score, a rank order position from 1 (highest) to 25 (lowest) based on the overall achievement (43). †Significant difference between cohorts with matching symbols: $P < 0.05$.  

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academic success (30, 56) and cognitive development (29) and can promote the sharing of effective learning strategies (48). Accordingly, the practical classes in the present study were modified to include discussion questions and group activities with the objective of providing social learning opportunities. The instructions and tasks within the practical classes directed students to discuss concepts and to question teaching staff and peers, and it was suggested by McKinney et al. (37) that such actions provide students with a sense of empowerment. Participants from all three courses reported high numbers of physiology-related social interactions with their peers during the practical classes, and this indicates that the changes to the resources were successful in promoting social engagement.

The physiotherapy students performed better than the other two groups in physiology assessments both before (2011) and after (2012) the introduction of the new teaching and learning resources, but there was no improvement in academic achievement when comparing the 2 yr. It is possible that the high-achieving students had already adopted effective learning strategies before university and were already engaging with the resources in ways that promoted effective learning. Indeed, one of the observations that prompted this study was that the physiotherapy students were more actively involved in completing tasks and more frequently participated in discussions during practical classes compared with the other students. For physiotherapy students, there was a positive relationship between high academic achievement in physiology and the number of hours dedicated to private study and total cognitive engagement with learning resources. These findings indicate that the physiotherapy cohort employed effective learning strategies and dedicated many hours to study every week.

The occupational therapy students achieved significantly better academic results in physiology in 2012 than in 2011. This result supports the findings of Freeman et al. (17), who reported that the replacement of passive learning by active learning interventions increased examination scores and reduced failure rates. The new learning resources used in the present study may have contributed to the improvement in academic achievement for the occupational therapy students, but had no effect on the performance of the physiotherapy and sport and exercise science students. In their study, Freeman et al. (17) confirmed the previous research finding, for example, Jensen and Lawson (26), that higher level cognitive skills are more positively impacted by active learning than are lower level cognitive skills. The majority (85%) of examination questions used in the present study were at the knowledge and comprehension cognitive levels and were consistent among the examinations for the three courses and across the 2 yr of the study. It is possible that the higher examination results of the occupational therapy students when learning with the active pedagogy were due to an improvement in their performance on those higher level questions, but this does not explain the different results among the three courses.

Another factor to consider when interpreting these results is the time that each cohort of students dedicated to private study. Tinto (55) proposed that the more time students invest in learning activities, in particular those activities completed outside the classroom, the more they learn. Supporting this relationship, Sturges and Maurer (52) found that many physiology students who did not perform well academically admitted to not studying consistently. The sport and exercise science students engaged in 8 h/wk in private study compared with 13 h/wk committed by physiotherapy students.

When examining the academic achievements of these three groups of students, another factor to consider is their differing academic backgrounds before starting university. Many physiological concepts are complex and depend on knowledge from several disciplines, including chemistry (38) and biology (21). A similar percentage of students (~67%) in all three cohorts had prior learning in biology. However, in contrast to the sport and exercise science students (30.4%), a much greater percentage of the physiotherapy students (70.0%) had studied chemistry at school and thus had a valuable knowledge base for their university studies. This factor alone would have assisted them in understanding the physiology curriculum and contributed to their higher achievement in physiology. Green et al. (18) reported that completion of science prerequisite courses (including chemistry) at high school is important for the success of the academically lower performing students learning first-year physiology. Despite the promotion of active and social learning, the sport and exercise science students, who had less prior knowledge of chemistry, also devoted less time to learning physiology. These factors prevented them from achieving the same depth of understanding of the physiology content compared with the other two cohorts. The use of appropriate bridging (supplementary) modules would be valuable to physiology students who have little prior knowledge of chemistry (53).

Positive relationships between high school achievement/college admission test scores and the academic achievements of first-year students have been reported across many disciplines, including physiology (1, 14, 18, 49, 59). This relationship may be explained, to some degree, by prior knowledge supporting the acquisition of new knowledge, as described above (19). In addition, the knowledge and confidence provided by past academic success are likely to enforce further engagement in learning (35). In the present study, the relationship between university entrance scores and first-year academic achievement in physiology supports the findings of these earlier studies, but only applies to students studying physiotherapy. In addition to advantages provided by their learning experiences in school, the physiotherapy students made different choices with regard to their learning, compared with the sport and exercise science and occupational therapy students and were more actively engaged in class (prestudy), more cognitively active when using the learning resources, and spent more time studying outside of class.

The ability to effect positive change in a learning environment can be determined by many factors, including the experience and enthusiasm of the teaching staff (20). In the present study, the same group of teaching staff taught all three groups of students over several years, including the years included in this study. Thus it is possible that the existence of the research may have enhanced in-class teacher enthusiasm; however, if this were the case, it is likely that it would have had similar effects across all three groups of students.

According to Thibodeaux et al. (54), student academic achievement can be affected by their academic self-regulation, with high-achieving students more likely to have high levels of self-regulation than those with lower achievement levels (60). Academic self-regulation involves setting goals, planning, choosing appropriate learning strategies, and reflecting on
performance (61). It is likely that the learning behaviors of the physiotherapy students contributed to their higher academic achievement in physiology. Further investigation into students’ academic self-regulation will provide guidance as to additional ways to encourage and assist student learning in physiology.

Conclusions

Many of the learning resources used in first-year combined anatomy and physiology courses in three health science programs at JCU were modified in an attempt to enhance student engagement and academic achievement. Our study explored the relationships between the learning environment, learning resources, and academic achievement for physiology students. The academic achievements of physiotherapy students studying physiology did not change after the introduction of the new “active” resources; however, students in this program had already demonstrated high activity and social interactions, as well as superior academic achievements, before the study. In contrast, the less academically successful occupational therapy students showed a significant increase in academic achievement with implementation of the new resources. There was no change in the modest performance of the sport and exercise science students. Few of the sport and exercise science students had previously studied chemistry, which is essential for understanding many physiology concepts, but they also devoted less time outside of class studying compared with the other two cohorts. The findings of this study support previous research showing that a supportive environment and opportunities for active learning support students who are studying physiology. However, we showed that background knowledge, academic self-regulatory skills, and the experience of the teaching staff are also factors that must be considered when attempting to improve student involvement and outcomes. It is recommended that future studies examine academic self-regulation and the importance of teaching basic chemistry to students who are learning physiology.

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DISCLOSURES

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

AUTHOR CONTRIBUTIONS

N.B.R. conceived and designed research; performed experiments; analyzed data; interpreted results of experiments; drafted manuscript; edited and revised manuscript; approved final version of manuscript.

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