Interteaching within a human physiology course: a comparison of first- and second-year students’ learning skills and perceptions

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Byrne B, Guy R. Interteaching within a human physiology course: a comparison of first- and second-year students’ learning skills and perceptions. Adv Physiol Educ 40: 349–353, 2016; doi:10.1152/advan.00141.2015.—This article describes student perceptions and outcomes in relation to the use of a novel interteaching approach. The study sample (n = 260) was taken from a large human physiology class, which included both first- and second-year students. However, unlike the first-year students, the second-year students had significant prior knowledge, having completed a previous physiology course. Active learning, where students were required to engage with course material in a self-directed manner before tutorials and to identify areas of difficulty and discuss these within tutorial sessions, was a central component of the study. The second-year students adapted quickly to the novel approach, as indicated by stable levels of perceived difficulty and understanding. In contrast, the first-year students demonstrated a decrease in perceived difficulty and an increase in perceived individual understanding throughout the study. These results notwithstanding, there was a consistent low level of interest for both years but no significant difference between the first- and second-year individual and group learning skills by the end of the study, as measured by their performance in the tutorials. Overall, the results were encouraging, with both years achieving a reasonably high learning skill level (average: ~70%) within the interteaching environment. The improvement of active learning shown by the first-year students may have compensated, to some extent, for the prior learning advantage of the second-year students, since both groups achieved similar marks in the written components of final exams for both interteaching modules.

Interteaching; active learning; student perceptions

There is increasing evidence that active learning facilitates understanding by stimulating engagement in higher-order thinking tasks (1, 9, 38), where students build, test, and refine mental models of what is being learned (20, 21, 25). Active learning is particularly focused on learning rather than teaching (2) and, by its nature, is student centered (25). To encourage the use of active learning in a physiology context, we developed and implemented an “interteaching” format that incorporated both self-directed learning and discussion.

Boyce and Hineline (5) introduced the term interteaching, and there have been a number of studies supporting the effectiveness of this method of learning (e.g., Ref. 6). Although there are many different formats, the basic model involves self-directed learning (students work through study materials before class time). During class time, students then discuss their understanding of the study material (and describe any difficulties encountered) with their peers. An instructor, who may answer questions and encourage discussion, usually facilitates this process, and information regarding areas of difficulty is then used as a basis for followup lectures (5, 30). Thus, the format represents a reversal of traditional didactic teaching (lecture first and then discussion). Within this framework, active learning plays a pivotal role (4, 38) because it enhances the retention of concepts (9), encourages students to think more deeply about study material (9, 38), and involves students doing something rather than just being passive receivers of information (22). However, interteaching may be hindered by a number of factors, including students’ lack of understanding of how to actively learn as well as an unwillingness of teachers to change their approach and their lack of experience/familiarity with active learning methods (23). Despite these difficulties, interteaching typically results in better student learning outcomes than lecture-based learning (6, 30, 31, 32). There are also other self-directed or interactive teaching formats similar to interteaching, such as the “flipped classroom,” which Lage and colleagues (16) defined as an educational format that consists of interactive group learning in the classroom, including peer-assisted learning, and video-based individual instruction outside the classroom.

In our novel interteaching model, students from a large multidisciplinary human physiology class (n = 380) were provided with an introductory lecture and subsequently undertook self-directed learning before attending tutorial sessions. However, unlike other interteaching formats, students were only asked to identify and discuss areas of difficulty with their peers and, although a tutor was present to encourage discussion, no feedback was provided regarding the study material itself or answers to study questions. Therefore, the students were directly in control of their discussion, and areas of difficulty identified were then used as a basis for teacher-generated short explanatory video clips, which were made available online after the tutorial session. The present study examined the outcomes of this interteaching approach by assessing student perceptions of their learning and by measurement of academic performance. Since the class contained both first- and second-year undergraduate students, it was of particular interest to compare how these different groups dealt with a novel learning environment. In contrast to the first-year students, the second-year students had already completed a semester of physiology, and we were therefore interested in how their prior experience might affect their perceptions of the interteaching exercise (14).

Materials and Methods

Participants. The participants in this study were drawn from 380 undergraduate students studying human physiology at RMIT University. The class comprised first-year Health Sciences students (67%) and second-year Medical Sciences students (33%), with 54% female
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students and 46% male students between 18 and 47 yr (mean: 23 yr), of whom 76% were aged between 18 and 20 yr. Two hundred sixty participants agreed to take part in the study representing 68% of the total class: 135 first-year students (57% of the first-year enrollment) and 125 second-year students (88% of the second-year enrollment). All students participated in all aspects of learning and assessment, and students who did not give consent to participate in the study were not disadvantaged in any way.

Procedures. Two types of learning models were used during the teaching period for the one-semester undergraduate Human Physiology course. Teaching was divided into four modules of 3 wk each. Modules 1 and 4 used a traditional lecture-based teaching model, whereas modules 2 and 3 used a novel interteaching method. Students were provided with an online manual containing an introduction to the interteaching methodology, reading material and relevant references to their textbook, case scenarios, summary information, and review questions. They were required to go through this material and attempt the questions before attending tutorials, which started in the second week of modules 2 and 3. Module 2 covered the renal system, with a detailed coverage of processes and clearance and control systems, whereas module 3 covered blood (including the structure, functioning, and function of blood and blood cells) and immunity (including cell types and formation as well as immune activities and allergic reactions). The module assessment included an online multiple-choice quiz, a laboratory, and questions in the final exam (both written and multiple choice). This assessment structure was the same for the noninterteaching modules as well. Although it would have been preferable to randomise the order of the interteaching modules, this was not possible due to logistical issues related to program timetabling.

Tutorials. Tutorials were based on student-oriented discussion groups, each of ~10 students, randomly assigned from the same program and year level. Study material and questions were discussed by each group to identify areas of difficulty. This information was also shared during large class discussions where the groups came together. Short video clips were subsequently generated by the academic staff to cover identified areas of difficulty and made available online for students to access after the tutorial. These were used instead of lectures to provide effective flexible delivery to a large class (24). For each interteaching module, students participating in the study also completed a questionnaire at the end of each tutorial, covering issues relating to their perceptions of their learning and understanding (see below).

Learning skills. All students were assessed with respect to their active learning skills and demonstrated prior preparation, engagement within tutorials, and identification of areas they were having difficulties with. Students were given a copy of the assessment guidelines before the start of the tutorials. The assessment was partly a group assessment within peer groups (50%) and partly an individual assessment (50%). Although a tutor invigilated, each tutorial was student centered, while another tutor observed and assessed the students’ performance during each tutorial. Tutors were rotated between groups to avoid these being confounding variables, whereas students remained in the same groups to remove student variability as a confounding variable.

Questionnaire. The questionnaire comprised the following five questions, with a four-point Likert scale (in parentheses), and was only given to students who consented to the study:

1. How prepared were you for the tutorial? (I = not prepared, 2 = a little prepared, 3 = adequately prepared, and 4 = very prepared)
2. How interested were you in the material covered for the tutorial? (1 = not at all interested, 2 = a little interested, 3 = somewhat interested, 4 = very interested)
3. How difficult was the topic that was covered in the tutorial? (1 = very easy, 2 = easy, 3 = difficult, 4 = very difficult)
4. How good was your understanding of the topic covered in the tutorial? (1 = poor, 2 = adequate, 3 = fair, 4 = excellent)
5. How good was your group’s understanding of the topic covered in the tutorial? (I = poor, 2 = adequate, 3 = fair, 4 = excellent)

Human ethics. Approval for this study was obtained from the RMIT Human Ethics Committee. All students were given a plain language statement and a consent form to complete if they wished to take part in the entire study, which included completing a questionnaire in the tutorials. Only data from students who consented to participation were used in this study.

Data analysis. Statistical analyses were carried out using SPSS. Analyses for homogeneity (Levene’s test) and normality (Shapiro-Wilks test) were carried out to determine whether to use parametric or nonparametric analysis. Data were found to be both normally distributed and to have homogeneity for variance. Analyses carried out were correlation (Kendall’s), independent t-tests comparing first- and second-year students, and paired t-tests for comparison between modules for each group, using P < 0.05 for statistical significance. Reliability analysis for the questionnaire found a high level of validity (Cronbach’s α = 0.87). Data are expressed as means ± SD.

A statistical analysis of the final written exam results was performed for modules 2 and 3 using an independent and paired t-test. Comparisons were made between first- and second-year students within and between these modules.

RESULTS

Tutorial questionnaires. While both first- and second-year students gave perceived difficulty the highest response in module 2, first-year students reported a significantly greater level of perceived difficulty than second-year students [first-year students: 3.62 and second-year students: 3.17, t(256) = 2.21, P < 0.05; Fig. 1A]. However, for module 3, first-year students reported a significant reduction in perceived difficulty [t(256) = 1.65, P < 0.05], with no significant difference compared with second-year students [first-year students: 3.21 and second-year students: 3.01, t(256) = 1.83, P > 0.05; Fig. 1A]. The level of reported preparation for both groups was comparable for module 2 [first-year students: 2.92 and second-year students: 2.71, not significant (NS)], and although the second-year value remained stable for module 3 (2.71), the first-year value rose to a significantly higher level than the second-year value [first-year value: 3.09 and second-year value: 2.71, t(256) = 2.19, P < 0.05]. In comparison, the level of perceived interest was low and stable for both groups (Fig. 1A), with no significant difference found for either module [module 2 t(256) = 0.98, NS; module 3 t(256) = 0.08, NS]. Although the level of perceived individual understanding was similar for both groups for module 2, first-year students had a significant increase in their perceived understanding for module 3 compared with second-year students [first-year students: 3.6 and second-year students: 2.35, t(256) = 9.35, P < 0.01; Fig. 1B]. However, the level of group perceived understanding did not differ between first- and second-year students throughout the study (module 2 first year: 3.08 and second year: 3.07, NS; module 3 first year: 3.01 and second year: 3.01, NS), nor was there any significant change in the level across the study for either group (Fig. 1B).

Correlations. A significant positive correlation was found for first-year students for module 2 between reported preparation and perceived individual understanding (r = 0.514, P < 0.001, r² = 0.264), whereas perceived difficulty and perceived individual understanding were negatively correlated (r = -0.353, P < 0.01, r² = 0.125) for module 3. However, for second-year students, the only significant correlation was be-
modules 2 year individual active learning increased significantly between 69% and second-year students: 70%, NS). The level of first-
between first- and second-year students (first year students: 55% and second-year students: 71%),
skills than first-year students [first-year students: 55% and second-year students: 63% and second-year group: 70%,
significantly higher than that for the first-year group [first-year students: 55% and
0.05; Fig. 2]. However, for module 3, there was no significant difference between first- and second-year students (first year students: 69% and second-year students: 70%, NS). The level of first-year individual active learning increased significantly between modules 2 and 3 [module 2: 55% and module 3: 69%, \(t_{(246)} = -9.34, P < 0.01\)].

For module 2, the second-year group active learning was significantly higher than that for the first-year group [first-year group: 63% and second-year group: 70%, \(t_{(246)} = 1.95, P > 0.05\); Fig. 2], however, for module 3, there was no significant difference between the level of group active learning (first-year group: 68% and second-year group: 70%, NS).

Exam results. A statistical analysis of the final written exam results for modules 2 and 3 found no significant differences between first- and second-year students for the average mark for either module [module 2 \(t_{(256)} = 6.01, P > 0.05\); module 3
\(t_{(250)} = 5.97, P > 0.05\) or for first- or second-year students within each module [module 2 first-year students: \(t_{(248)} = 1.95, P > 0.05\); module 2 second-year students: \(t_{(236)} = 3.24, P > 0.05\); module 3 first-year students: \(t_{(248)} = 0.03, P > 0.05\); and module 3 second-year students: \(t_{(236)} = 3.45, P > 0.05\).

**DISCUSSION**

Overall, we were encouraged by the adjustment of both first- and second-year students to the novel learning environment. The interteaching method ensured that students were exposed to active learning, both in preparation for the tutorials and within the tutorials themselves. Although the time course of adjustment differed between the first and second years, all students, on average, achieved a reasonable measure of active learning (~70%) by module 3.

Student progress was very much dependent on self-directed learning rather than didactic lecture presentations. The first-year students, without the benefit of a prior semester of physiology, started the interteaching period with a lower measure of active learning with respect to both individuals and groups but adjusted their active learning to match the second-year students during module 3.

A key component of our study was the introduction of active learning within a novel interteaching learning environment. Some of the survey questions related to self-efficacy, task value, and goal orientation, all of which are motivational components (27, 28, 37). This is particularly important since motivation is a key contributor to strategy selection (2) and academic performance (7, 27, 35). For example, feedback on difficulty relates to self-efficacy, i.e., a student’s judgement of their ability to complete a task. Self-efficacy also depends upon prior knowledge and is closely related to academic outcomes (8, 10, 11, 16, 26, 28). The second component of motivation, interest, is closely related to the task value assigned by students, defined by how important the performance of a task is to them personally (15). Finally, understanding is closely related...
to learning goals since students compare the perceived gap between their current learning and the specified goal(s). In addition to motivational feedback, the students also provided strategic feedback with respect to their degree of preparation for the tutorials; we were thus able to compare motivational and strategic perceptions with the quantitative measurements of individual and group performance in the tutorials.

The second-year students’ stable level of perceived difficulty and their reasonably high level of active learning in the tutorials suggested a rapid adjustment to the new learning situation. This is likely related to the fact that they had already completed a semester of physiology and thus possessed prior knowledge and study approaches that gave them confidence in their approach to the learning material. On the other hand, the first-year students, who lacked such prior knowledge, started the interteaching project with a lower measure of active learning and a much higher level of perceived difficulty. However, their perception of difficulty decreased (with a concomitant increase in self-efficacy) and their active learning was equivalent to the second-year students for module 1. The importance of this improvement is highlighted by the negative correlation found between perceived difficulty and perceived understanding in module 3 ($r = -0.353, P < 0.01, r^2 = 0.125$) for the first years. This process may have been facilitated by the requirement for the students to undertake self-directed learning and identify areas of difficulty before the tutorials, because this requires high-level cognitive strategies (3). In addition, improved self-efficacy may have been facilitated by the peer-based interactive tutorials. It is logical to assume that the feedback students received from their peers about their understanding resulted in affirmation of their learning capability (13). In this vein, it has been shown that discussion is a particularly powerful method of encouraging information retention, motivation, and the development of thinking skills (19).

Both first- and second-year students demonstrated a low level of perceived interest during the study irrespective of their level of active learning in the tutorials, their level of prior experience, or, in the case of first-year students, changes in their perceived level of difficulty and understanding. This finding appears surprising, particularly since it would be presumed that there is a strong relationship between interest and academic success. However, there are numerous studies that have shown diverse outcomes in relation to interest and learning (e.g., Refs. 34 and 36). Our findings in relation to interest are in line with a study of deep comprehension, where no relationship was found between interest level and prior knowledge (33). However, the lack of interest does not necessarily mean that the students were not engaged, because they were placed in a learning environment where they were required to actively interact (26).

Second-year students appeared to underestimate their individual perceived understanding or overestimate their perceived group understanding, based on the finding that individual understanding was significantly lower than group understanding, for both modules, despite a lack of significant difference between measures of individual and group performance in tutorials. On the other hand, for module 2, first-year student perceptions of understanding were in line with the level of individual and group active learning in tutorials. However, for module 3, first-year students rated their individual understanding as significantly greater than that of the group, even though the individual and group performance in tutorials were essentially the same. Although we are unable to determine the basis for these misconceptions, particularly the opposite bias demonstrated by first- and second-year students in module 3, it is clear from the literature that student self-assessment is often less accurate than their assessment of another person or group (12, 17).

We were able to gain some insights into the strategic approaches used by the students since they provided feedback with respect to the amount of preparatory work carried out before the tutorial sessions. The amount of reported preparation carried out by second-year students remained constant between the two modules, indicating that they felt their preparation was appropriate for the task. However, by module 3, first-year students had a level of reported preparation significantly higher than second-year students, a feature corresponding with their increased individual understanding and improved active learning. The development of first-year learning skills appears to have compensated for the “prior learning” advantage of the second years. This “equalizing” effect also translated to the final exam (essay component) where no year differences were found for either module 2 or module 3 scores.

Limitations. There are four main limitations to our study. First, we did not attempt to make a comparison between the intertaught modules and the traditionally taught modules with respect to end-of-course results. Thus, we were unable to comment on whether the student-centered approach was more effective than the traditional didactic approach. Second, the first- and second-year students differed not only in whether or not they had taken a prior physiology course but also with respect to the programs they were undertaking. Be that as it may, several programs contributed to each of the year groups studied and we have no reason to believe that the nature of any program per se impacted on how students performed in the interteaching intervention. Even if some bias did exist, we suggest that the main difference between first- and second-year students related to their prior experience. Third, the comparison between qualitative and quantitative results leads one to question to what extent students are accurately judging their performance (29); however, we feel that potential biases in this area do not necessarily invalidate the general study findings (18). Finally, perceived difficulty will depend on both the self-efficacy of a particular student and the “actual” (from an academic perspective) difficulty level of the topic. The decrease in level of perceived difficulty shown by the first-year students between modules 2 and 3 may well depend on a dynamic interaction between these two components. It might be argued that these changes could be explained by a difference in the actual difficulty level between the modules (with module 3 being easier than module 2). However, no difference in perceived difficulty was found for the second-year students and, in addition, there was no significant difference between the final exam marks (essay component) between modules 2 and 3 for either year group. The increase in pretutorial preparation shown by the first-year students also makes it unlikely that they were transitioning to an “easier” module. However, the first-year students did show increased learning capability during this period, and the increase in self-efficacy appears to be supported by the fact that the final exam marks (essay...
component) was not significantly different between modules 2 and 3 for the first-year students.

The overall comparison between first- and second-year students provides us with information regarding the potential benefits of prior learning and the time course required for adaptation to the interteaching method used. Such information may be useful when introducing interteaching in other contexts.

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DISCLOSURES

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

AUTHOR CONTRIBUTIONS

B.B. and R.G.G. conception and design of research; B.B. performed experiments; B.B. and R.G.G. analyzed data; B.B. and R.G.G. interpreted results of experiments; B.B. prepared figures; B.B. drafted manuscript; B.B. and R.G.G. edited and revised manuscript; B.B. and R.G.G. approved final version of manuscript.

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