Redesigning A Core First Year Physiology Subject In Allied Health To Achieve Better Learning Outcomes

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Keywords: guided inquiry learning, constructive alignment, collaborative testing, nursing education, curriculum redesign, subject redesign, collaborative learning

International Journal of Innovation in Science and Mathematics Education, *21*(2), 37-52, 2013

Abstract

In an era of rationalization and emphasis on economies of scales (Hare, 2011; Johnson, 2009; Trounson & Ross, 2011), many allied health and nursing programmes are finding the need to develop Core Subjects that can cater to the needs of a diverse range of students. Historically, human bioscience (anatomy and physiology) has been a major stumbling block to student success in nursing education. Part of the problem is that teaching activities and content knowledge has traditionally been skewed to cater for the most advanced student, with less adequately prepared or academically skilled students left struggling to keep up. Here we describe a subject redesign that switches the emphasis on teaching and learning from the maximalist approach to one where the emphasis is on teaching and learning activities focused on the core concepts that students are obligated to know and where advanced concepts are learned via self-directed, self-motivated learning. This redesign utilises team based guided inquiry and collaborative testing to encourage time-on-task, active learning and constructive teamwork to promote good learning and study habits. The new subject design is intended to meet individual stake-holder needs for human bioscience, promote student success and meet the University's "excellence in subject design principles."

Introduction

Since the start of the 2009 academic year, most students who enter into either the Bachelor of Health Science programme or the Bachelor of Nursing programme at La Trobe University enter into a common Core First Year (CFY) programme. A stated purpose of this programme is to allow maximum flexibility of students who fail to achieve entry marks for other allied health courses alternative entry into those programmes after successfully completing first year ("Health Science: Flexible Learning for Undergraduates," 2011). In addition to allowing greater flexibility and opportunities for students entering the courses, the Core First Year programme in the Bachelor of Health Science is intended to build the skills necessary for graduates to succeed as part of a multi-disciplinary allied-health team in professional practice (O. o. t. D. V.-C. La Trobe University, 2009). In first semester of the Core First Year, students study subjects such as Inter-professional Practice, Perspective of Health and Wellbeing & Individual Determinants of Health. Key Learning Objectives in these subjects include the development of skills to work in teams, ability to engage in Enquiry Based

Learning and academic skills including critical thinking and research skills (Student Study Guide HLT1IPA). In addition to these three subjects, students in first semester of first year are required to complete a first semester physiology/human bioscience subject. Although some practitioners feel that human bioscience educations waste valuable space in the curriculum (Davies, Murphy, & Jordan, 2000; Jordan, 1994) most nursing (Davis, 2010; Friedel & Treagust, 2005; Jordan, Davies, & Green, 1999; Leathard, 2001; Logan & Angel, 2011; McVicar & Clancy, 2001; Ostlind, 2007) and allied health (Finnerty et al., 2010; McColl, Bilszta, & Harrap, 2012; McMeeken, Webb, Krause, Grant, & Garnett, 2005; Pangaro, 2010; Woods, Brooks, & Norman, 2007) programmes recognise the importance of Anatomy and Physiology in providing the foundation to understanding the theoretical basis of their clinical practice. As lifelong education (through mandatory continuing education) becomes the norm, human bioscience provides the scaffolding for clinicians to understand the biological mechanisms of advanced practice (McMeeken, et al., 2005). At this University, first year anatomy and physiology are largely taught as separate disciplines, with physiology taught in semester one and anatomy taught in semester two.

Entry into most Universities in Australia, in most states, is largely determined by a student's Australian Tertiary Admission Rank (ATAR). ATAR has been in operation since 2009. ATAR Ranks a student's year 12 (final year of high school) grade against every other year 12 graduate for that year, in the state where the school leaver was educated. ATAR score is a percentile; students who score an ATAR of 80 indicate that they outperformed 79% of other students in the state. Only 19% of students did better ("ATAR," 2013).

Entry into a common core subject with different disciplines of allied health with their specific bioscience requirements poses challenges for providing such a service subject. Students entering first year Health Science and Nursing at the University enter the course(s) with a wide diversity of academic experience and ability which has historically impacted on the ability of students to perform in first year human bioscience subjects (Green, Brown, & Ward, 2009). Within the Bachelor of Health Science intake for 2011, the University enrolled students into physiotherapy who had an ATAR in the 96th percentile at the same time as enrolling students into nursing whose ATAR was below the 52nd percentile (data for 2012 is presented in Figure 1) ("ATAR Clearly in data," 2011; "Health Science "What ATAR do I need?"," 2012). To further compound this disparity between academic performance of students in the same classroom, pre-requisite high school subjects for these two courses differ, with physiotherapy students requiring two sciences in their final year of high school and nursing students requiring no science at high school level to enter into the University program, ("ATAR Clearly in data," 2011). These disparities in academic preparation, ability and background have historically been correlated very strongly with success in human biosciences at La Trobe University (Green, et al., 2009) and at other Australian universities (Whyte, Madigan, & Drinkwater, 2011). Indeed, poor performance in human bioscience by nursing students is common in nursing education around the world (Davies, et al., 2000; Davis, 2010; Gresty & Cotton, 2003; Jordan, 1994; Jordan, et al., 1999; Larcombe & Dick, 2003; McCarthy, 2004; McVicar, 2009; McVicar & Clancy, 2001; McVicar, Clancy, & Mayes, 2010; van Rooyen, Dixon, Dixon, & Wells, 2006). A recent study from the United Kingdom (Gresty & Cotton, 2003) has found that 65% of nursing students entering University self-report a below average understanding of science upon starting their training. In this context it is unsurprising that over the three year period since the Core First Year was introduced at La Trobe University, failure rates in first semester, first year physiology have been consistently above 30%, with students in low ATAR disciplines making up the majority of failed students (up to 40% of students in some disciplines) (personal observation).

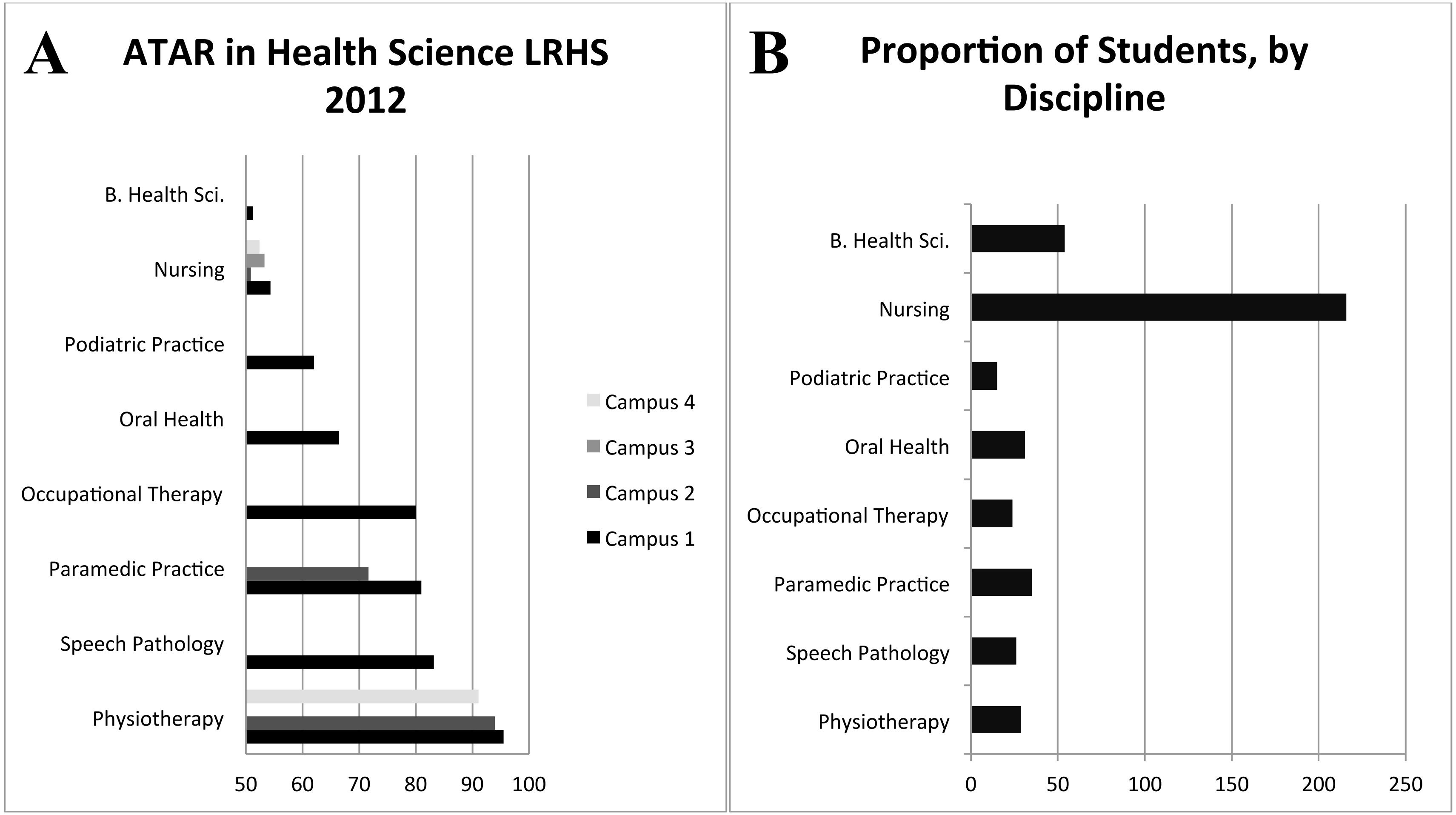


Figure 1: (A) Australian Tertiary Admissions Rank (ATAR) for students entering the Bachelor of Health Science by discipline or Bachelor of Nursing in 2012 for students enrolled in the La Trobe Rural Health School (LRHS). ATAR data for 2011 (not shown) was similar to 2012. (B) Number of students entering the subject by discipline. Sixty two percent of students entering this subjects have ATARs lower than 55, while 26% have ATAR higher than 80. ATAR data abstracted from the La Trobe University web site ("Health Science "What ATAR do I need?"," 2012).

In light of the historic educational problems and issues in achieving success in first year first semester physiology, this paper will describe a redesign process that attempts to improve success in this Core First Year subject without compromising the stake-holder needs for human physiology. Stake-holders in the first year human biosciences, other than nursing and health science students, include physiotherapy, occupational therapy, paramedic practice, oral health, speech therapy, dietetics and podiatry, amongst others. While in many cases it is hard to find education standards policies for these disciplines in an Australian context, in the United States and United Kingdom standards for comparable disciplines are available (2011; Administration, 2009). Some stake-holders in the Core First Year physiology subject we are designing require both a breadth and depth level of understanding of physiology (2011; Administration, 2009). Human bioscience needs in nursing are conflicted (Ostlind, 2007), which probably reflects the dichotomy between the knowledge and expertise of nurse educators (Friedel & Treagust, 2005) and the needs of the discipline to evolve and prepare students for independent practice (Jordan, 1994).

Here we will describe a subject redesign that is learning design orientated and is explicitly designed to target its teaching to *minimum core standards* necessary to pass the subject, while at the same time making students responsible for their own *deep* learning of the material as per discipline specific requirements. The purpose of this approach is to improve success in the subject by academically weaker students and at the same time to hold stake-holders accountable for the subject needs of their own students. Where disciplines expect that their students need content in excess of the minimum core standards physiology staff members design extension modules for the students to aid in achieving these standards.

The Redesign Brief

Curriculum redesign is often driven by internal and external drivers. The key driver here was the internal focus. Following the high fail rate in first semester human bioscience (particularly amongst nursing and public health students) it became urgent that this subject be redesigned to reflect the "Overarching principles" of "curriculum redesign" policy paper of La Trobe University (O. o. t. D. V.-C. La Trobe University, 2009). The Policy, in part, states

> "All students who are accepted into the University, regardless of their level of preparation for tertiary study … will be given the *learning* opportunities necessary for success." (Emphasis added)

Further the principles state

> "La Trobe's approach to learning and design of curriculum will be characterised by the use of evaluation, evidence and review…"

Based on these "Overarching principles" a new physiology subject design needs to account for the disparate skills and knowledge backgrounds of students entering the subject to make available to them the best *learning* environment that is likely to lead to their success in the subject. Further, the design must reflect the best evidenced-based pedagogy model that can meet these requirements. To meet the principles these design parameters were followed:

- Learning activities in the subject should be learning or student centred (Active Learning);

- While historically the focus of teaching in physiology has been teacher-centred through lectures and tutorial, the new subject explicitly shifts the focus of learning away from a didactic approach to an Inquiry based approach (Brown, 2010; Jensen, 2011) which is designed to engage students in the learning process;
- Learning activities should encourage peer-to-peer learning;
- The new subject explicitly shifts the learning to guided group based activities, building broader skills and capabilities like teamwork and communication skills, as well as physiology discipline knowledge and skills;
- Learning activities should focus on the minimum core concepts and knowledge necessary to demonstrate mastery of the designated core subject matter;
- Focus on core concepts ensures the students have the required basic threshold knowledge and skills at first year level;
- Focus on the Minimum learning objectives is intended to give students with the weakest academic background the *best opportunity for academic success in the subject.*

Thus in addition to altering the subject teaching and learning activities from a didactic to a combined didactic and enquiry based model, the decision has been made to explicitly identify what the minimum level of understanding of physiology would be required from the lowest achieving group in the subject and to teach the subject to those minimum standards. Having identified those core concepts as *Minimum Standards* the subject is then designed so that students who show competency at that standard receive a passing grade. In this way, the approach taken in the new physiology subject radically differs from earlier iterations of the subject, which focused its learning objectives on the highest possible learning outcomes, to meet the needs of the best performing students. In addition to teaching and learning activities being directed at the *Minimum Learning Objectives* (MLO) to achieve core basic knowledge, all students have the option to complete individual modules covering the learning objectives beyond the MLO (the *Extended Learning Outcomes,* ELO) to extend their individual learning outcomes. An example of the distinction between MLO and ELOs can be seen in Table 1. Disciplines that require students to have knowledge of material in excess of the MLOs can stipulate their students must complete some, or all of the ELOs. Students aiming to transfer course will also have to meet the threshold criteria stipulated by the relevant course stake-holders. All grades beyond 60% (see below) are earned through completion of and testing in ELOs, motivating the students to extend themselves beyond the minimum core level. The rationale for focusing the formal teaching and learning activities on MLOs while expecting students to master the ELOs in self-directed learning activities are illustrated in Figure 2.

The Next Steps - Aligned teaching and learning activities

In an Enquiry based model of teaching, the principle purpose of the model is to encourage *depth* of learning, even at the expense of breadth of learning (Feather & Fry, 2009). This possibly runs counter to the brief of the redesign, which is intended to make the subject more achievable. Nevertheless several models of enquiry based teaching have been trialled in physiology education. Two prominent ones are “Directed Case Study” (Cliff & Wright, 1996) and Process Oriented Guided Inquiry Learning (POGIL) (Brown, 2010). The premise behind both of these approaches is to encourage peer-to-peer learning and student centred learning.

Table 1: Example Of MLO and ELO for Neurophysiology. The Minimum Learning Objectives focus on the ionic basis of Action Potential generation, while the Extension Learning Objectives address the differences between graded potentials and action potentials, and provide a molecular basis of orthodromic transmission.

Minimum Learning Objective	Extension Learning Objectives
o Describe and identify the major components of a neuron, with emphasis of the specific role each structural component has on the function of the neuron o Describe the structure of the nervous system, with reference to the major divisions : central versus peripheral, sensory versus motor, somatic versus autonomic o Describe the different functions of the major divisions of the nervous system o Define Resting Membrane Potential (RMP)and recognise the contribution that ion distribution across the membrane makes to RMP o Be able to predict the movement of Na^+, K^+, across the cellular membrane in response to changes in permeability of the membrane to each of these ions o Describe the difference in function of ligand-gated ion channels, mechanically- gated ion channels or voltage gated ion channels and predict where you would find them on neurons or within the nervous system. o List the major events that occur in an action potential and state whether movement of sodium or potassium ions into or out of the cell are responsible for each event o Describe how neurons communicate with each other by chemical signalling molecules released at the synapse	o Describe the relevance of graded potentials such as EPSP and IPSP to synaptic transmission o Describe how signaling in dendrites differs from signaling in axons o Describe why post-synaptic potentials do not necessarily bring neurons to threshold and explain how many post-synaptic potentials, which occur nearly simultaneously, summate to bring a neuron to threshold o Explain why neurons have absolute and relative refractory periods and recognize why this means that action potential propagation can only be in one direction. o Explain the difference between saltatory and continuous action potential propagation, and explain the role of myelin sheath (nodes of Ranvier) in the determining the speed of action potential propagation. o Given that action potentials are always the same amplitude, describe the mechanism by which stimulus intensity is encoded for within a single neuron

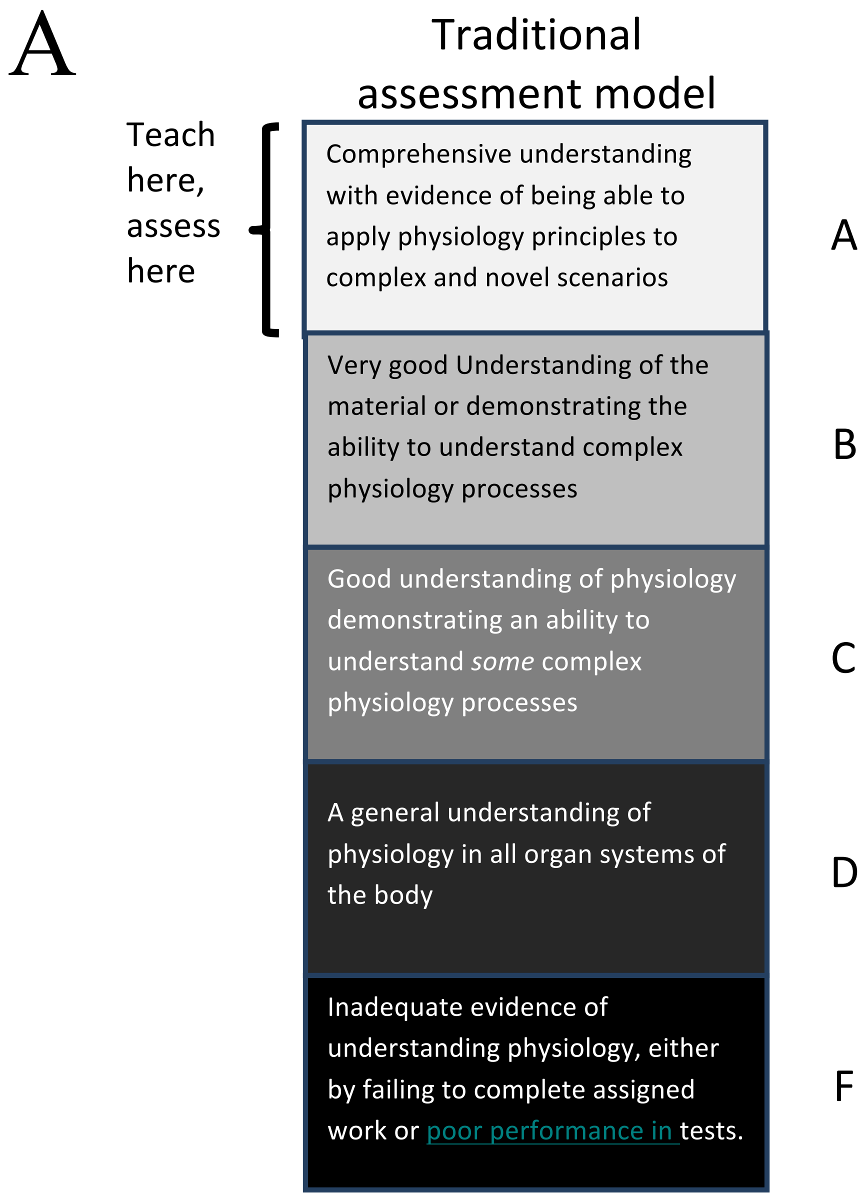


Figure 2: Change of assessment structure of the new Human bioscience structure. (A) In the Traditional model, teaching and learning activities are intended to align student learning with the requirements to achieve an "A". Thus the teacher teaches all the content necessary to get an "A". Typically students who demonstrate mastery of half the subject content earn a "D" grade and is said to have passed the subject. Since teaching and learning activities are geared towards the "A" level students, the needs of less well credentialed or motivated students are not catered for. (B) Redesigned subject letter grade meanings. There are two levels of participation in the subject; Minimum and Extension Learning Objectives. A student can only pass this subject if they first pass the MLOs. This is sensible since MLOs have been determined to be *essential* knowledge to successfully progress through the degree. A "D" grade in this subject shows that students have engaged in the subject, and are able to work with their teams to demonstrate an understanding of MLOs. A student who earns a "D" through MLOs has the opportunity to then improve their grade by engaging at some level with ELOs. Students can also achieve a "C" by showing a comprehensive understanding of MLOs both with their team and as individuals. Grades higher than "C" require increasing mastery of ELOs. These grades also demonstrate student acceptance of individual responsibility for their own learning.

B

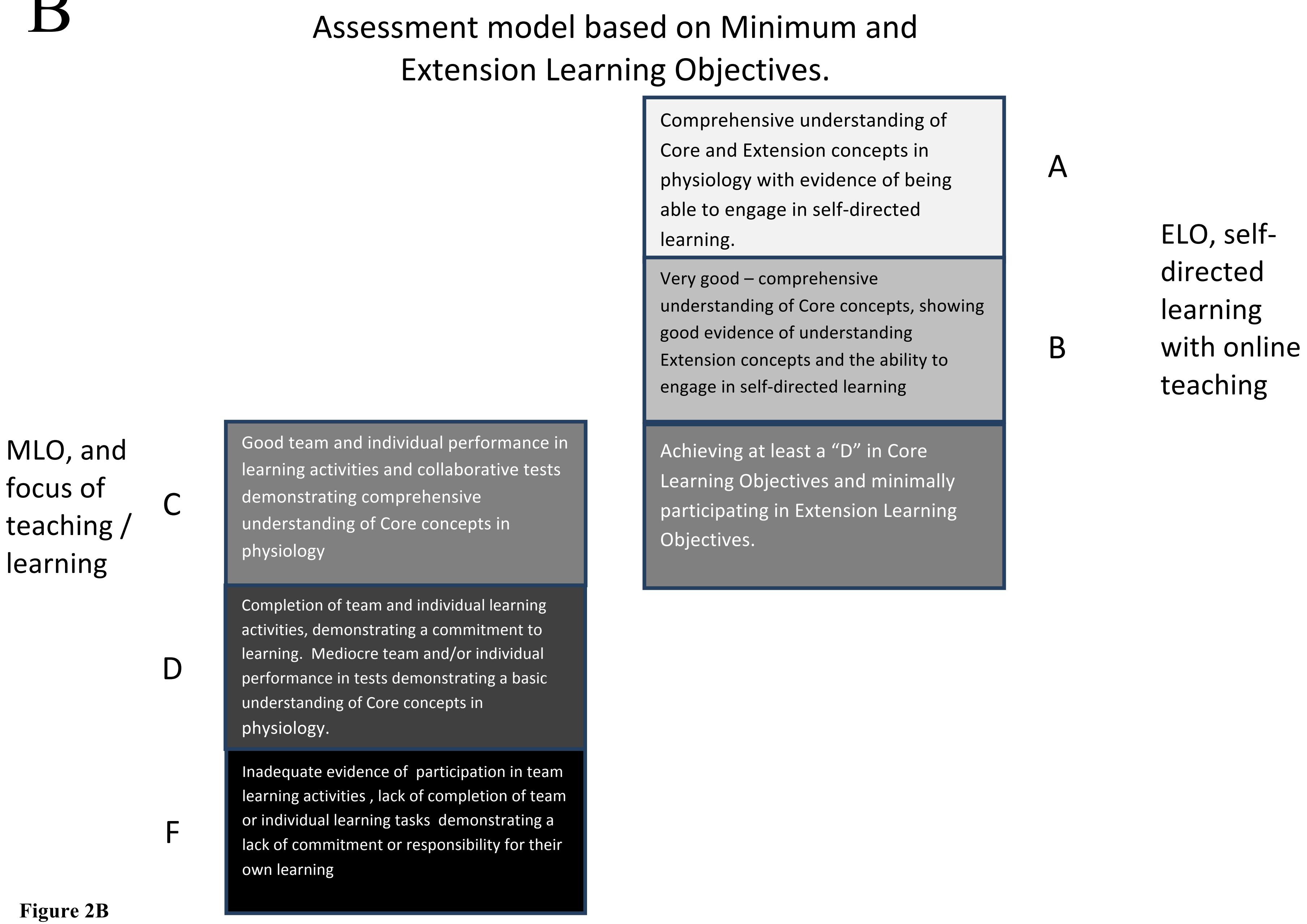

Assessment model based on Minimum and Extension Learning Objectives.
Comprehensive understanding of Core and Extension concepts in physiology with evidence of being able to engage in self-directed learning.
A
Very good – comprehensive understanding of Core concepts, showing good evidence of understanding Extension concepts and the ability to engage in self-directed learning
B
ELO, self-directed learning with online teaching
Achieving at least a "D" in Core Learning Objectives and minimally participating in Extension Learning Objectives.
MLO, and focus of teaching / learning
C
Good team and individual performance in learning activities and collaborative tests demonstrating comprehensive understanding of Core concepts in physiology
D
Completion of team and individual learning activities, demonstrating a commitment to learning. Mediocre team and/or individual performance in tests demonstrating a basic understanding of Core concepts in physiology.
F
Inadequate evidence of participation in team learning activities , lack of completion of team or individual learning tasks demonstrating a lack of commitment or responsibility for their own learning

Figure 2B

In Directed Case Study design, students are presented with a pathophysiological case as a /var/folders/kp/y8qfcltx1pz3ggxq6tkntfv40000gn/T/com.apple.Preview/PreviewTemp-a5oFVs/IJISME Biomed Spec Issue - Rathner, Hughes and Schuijers.3 (dragged) 1.pdf

mechanism for engaging the students with the physiology behind the disease. One of the more common extended comments on the Subject Evaluations is a desire by students to see how the study of physiology is relevant to their course needs. By placing the physiology within a clinical context we demonstrate how knowing the normal physiology begins to inform us about abnormal situations. In directed case study design, questions about physiology are asked as they relate to the clinical scenario. Some publishers have published "applications" manuals to support this type of approach (see Cliff & Wright, 1996 for references). On the down side of this approach, at least as designed by Cliff and Wright, students were expected to complete the case studies as homework, rather than as a class inquiry. Directed Case Studies expect students to apply physiological concepts in a manner that is opaque from the stated learning objectives. We did not adopt directed case studies, since the learning of human bioscience in this model is implicit rather that explicit, and studies show that the learning of the implicit knowledge requires well prepared self-directed learning to achieve (Logan & Angel, 2011).

POGIL, on the other hand, makes students (in very small teams) accountable for their learning on a week by week basis. Process Based learning focuses on designing a subject curriculum and class activities around the student centred learning. If the task is right and the class is properly structured, students can work together to achieve the learning objectives of the week. In designing the class, teams are established in a structured way that engages students in the learning task and intends to hold each member of the team accountable for knowing all the conclusion and answers that his/her team produces. Patrick Brown (2010) suggests teams of four students, while Murray Jensen (2010) suggests teams of three. One of the keys to this model is that the teams report their findings back to a small group (pod) at the end of the session, with the pod negotiating their best collective answers on the basis of the individual teams' responses. At the end of the class, each Pod then reports their best answer to the whole class, with the view that this might initiate discussion amongst students about the best possible answers.

Brown (2010) introduced a POGIL teaching approach to a second semester of a two semester integrated A & P stream. In his design the only thing he altered in his class was the introduction of POGIL. His learning outcomes remained unaltered, his student handout remained the same and crucially, his final exam remained the same. Over the course of three cycles of the course, failure rates in his subject dropped to zero and his A/B:D/F ratio significantly improved, suggesting that POGIL alone improved learning amongst his students. Brown did introduce the need for team reports to be submitted on a weekly basis, again with the view of making the students accountable for their efforts weekly. By requiring students (even in teams) to submit weekly work, the inevitable outcome is that students must complete the work in a timely fashion and that they are engaging in the learning process. Furthermore, weekly submission of works allows the instructor the opportunity to monitor the teams work and ensure that misconceptions about content do not go unaddressed.

Staff resistance to "process" in POGIL meant that fully adopting POGIL was not considered as part of this subject design. Nevertheless, the idea of Guided Inquiry Learning fully reflected the ambitions and pedagogy of the redesign. Consequently, while staff authored and implemented guided inquiry activities, encouraging active learning by students, little or no emphasis was placed on having students assume roles within the group. Group reporting and end of workshop summaries were more at the facilitator's discretion, rather than a formal part of the workshop implementation. Consequently, our workshops adopted the active learning model advocated by POGIL, without the "process".

While adopting a more student centred, active learning approach, we have maintained 2 hours of lectures a week (26 hours per semester) as a major mode of delivering content to students. Evidence in the literature suggest that students and faculty alike see them as beneficial and effective means of transmitting factual knowledge and of placing the active learning tasks within a cohesive framework (Davies, et al., 2000; Walker, Cotner, Baepler, & Decker, 2008).

Aligned Assessment tasks

In the redesign of the subject the intra-semester assessment activities are designed around the group learning activities. Since the major learning activities revolve around group inquiries, it is necessary that the assessments revolve around the group as well. Formal assessment in the subject, geared to the MLOs addressing core concepts account for 60% of the total grade available. Of this group assessment twenty five percent of the final grade comes from weekly submission of inquiry work. These marks are a combined evaluation of *student participation* in the workshop by the team and the workshop facilitator. Facilitators are instructed, for instance, not to award marks to students engaged in electronic "social networking", who arrive (excessively) late or leave (excessively) early.

In addition to the weekly group inquiry submission, individual students will need to submit weekly homework assignment designed to ensure they have prepared for class (learning before class activity). Although the homework has no grade value, it is a hurdle requirement. The purpose of this hurdle is to ensure that students present for their inquiries having engaged with the material that is to be covered in the workshop *before* attending the workshop. It is hoped that by making students engage in the material in advance, each student will be better prepared to contribute to the groups learning during the workshop rather than have each group carried by a few dominant, self-learners and high achievers.

The remaining 35% of MLO grade comes from collaborative (or pyramid) testing. Collaborative testing is based on the concept of co-operative learning and has been shown to improve test scores (8.4%) (Kapitanoff, 2009). Research suggest that collaborative testing improves student knowledge, critical thinking, promotes interactive team work and problem solving skills (Gokhale, 1995; Michael, 2006; Tanner, Chatman, & Allen, 2003), all desirable graduate capabilities encompassed in the design principles in the University's white paper for Curriculum Revitalization (O. o. t. D. V.-C. La Trobe University, 2009).

Cooperative learning works best when there are sufficient rewards for the student to become invested in the group learning. These rewards are most evident when individual success is dependent on group success (McManus & Gettinger, 1996; Tanner, et al., 2003). There is, however, a need to provide incentive for the individual to achieve success and mastery of the material, otherwise the likelihood is that *strong* students will simply take over the group (or, alternatively, academically weaker students only passively participate). For this reason it is necessary that in all cooperative learning environments some individual accountability for learning is maintained (McManus & Gettinger, 1996; Tanner, et al., 2003). In the scheme we are proposing, collaborative test are broken up into two components, individual test worth

10% of the final grade and a collaborative component worth 25% of the final grade. An added benefit of the 10% individual assessment is that it allows students who restrict themselves to the MLOs a buffer for any missed inquiry submissions, i.e. students who fail to achieve all their inquiry participation grades still have the opportunity to pass the subject based on individual testing.

The team aspect of the Collaborative Test is performed in an open book manner. Many reports on collaborative testing have emphasised that teams for the collaborative test were randomly assigned on the day of the test (Jenson, Moore, & Hatch, 2002). In this design, the team part of the collaborative tests were completed in the stable teams that worked together during the semester. An advantage of the collaborative test is that it provides students with an instant formative feedback of their own progress as they compare answers and research their individual responses to the test items (Hickey, 2006). Repetition of the test items themselves have been shown to consolidate the material (Giuliodori, Lujan, & DiCarlo, 2008; Rao, Collins, & DiCarlo, 2002).

Human Bioscience; redesign in practice

Figure 3 illustrates how students' grades are earned in this subject. Final grades are the sum of grades earned from MLOs and ELOs (Figure 3A). MLO, material taught in the classroom and workshops, account for 60% of the final grade. These marks are earned entirely via assessment activities that occur during semester (Figure 3B). ELOs, Learning Objectives specified to students as requiring self-directed learning, are examined in the final exam (Figure 3A-C). Success in ELOs requires students to demonstrate both mastery of MLOs, as the foundation concepts that underpin ELOs and the ELOs themselves. Despite the division between MLO and ELO, individual assessment continues to account for 50% of the students' final grade (Figure 3C).

One additional feature of the subject redesign is that prior to workshops students are required to complete a weekly quiz. Although the quiz itself does not contribute to the final grade of the subject, failure to complete the quiz renders the student ineligible for workshop participation marks. In this way students are forced to prepare for the workshop, and attend the workshop prepared to contribute to the team learning. In essence, weekly quizzes help students remain up to date with their studies and accountable for their individual learning.

Outcomes

While a detailed analysis of the effectiveness of the subject redesign will be undertaken in the future, preliminary analysis of the results for 2012 demonstrate significant student performance in the redesigned subject. Mean marks for the first year physiology subject increased by 18% (Figure 4A. 2011: 53.8% +/- 0.61 n=455, 2012: 71.7 +/- 0.5 n=450, Mean +/- SEM $p<0.001$, one tailed T-test) between 2011 and 2012. This grade is the aggregate of MLO and ELO assessment activities. The results represent more than a shift in mean grade, as weaker students are in fact improving their performance. An analysis of the ratio of F-D:C-B students in 2011 (2.7) compared to the D-C:B-A ration in 2012 (0.7) shows that for every student who earned a C or B grade in 2011, 2.7 students earned a D or F; contrast this with 2012 where for every student who earned an A or B, 0.7 earned a C or D (Figure 4B). The analysis done assumes that students did at least one letter grade better in 2012 than 2011, hence the comparison of "F-D" in 2011 to "D-C" in 2012.

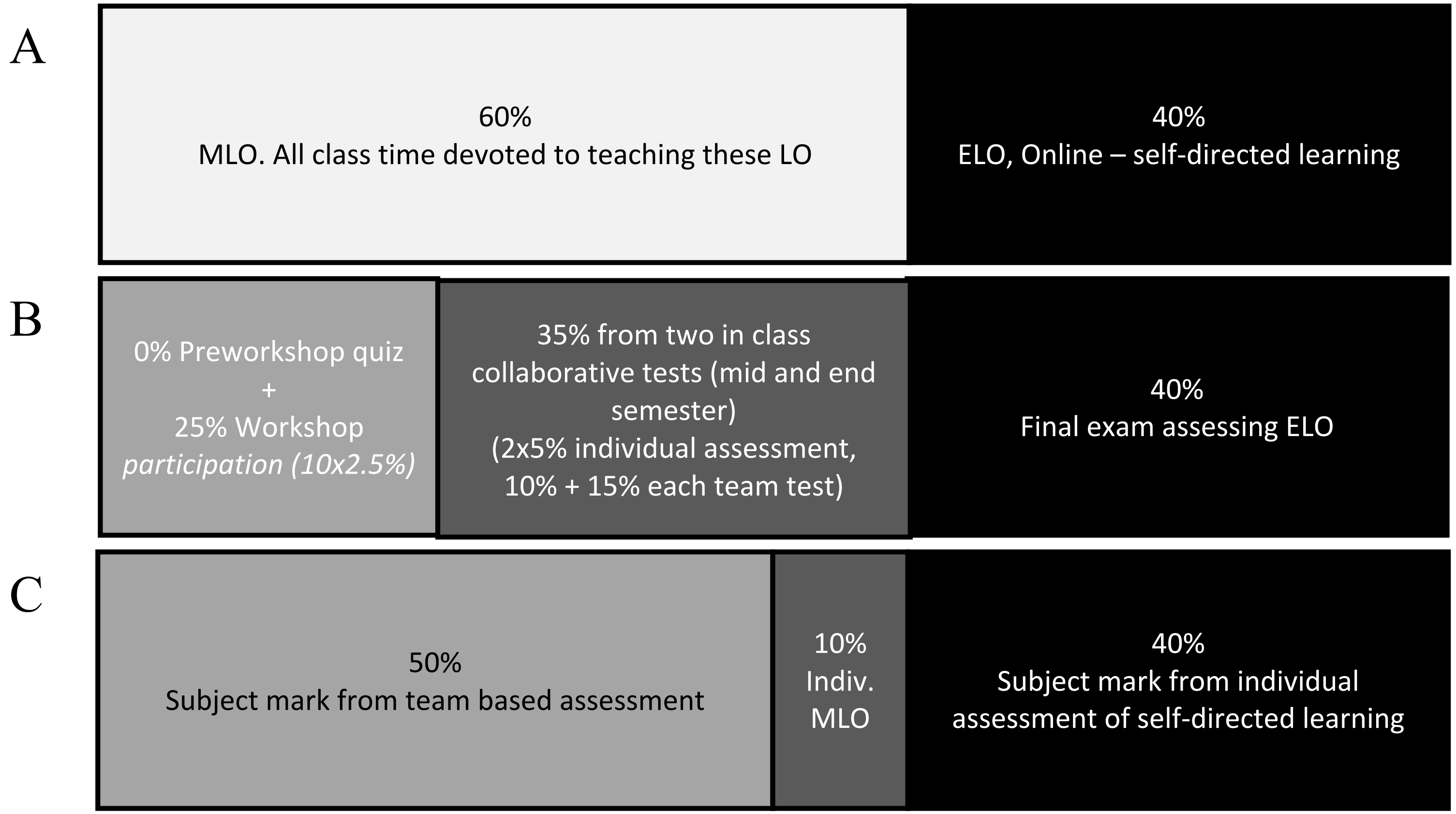
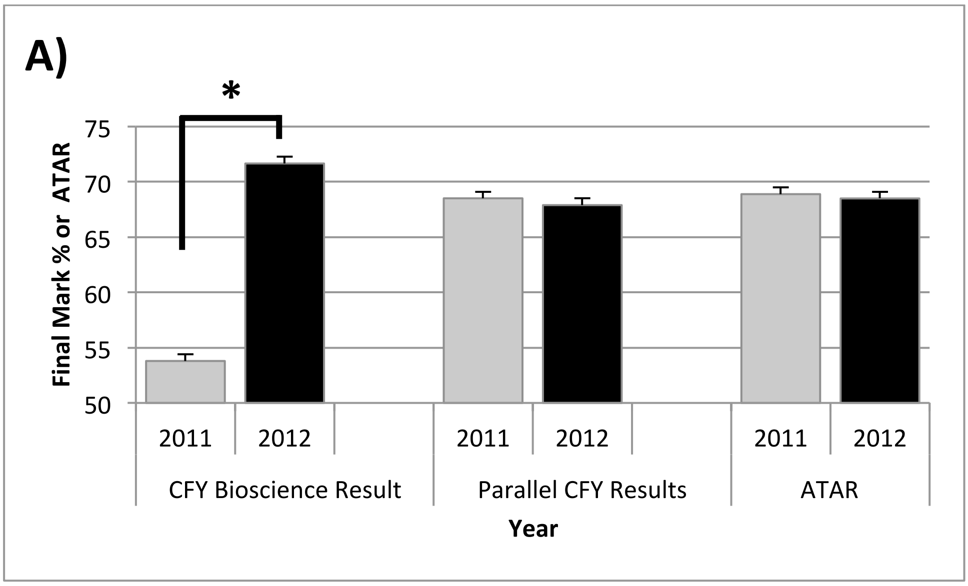


Figure 3: Schematic representation of teaching and learning activities in the redesigned Human bioscience subject. (A) *Division of the subject between Minimum Learning Objectives and Extension Learning Objectives.* In class Learning Objectives account for 60% of the final grade, the remainder of the subject marks come from a final exam focused on self-directed learning (Extension Learning Objectives, ELO). (B) *Assessment activities within the subject*. Assessment of Minimum Learning Objectives (MLO) is divided into three tasks. The first is a hurdle, where students are required to complete a pre-workshop quiz (online). Only after students complete the quiz are they eligible for workshop participation grades. Each workshop is worth 2.5% of the final subject grade. (C) *Break down of accumulated grades based on team and individual (Indiv) assessment tasks*. At the outset, it was intended that students would earn 50% of the subject grade from team based assessments. This was achieved, while still making students accountable for individual learning in MLOs via the individual component of collaborative tests.

Success in this subject beyond a "C" grade required students to master the Extension concepts via self-directed learning. That more students scored above a C than below a C indicates that the Guided Inquiry Learning provided a stronger foundation upon which the students were able to learn the more complex concepts and that students may have developed more mature study skills.



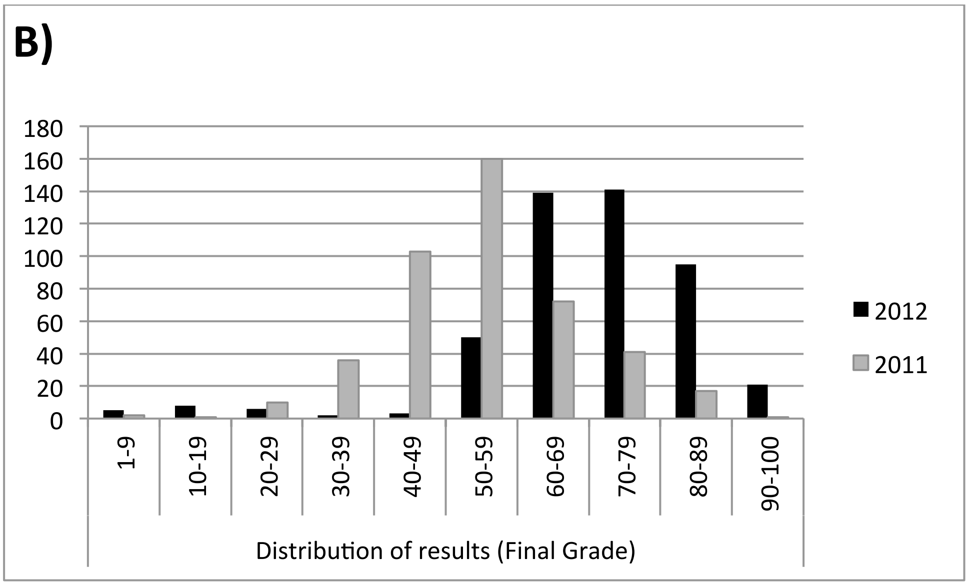


Figure 4: Improvement in overall student performance in first year, first semester Human bioscience taught to a mixed cohort of students. (A) Overall grades in the Human Bioscience subject increased by 18% (* indicates statistically significant effect, $p<0.001$) between 2011 and 2012. This compares favourably with both a parallel CFY subject and ATAR of entry, where no significant differences between the two cohorts of students where observed. (B) The overall distribution of scores between 2011 and 2012 shows skewness to the right, indicating that proportionately more students are scoring grades at the higher end of the spectrum in 2012 than in 2011

The possibility that the improved grade represents a "cohort" effect is unlikely when we compare both the ATAR of entry into Health Science at La Trobe University and these students performance in a parallel Core First Year subject. There is no difference in average ATAR of entry into the subject between 2011 and 2012 (Figure 4A. 2011: 68.9+/- 0.67, 2012: 68.5 +/- 0.71, p= 0.36, one tailed T-test). This suggests that students who enrolled in this subject in each year have similar academic abilities and/or background. Further, analysis of a Core First Year subject taught concurrently with human bioscience shows no difference in performance between the two years (Figure 4A. 2011: 68.5 +/- 0.74, 2012 n=475: 67.9 +/- 0.62 n=493, p= 0.26, one tailed T-test). The failure to see an improved grade in parallel subjects in Core First Year argues against the possibility that student differences between the years (cohort effect) explain the improved human bioscience grades. This leads us to conclude that the altered teaching and learning environment in the subject accounts (substantially) for the improved outcomes.

Conclusion

In 1987, in a landmark paper on designing subjects for undergraduate education, Chickering and Gamson (Chickering & Gamson, 1987) put forward seven principles of good subject design in higher education. Amongst the design principles was an emphasis on peer-to-peer learning, prompt feedback, active learning tasks and an emphasis on "time on task". In line with these seven principles, the University has established its own Undergraduate Capabilities (O. o. t. P. V.-C. La Trobe University, 2012) that students in all courses within the University must master. These capabilities include an ability to engage in inquiry or independent research, speaking and effective communications and team work. This paper reflects a subject design that consciously attempts to incorporate many of these principles into the teaching and learning activities. By adopting an emphasis on guided inquiry activities as a major mode of learning the new physiology subject promotes active learning, time on task, effective teamwork and good communications. This subject further promotes good team work and communication as well as high expectation of individual accountability through the use of collaborative tests as a significant mode of assessment and an expectation that students participate in all learning activities (weekly quizzes and workshops).

In what may be a novel approach, this subject tries to solve the "bioscience problem" by reorienting the focus of formal teaching and learning activities away from the "A" level of exceptional understanding of the subject matter that traditional subject designs are geared towards, and is beyond the ability of many students to achieve using traditional teaching and assessment designs. Instead the new design refocuses attention towards encouraging student to develop a solid foundation of the key threshold concepts. High achieving students, and students with a discipline need for deep learning, are provided the opportunity and scope to demonstrate higher academic achievement through self-directed learning activities tailored to the curriculum needs of the stakeholder disciplines. In this way other students are not burdened with the *extra* material that may distract them from the core knowledge and concepts. In practice, however, our subject redesign has motivated less credentialed students to achieve a deeper level of understanding than has been experienced historically in this subject. Students are doing better on assessments and are doing so on self-directed learning. The benefits of the redesign, however, will not be truly known until students progress further in their studies onto subjects for which physiology knowledge is required.

Acknowledgements

Data presented in this paper was deemed of "Negligible Risk" (in accordance with the National Statement on Ethical Conduct in Human Research 2007) by the Faculty of Health Science Human Ethics Committee (FHEC 13/018). The Authors would like to thank Dr Judith Lyons and Jane McCooey for their insightful comments on the manuscript.

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