ACSME
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The 23rd Australian Conference for Science and Mathematics Education

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PROCEEDINGS OF THE AUSTRALIAN CONFERENCE ON SCIENCE AND MATHEMATICS EDUCATION 2017
(22nd Annual UniServe Science Conference)

27TH – 29TH SEPTEMBER 2017
MONASH UNIVERSITY

SCIENCE AND MATHEMATICS TEACHING AND LEARNING FOR THE 21ST CENTURY

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EDITORIAL

The 23rd Australian Conference of Science and Mathematics Education (ACSME 2017) is held at Monash University, Clayton campus. This is the second time this conference made it to Melbourne, and also the second conference held under the management of the Australian Council of Deans of Science.

We have a rich program of talks in the form of orals, bites and poster bites, as well as poster displays. The keynotes are presented by Karen Burke DaSilva and Paul Francis, both recipients of a 2016 Australian Award for University Teaching, who will inspire us with tips and insights on how to best engage students in science learning and prepare them for their futures. Together, ACSME 2017 presentations represent the challenges faced by academics and professional staff today in their daily lives as science educators, and their innovative ways to address these. The variety of technologies available to us, the many types of assessment, what to do online and what not, the use of e-resources, the different approaches to teaching; all these provide many possibilities and hence there are many important decisions for those of us teaching science and mathematics. The passion, enthusiasm, creativity and expertise of the many ACSME presenters can only help to improve our knowledge, and assist us to make good decisions and to improve science teaching and learning at undergraduate level.

These proceedings contain abstracts and full papers presented at ACSME 2017. All contributions were reviewed by at least two reviewers. Each full paper submission was double blind reviewed.

We give our heartfelt thanks to all those who made ACSME 2017 happen, to the program committee, and to our many colleagues who working in the background took care of every little detail to make this conference a success.

We hope that you find ACSME 2017 enjoyable and stimulating, and that you take home new ideas to implement within your context.

Cristina Varsavsky, Tina Overton, Christopher Thompson
Local organising committee, Australian Conference for Science and Mathematics Education 2017

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The Proceedings of the Australian Conference on Science and Mathematics Education contains three types of papers:

- **Full Refereed Papers** which have been peer reviewed by two independent experts and satisfy the Australian DEST E1 category.
- **Full Written Papers (non-refereed)** which have been subject to editorial assessment and satisfy the Australian DEST E2 category.
- **Abstracts** (extract of paper) which have been subject to editorial assessment and satisfy the Australian DEST E3 category.

We look forward to seeing you at the Australian Conference on Science and Mathematics Education (23rd Annual UniServe Science Conference).

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TEACHING LARGE CLASSES WITHOUT LECTURES

Paul Francis

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KEYWORDS: lectures, flipped classes, large cohorts

ABSTRACT

There is now abundant evidence that traditional lectures are an almost completely ineffective learning experience. The reasons for this are clear – lectures are a passive experience for most students, their typical length is a poor match to human attention spans, the learning is not social, they are inflexible and they are almost always paced wrong. And the fraction of students showing up to lectures is in precipitous decline, which is probably sensible of them.

But what can we do in their place that is better? In ANU Physics we have "flipped" all our later-year classes across the whole program. Students start off by watching short (5 minute) videos interspersed with questions. These videos are mostly made by tablet capture (not live action) – the production values of the videos seem to make little difference to learning gains, indeed I would recommend using text materials rather than videos the first time you flip a class. The universal experience is that you can fit the content you used to cover in a 50-minute lecture into only 20 minutes of video! Students do homework, aided by drop-in tutorials, and submit it before coming to the weekly workshops. We have many different competing models for how to run the workshops – it's not yet clear what is best.

These flipped classes are popular with students. In the first year of operation they make no significant difference to student learning outcomes, but as they are optimised, student grades in the final course exam steadily rise, and we are seeing consistent 10-20% grade increases in the flipped courses once they have been running for 2-3 years. Details really matter when making this work – it would be very easy to have a flipped class which was a much less effective learning experience than traditional lectures, and I will tell you some of the things to avoid!

Our task now is to flip the large first year classes. These are a huge challenge, because the classes are too large to fit everyone into a flat teaching space at once, so we need to run multiple parallel sessions each week. This then becomes expensive, hard to staff and hard to timetable. I will discuss the issues and how we've tried to overcome them. It does seem to be possible to run a large flipped class in a cost- and time-effective way, but it's not easy…

A ROAD TO SUCCESS – PREPARING STUDENTS FOR AN UNKNOWN CAREER FUTURE

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ABSTRACT

The Office of Australia's Chief Scientist is calling on the education community to take practical steps to improve teaching and learning in order to develop graduates with employability skills that meet industry needs. A common request coming from science students is for more experiential learning, practical work, and industry-related skills. Designing programs to improve the student experience and enhance long term student outcomes whilst improving employability outcomes however, continues to be a challenge. Exposing students to real-life problems clearly supports the acquisition and enhancement of critical thinking and problem-solving skills essential for the work place. Designing authentic activities that are not highly-guided, verification-type experiences, with well-defined end-point can cause fear amongst many science educators. Providing professional development for staff to revamp teaching approaches that include time for problem solving is essential and can have a strong positive impact on student learning. Authentic learning experiences need to start at the first year level and continue throughout degree programs, ideally with opportunities to conduct research, to work with industry, and to gain invaluable international experience. The ultimate road to success for preparing students for an unknown career future is to progress beyond the passive application of pre-learned and practiced methods to a more adaptive and creative approach in which students take ownership of their own learning. The program at Flinders University has taken a step in this direction, where students are provided with a pathway to gain the skills and thrills of discovery that will ultimately provide them with a foot up the employment ladder.

DEVIATION FROM STEM PEERS AND EMPLOYERS IN EMPLOYABILITY FOCUSES: THE CASE OF MATHS, STATS, PHYSICS AND ASTRONOMY STUDENTS

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KEYWORDS: Career information literacy, Employability, STEM education

ABSTRACT

STEM employability is a non-homogenous phenomenon with mixed outcomes for graduates from different disciplines. A myriad of factors may contribute to the diverse employability. Here we examine the heterogeneity of career and employability development focuses among different STEM student cohorts in the curricular context. We utilised a structured framework of Career Information Literacy (CIL) to map career and employability focuses of STEM students and employers. This paper presents findings from the Mathematics, Statistics, Physics and Astronomy cohort.

Data was collected from final year capstone unit students at a STEM faculty in an Australian university (N=517, response rate 44%). Of which, Maths, Stats, Physics and Astronomy (MSPA) students were analysed as a cohort (N=80, response rate 73%). Concurrent data collection took place with STEM employers and industry stakeholders who engaged this faculty in recruitment and employability activities (N=62, response rate 78%). Upon comparing student cohorts' focuses on career and employability development with their peers and employers, we found MSPA students differ from both their STEM peers and employers. Most other STEM student cohorts differ from employers, but not their peers. The implications point to a different career development need of this cohort to fully realise the benefits of their STEM education.

GRADUATE EMPLOYABILITY IN SCIENCE: ACADEMICS' PERCEPTIONS

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KEYWORDS: Graduate employability, generic skills

BACKGROUND

Graduate employability is a key issue for higher education as new graduates face a highly competitive and rapidly changing employment sector. To maximise their likelihood of employment, graduates need to be able to demonstrate the skills and attributes most valued by employers. Employers, however, have long criticised the ability of graduates to contribute effectively to the workplace, especially due to a perceived lack of generic skills. This indicates a mismatch between the skills required by employers and those possessed by graduate applicants.

PURPOSE

This research aimed at understanding science academics' perceptions of graduate employability and underpinning skills. More specifically, this research explored academics' perceptions of: (a) which of the targeted generic employability skills were developed and assessed through the science units they coordinated, and (b) the challenges encountered in the development and assessment of the skills.

DESIGN AND METHOD

A mixed-method approach was adopted to design this research with a view that a complete picture of human behaviour and experience can be constructed by using a combination of quantitative and qualitative methods within a research study. Academics coordinating a total of 133 units across the Faculty of Science of Monash University completed an online survey, which asked them to map the extent to which some selected generic employability skills were developed and assessed through their science units. 10 of these coordinators were subsequently interviewed to elicit their insights into the promotion of employability skills and associated challenges.

FINDINGS

Analysis of the survey data showed that of the 14 targeted generic skills, 4 were neither developed nor assessed in more than 50% of the units. Whilst 10 skills were developed in at least 50% of the units, six of them were not assessed in more than 50% of the units. There was at least 25 points difference between the development and assessment data for four of the skills. The interview data elaborated academics' perceived challenges to find strategies to best assess the generic skills, which they thought contributed to the mismatch between the development and assessment of the skills.
Academics also articulated the approaches they employed to embed employability aspects into their units without negatively impacting discipline-specific education outcomes.

CONCLUSIONS

Academics' perceptions, as revealed in this research, reinforce calls to shift from transmissive pedagogies to more problem-based approaches in the classrooms and research labs, so that students are provided with opportunities to develop the skills and qualities that employers demand from a science graduate.

BEYOND PLACEMENTS: USING CURRICULUM MAPPING TO EMBED WIL ACROSS A CHEMISTRY MAJOR

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KEYWORDS: Work-integrated learning, chemistry, threshold learning outcomes, curriculum mapping

PROBLEM
The University of New England (UNE) is located in regional NSW, and approximately 50% of our science students study off-campus. Improving graduate employability through WIL activities at UNE is a challenge because work placement and industry interaction are more difficult than for large city- based universities with primarily on-campus students. The Chemistry major at UNE is accredited by the Royal Australian Chemical Institute. However, previous mapping exercises have not provided information on where and when core competencies are *taught*, *practiced* and *assessed*, nor included certain WIL skills that are not explicitly captured by the Chemistry Threshold Learning Outcomes (TLO). To guarantee the employability of our graduates, we need to ensure the primary foci of our program are development of the core skills that enable an individual to walk into a position and adapt to that role and that WIL skills are embedded throughout.

PLAN
In developing employability capabilities in our students, our focus is to embed WIL throughout our program of study, ensuring it is contextualized and scaffolded so that our students can integrate disciplinary knowledge with industry practices and develop non-discipline specific 'soft skills' without requiring industry placements. Our plan is to provide a clear picture of where we can implement improvements in our major, and identify opportunities for curriculum re-design where learning can occur within a WIL scenario. Integrating the development of core discipline knowledge with WIL skills in this contextualized setting will enhance the student experience and learning outcomes. Universities cannot teach all the applications that exist, so we aim to equip our students with a stronger understanding and ability in the core concepts and skills that will enable them to 'learn on the job', and adapt to a wide range of employment opportunities.

ACTION
We will map discipline TLO's, program Graduate Attributes and WIL-based skills for use in the Chemistry major. This six-step process will include drilling down into the Tier 3 Chemistry TLO's to develop a 'fine-tuned' mapping of which core concepts or skills are taught, practised and assessed within our major, when this occurs and at what level.
1. Pre-mapping survey of academics' attitudes and understanding of WIL.
2. Academics and industry representatives to identify WIL skills for the Chemistry major.
3. Unit coordinators to map Chemistry TLOs and WIL skills for each unit.
4. Produce a map across the major, and use it to identify, gaps, duplications and inefficiencies.
5. Post-mapping survey of academics to identify any changes in academics' attitudes and understanding of WIL.
6. Develop Action Plans for implementing curriculum change.

REFLECTION
In this presentation we will first discuss academics' understanding of and attitude toward implementation of WIL. Secondly, we will present the results of the mapping of TLOs and WIL skills cross the Chemistry major, and discuss the resulting changes to the curriculum. Finally we will reflect on the process and describe changes that will be made to enable the process to be rolled out across other science majors.

OPTIMISING VIDEO FEEDBACK – WHAT ASSESSMENT FITS BEST?

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KEYWORDS: Video feedback, Feedback-analytics, Learning-analytics

BACKGROUND

Delivering detailed, appropriate, and timely feedback for assessment is crucial for supporting student learning (Gibbs and Simpson 2004-2005), yet it remains a constant struggle for instructors. To compensate for the limited opportunities for face-to-face feedback in large courses, instructors can provide personalised insight on student assessment through video feedback (Henderson and Phillips 2015). To date, the applicability of video feedback across different assessment modes has yet to be evaluated, and learning analytics can provide detailed information on students' video-viewing behaviour to optimise guidelines for how and when to deliver video feedback.

AIMS

The project team investigated student viewing activity across instructor feedback videos for hands-on laboratory-based versus written science communication assessment tasks. Variables such as instructor experience, video length, pausing and seeking activity, timestamp correlations, and student demographic data were evaluated using learning analytics to differentiate student engagement with video feedback across different modes of assessment.

DESIGN AND METHODS

Students enrolled in the 2016 and 2017 offerings of MICR2000 ('Microbiology and Immunology', n=398) and MICR3003 ("Molecular Microbiology", n=139) at The University of Queensland (UQ) were given video feedback for laboratory-based and science communication assessment tasks. Instructors of vary levels of teaching experience (tutors, lecturers, course coordinators) recorded feedback videos for students, whose video-viewing behaviour was monitored through learning analytics after obtaining informed consent (Approved by UQ Ethical Review Committee: project #2012000755). Student participants were interviewed before and after viewing feedback videos for their perceptions on feedback efficacy.

RESULTS

Over 60% of enrolled students logged in to watch their feedback videos, and 80% of these students finished watching their video in its entirety. Students on average recorded 5 pausing and seeking actions per video, and no significant differences were observed between feedback videos for laboratory assessment versus science communication assignments. Instructor experience was also not a factor in determining levels of student engagement with videos created. Interviews with student participants revealed clarity, accessibility, and specificity of feedback to be the most important factors, and found video feedback to be equally applicable across hands-on laboratory assessment tasks versus written science communication assignments.

CONCLUSIONS

The data revealed a high-level of student engagement with video feedback, which improved the specificity, clarity, and accessibility of feedback in large classes. Using learning analytics, the project highlighted the broad applicability of video feedback across different assessment items, further strengthening its advantages for instructors to diversity course-based student interactions.

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DO STUDENTS LEARN INTRODUCTORY PHYSICS EFFECTIVELY IN AN ONLINE ENVIRONMENT?

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KEYWORDS: concept inventory surveys, online, learning gains

BACKGROUND
Students interested in studying a non-Calculus based introductory physics course at UNSW can choose between *Fundamentals of Physics* a very traditionally taught course with 6 hours of face-to- face teaching each week and *Everyday Physics*, an entirely online course. *Fundamentals of Physics* runs twice a year with approximately 200 enrollments each semester and Everyday Physics runs three times a year also with approximately 200 enrollments each semester. Students in these courses have been asked to complete the Force Motion Concept Evaluation (FMCE) survey to measure their learning gains over the semester. *Everyday Physics* has been designed specifically for an online environment, with students studying a different topic each week directly relating physics to the world around them. This data has been collected during 2016 and 2017.

Students completing our calculus based course, *Physics 1A* have been able to elect replace the face- to-face lecture component of the course with online interactive lectures during 2017. All the students in the course were invited to take the Force Concept Inventory (FCI) and Thermal Concept Inventory (TCI) to measure their learning gains. 1647 students enrolled in *Physics 1A* with 188 electing to enroll in the online lecture stream. The interactive lectures consist of short videos followed by questions. For a lot of the demonstrations students are asked to enter their prediction before viewing the outcome (making use of predict-observe-explain). All students in the course attend a 2 hour lab and 1 hour problem solving workshop each week.

AIMS
Staff at UNSW are being encouraged to offer online courses, and online alternatives to face-to-face components. Motivations for this include freeing up lecture space so that we can accommodate more students and also perceived demand from students for a more flexible way to study. There are very few studies on the effectiveness in terms of learning gains of entirely online courses. The majority of online courses studies have been MOOCs which have a uniquely high drop out rate, not present in courses covered under HECs such as the ones studied here. This study aims to compare the learning gains between similar cohorts of students (same university, similar level courses) to see if one teaching methodology is more effective than another.

Entirely online or face-to-face are not the only options, by looking at learning gains for the Physics 1A students who elected to study lecture material online compared to students who chose to study this face-to-face we can start to address the question how much of a course should or can go online without having a negative impact on learning gains.

DESIGN AND METHODS
Students in these courses are asked to complete the concept inventory tests before learning the relevant material in the course. To motivate students to complete the survey there is a bonus mark for one of the assessed quizzes in the course if they complete both the pre- and post-surveys. Data about the student's gender, program of study and stage of their degree is collected from the student enrollment files. Students were also asked about their reason for choosing to study the course.
Students were included in the study if they gave consent to be included, they completed both the pre and post survey, spent more than 10 minutes completing these and scored less than 90% on the pre survey. Normalized learning gains were calculated as outlined in Hake, 1998.

RESULTS
Normalized learning gains in *Everyday Physics* and *Fundamentals of Physics* were very similar over the semesters studied (with *Everyday Physics*) being slightly ahead (14% normalized gain, 40% pretest score for *Everyday Physics* averaged over 5 semesters compared with 12% normalized gain, 33% pretest score for *Fundamentals of Physics* averaged over 3 semesters). This is an interesting result as it suggests that

online can be as effective as face-to-face teaching. However, the learning gains were not high. It seems likely the learning gains for *Fundamentals of Physics* could be improved by making the lecture and tutorial component of the course more interactive. These learning gains are similar to those found by Hake,1998 for traditionally taught courses.

In the FCI survey the normalized learning gains for the students enrolled in the online lectures were slightly lower than for the cohort overall, 22% (pretest average 63%) compared with 29% (pretest average 61%), 686 students in total qualified for the study. Part of this difference is due to the fact that the majority of them did not complete the lectures. Of the 188 students who elected to take their lecture component this way only 31 students completed 80% or more of the online lectures in the mechanics topic and only 24 of these qualified to be included in the study. The results for the thermal topic were different, but are probably skewed by small numbers. The normalized learning gains for those enrolled in the online lecture stream was 35% (pretest average 59%), 24 students in this category qualified for the study, the normalized gain for the overall cohort was 28% (pretest average 61%), 538 students in total qualified for the study. Only 7 of the 188 students enrolled in this stream completed more than 80% of the online lectures on this topic. For all students who completed at least 80% of the online lectures the normalized gains were 36% (52 students in total). Attendance was not taken in lectures, some students chose to enroll in the online lecture stream and then attend lectures. Many students enrolled in face-to-face lectures elected to use the online lectures, it is not known if they also attended face-to-face lectures.

CONCLUSIONS

It is important to collect data about the effectiveness of online teaching and learning as it is becoming increasingly prevalent in the tertiary sector. The data from these courses showed that the learning gains for an online course were equivalent (if not higher than) to the learning gains in a traditionally taught course covering the same material. Students who engaged with online lecture material in a blended course had higher learning gains than the average student in the course but many chose this option and then did not engage with the materials. The challenge is making students engage with these materials. The number of students in this study was not large, hopefully when combined with data from other courses at other institutes we can get a more thorough picture of the effectiveness of online learning as measured by learning gains.

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USING INDUSTRY DEVELOPED ONLINE TOOLS IN TERTIARY AGRICULTURAL SCIENCE TEACHING

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KEYWORDS: real industry technology learning systems, agriculture, grazing systems

PROBLEM

With the gross value of farm production predicted to rise by 8.3% in 2016–2017 to be worth $A63.8 billion, agriculture is an important industry to the Australian economy (ABARES, 2017). However, agriculture has one of the lowest proportion of workers with post-secondary qualifications across the economy (Parliament of Australia, 2012) with an estimation of approximately 7.8% of the agricultural workforce with tertiary qualifications compared with 25% for the broader population (Pratley, 2012). Pratley and Acuna (2015) have also reported that there is already a skills shortage in the agricultural industry with an estimated four jobs available for every tertiary agricultural graduate in Australia. A recent round of workshops conducted for the Rural R&D for Profit Research Project 'Accelerating Precision Agriculture to Decision Agriculture' (http://www.farminstitute.org.au/P2Dproject) highlighted that tertiary agriculture education requires content modification to reflect the technology and data needs of modern day agriculture (D. Lamb, personal communication, May 30, 2017).

PLAN

The SmartFarm Learning Hub (the Hub) is a collaboration between 7 universities (namely the University of New England, University of Tasmania, University of Central Queensland, University of Southern Queensland, University of Melbourne, University of Sydney and New Mexico State University), with each university farm representing a varied range of agricultural enterprises and geographical locations. The objective of the Hub is to address two key issues faced by the agricultural industry:

Increase the skills and knowledge of agricultural graduates to improve their employability in the agricultural industry.
Encourage and inspire students from a younger age to consider tertiary education and a career in agriculture by demonstrating the innovative and high tech nature of sector (Trotter et al., 2016).

The Hub will achieve these objectives by each participating university developing a learning module that utilises genuine farm data in a real industry technology learning system (RITLS) (Cosby et al, forthcoming).

ACTION

Each of the RITLS modules will be evaluated as part of an action research cycle (McTaggart, 1991) providing both research outcomes and critical feedback to improve the learning materials. Students are invited to complete an online survey, consisting of Likert scale questions (Likert, 1932) asking their perception on a range of aspects of the practical. The subject of the questions includes whether they perceived the learning outcomes (derived from Learning and Teaching Academic Standards Statement for Agriculture) (Botwright Acuña & Able, 2016) were achieved, their level of enjoyment, the applicability of the learning module to future employment, ICT skills, the system usability scale and their demographic details.

REFLECTION

Student responses indicate that they believe the use of industry tools in teaching is important for their future career with 90% of respondents indicating they would use the knowledge derived from completing the 'Rainfall to Pasture Growth Outlook Tool' practical in their future employment. When asked whether completing the same practical would increase their employability in the agricultural industry, one student said:

It's important to be able to apply data about environmental factors to on farm management decisions and future planning. However, there are still tighter links which can be made in the practical to employability skills. One suggestion is that key skills that students can include on their CV could be highlighted in each RITLS module. As per the action research cycle the learning materials will improved based on student feedback and evaluated again in 2017.

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BUILDING 'EMPLOYABILITY' SKILLS IN A BIOMEDICAL SCIENCE CAPSTONE UNIT

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KEYWORDS: Employability, Skills, Work, Career, Capstone, Biomedical Science

BACKGROUND & AIMS

Young people in the 21st century face unprecedented work uncertainty (CSIRO, 2016) as a consequence of ongoing globalization, rising socio-economic pressures and rapid technological automation (CEDA, 2015; WEF, 2016; Hajkowicz et al., 2016; Beer et al. 2016). Disconcertingly, tertiary students are not adequately prepared for the transforming nature of work, lacking the transferable 'employability' skills required to thrive in a contemporary global workforce (Randstad, 2017; FYA, 2016). Transferable skills, including communication, teamwork and critical thinking, are increasingly valued by employers over discipline-specific technical skills and knowledge (Rayner & Papakonstantinou, 2015). It is therefore essential that tertiary educators focus on student development of transferable skills. Whilst employability programs have been run in parallel to existing curricula (Choate, et al. 2016), our aim was to embed the development of transferable skills within a capstone unit to enhance student awareness and improve graduate employment outcomes.

DESCRIPTION OF INTERVENTION

Within a newly established Biomedical Science capstone unit, development of transferable skills (communication, teamwork and critical thinking) was specifically embedded in all tutorial learning activities and assessment tasks over a 12-week semester. Students were immersed in these skills through exploration, application, demonstration and reflection during pre-class, in-class and post- class activities, discussions, and assessment.

DESIGN AND METHODS

Employing a mixed methods approach, third-year Biomedical Science students were anonymously surveyed at the commencement and conclusion of the unit. Students evaluated their perceptions of transferable skills including development, ability and future use via dichotomous, multiple-choice and Likert scale responses. Focus groups provided qualitative data. Data was analysed using *SPSS*. Human ethics has been obtained for this project (MUHREC #7954).

RESULTS & DISCUSSION

Third-year Biomedical Science students realise the importance of transferable skills to work
Preliminary data from the first survey (n = 124) illustrated that a proportion of students could not correctly categorise skills as either general or workplace-specific. For example 46.5% of students failed to correctly identify 'researching literature to find solutions' as a general workplace skill.
However, when considering their future employment, almost two-thirds of students (62.8%) thought that transferable skills would be more important than discipline-specific knowledge or technical skills, with students expecting to use transferable skills to a large extent (3.86 ± 0.37; scale 1 = very little to 4 = greatly).

Given a strong emphasis on discipline-specific knowledge and skills in the Biomedical Science curriculum, it was unexpected to find that a majority of students appreciated the significance of transferable skills. Analysis of the post-unit survey will identify the effectiveness of the current intervention in improving students' appreciation of transferable skills. Reassuringly, focus group data suggests a positive outcome; '... it's given me the opportunity to intentionally think about these skills… by giving a name to these skills and by specifically identifying them I think it… comes to… our more conscious awareness...'.

CONCLUSIONS

Preliminary findings indicate students are aware of transferable skill importance in future employment, however identify their inability to categorise specific types of transferable skills. Analysis of the post- unit surveys will elucidate the effectiveness of the intervention on students' transferable skills perception. Given these early positive findings, we propose embedding transferable skills across other capstone units, particularly in disciplines where graduates face growing career uncertainty.

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DEVELOPING UNDERGRADUATE CAREERS AWARENESS AND EMPLOYABILITY SKILLS VIA AN ASSESSED PROFESSIONAL DEVELOPMENT PROGRAM

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KEYWORDS: employability, careers, engagement

THE CHALLENGE

The Australian higher education sector is experiencing increasing undergraduate biomedical and science enrolments, with declining employment rates for these students upon graduation (Graduate Careers Australia, 2014). At Monash University, anonymous survey feedback indicated that biomedical science and science (physiology major) students were anxious and unaware about careers options (apart from research and medicine) and their employability skills development (Choate, Green, Cran, Macaulay & Etheve, 2016). Despite uncertainty about employability skills, students were comfortable with, and indeed focused on, discipline content knowledge. Having identified a critical need to develop students' employability skills and career management, a team of biomedical academics and careers staff developed a professional development program. The goals of the program were: (i) To address students' assumptions about linear career pathways; (ii) To raise students' awareness of their employability skills development; and (iii) To assist students in building their capacity to effectively communicate their employability skills (Choate *et al.*, 2016).

DESIGN AND METHODS

The program contains five modules, delivered into core subjects in years one, two and three of the biomedical degree program. Each module has a lecture, with invited speakers (mainly recent biomedical graduates), and an assessment that is linked to the development of an electronic portfolio. On completion of the five modules students will have produced a profile reflecting their career-related experiences and employability skills. The program commenced with first year students in 2015, with single degree students completing the program this year. After each module, students completed an anonymous careers awareness survey, with responses on a five point Likert scale (analysed with a Kruskal–Wallis test by ranks), and two open-ended questions (written comments were grouped into themes by an independent administrator).

RESULTS

Student engagement with the program was evaluated via assessment submission rates (high: 90% in 2015; 86% in 2016; 91% in 2017), lecture attendance (normal), attendance at extracurricular sessions with careers advisors (this increased in parallel with the introduction of the program) and focus group feedback (students appreciated the opportunities to consider their careers and employability skills within their course). Student feedback indicated that engagement with the program was facilitated by the assessments and careers presentations from recent graduates. Assessment timing for this program is important, as students prioritised other, more highly weighted, assessments due at a similar time. Students appreciated the opportunity to consider careers and employability skills, especially early in their degree, and liked the non-medical careers focus. Despite the program, we found a decrease in student awareness of careers options from year one to the end of year two ($P<0.05$) that may reflect insecurity about their careers as they head into their final year. Issues with program integration, in which students struggled to understand progression from one module to the next, were addressed through the creation of a dedicated on-line learning site. Some students also struggled with the portfolio platform.

CONCLUSIONS

Student will engage with a professional development program if it is assessed and in-curriculum. This should lead to decreased careers anxiety, but students may require help with unfamiliar technologies.

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BARRIERS AND OPPORTUNITIES FOR ENGAGING SCIENCE STUDENTS IN WORK-INTEGRATED LEARNING

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KEYWORDS: work-integrated learning, student engagement, teacher perceptions

Work-integrated learning (WIL) is a key vehicle for developing the employability skills and knowledge of graduates. However, science students participate in work-integrated learning (WIL) less than students in other STEM disciplines, such as engineering and agriculture (Edwards, Perkins, Pearce, & Hong, 2015). The Office of the Chief Scientist, and the Australian Council of Deans of Science, have recognised the need to upscale the implementation of WIL in Science. Initial work shows that science faculties are at different levels of readiness: ranging from little or no systematic adoption of WIL or enabling strategies, through to faculties with significant investment and support from their institution (Australian Council of Deans of Science, 2017). However, participation may also be adversely affected by low levels of engagement and uptake by students. Here we report preliminary findings from a project designed to investigate how engagement with WIL can be made a priority and more meaningful for science students. First, we interviewed 23 university staff involved in the design and delivery of WIL in science (WIL specialists) to investigate why and how they think science students engage with WIL. In research underway, we are comparing WIL specialist perceptions with those of students themselves, through focus groups and interviews.

Preliminary analysis of WIL specialist perceptions suggest that science students are very interested in WIL opportunities. However, WIL specialists were often focussed on a small proportion of students who had engaged with elective WIL opportunities. WIL specialists suggested that barriers to broader engagement include: insufficient visibility of and access to opportunities and student specific factors such as career orientation, time (within and beyond the curriculum) and confidence. WIL specialists recognised the importance of repeated and explicit communication to students and suggested that more staff could be involved in communicating to students about the importance and availability of WIL. Evidence so far, suggests that cultural shifts on the part of both staff and students are needed to improve engagement with WIL. In this presentation we will elaborate on barriers and opportunities for student engagement.

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A CROSS-SECTIONAL STUDY OF PERFORMANCE ON A PILOT CHEMISTRY CRITICAL THINKING TEST.

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KEYWORDS: Assessment, Quantitative, Student Development Tool

Philosophers, cognitive psychologist and education researchers commonly employ terms such as 'analysis', 'evaluation', 'judgement' and 'desirable outcome(s)' when defining critical thinking (Facione, 1990; Halper, 1996; Tiruneh, Verburgh & Elen, 2014). A recent study identified chemistry students, teaching staff and employers emphasize the use of terms such as 'analysis' and problem solving' when defining critical think (Danczak, Thompson & Overton, 2017).

The development of critical thinking in university students is important because; i) 34% of recent graduates are finding full time work in disciplines unrelated to their studies (Graduate Careers Australia, 2015), ii) graduate employers state critical thinking as the second most desirable trait in graduates (behind self-directed learning) (Jackson, 2010; Prinsley & Baranyai, 2015), and iii) critical thinking or similar terms are listed as graduate attributes of almost all tertiary qualifications at nearly every higher education institution.

To be able to evaluate the critical thinking ability of undergraduate chemistry students at various stages of their studies would be pedagogically useful. In the context of institutions with large student numbers several constraints were required of the test. A test needed to be able to be delivered reliably to a large number of students, it needed to be administered on a voluntary basis and the ability to do well on the test needed to be independent of prior chemistry knowledge.

To this end a chemistry critical thinking test (CCTT) was developed. It contains 30 multiple choice questions designed to assess making assumptions, developing and testing hypotheses, drawing conclusions and analysis of arguments. To date the CCTT has undergone three revisions based on studies testing for internal reliability, test-re-test reliability, convergent and content validity.

The third iteration of the CCTT was administered to first year undergraduate chemistry students (n=199), third year undergraduate chemistry students (n=54), chemistry postgraduates (n=40) (consisting of post-doctoral researchers, honours and PhD students), and chemistry academics drawn from an online community of practice (n=46). The responses to the test were collated and imported into IMB SPSS v22. Tests where less than 23 items were attempted were not considered genuine attempts and excluded from analysis. Mann-Whitney-U tests were performed comparing each cohorts' median score on the CCTT to determine if there were any statistically significant differences in scores between the various cohorts. Analysis revealed a significant difference ($p < .001$) between all cohorts with the exception of the comparison between postgraduates and academics, where no significant difference in median score was identified between these two cohorts ($p =.841$). All statistically significant differences exhibited medium to large effect sizes ($r =.22 - .57$).

These results suggest the CCTT may be suitable for a variety of applications throughout undergraduate students' studies. These include as a cross sectional analysis of the critical thinking ability of several cohorts at a given point in time, or in longitudinal analysis of a specific cohort as they progress through their studies.

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CRITICAL THINKING: A STEM-INDUSTRY PERSPECTIVE

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KEYWORDS: critical thinking, industry expectations

BACKGROUND

A 2015 report from the Australian Office of the Chief Scientist identified 'critical thinking' (CT) as the second most-important skill required of STEM-qualified staff in industry (Prinsley & Baranyai 2015). Whilst a precise definition of CT is debated (Ennis 2015), two well-regarded conceptions (Popil 2011; Flores et al., 2012) are the cognitive skills outlined in the *Delphi Report* (Facione 1990) and the intellectual criteria of Paul and Elder (2008). These two approaches define CT in terms of the actions and traits of a good critical thinker. However, more clarity is required on industry expectations of CT in the STEM graduates they employ.

AIMS

This study sought to (i) better understand how industry conceptualises CT amongst its workforce, and (ii) better understand industry expectations of graduates regarding their CT skills.

DESCRIPTION OF INTERVENTION

Representatives undertook a 60-minute, semi-structured interview to gain their opinions on, and understandings of;
- CT skills of the graduate in the workplace generally, and
- The CT concepts of Facione (1990) and Paul and Elder (2008).

DESIGN AND METHODS

Technical managers and H.R. representatives (n = 37, n = 2, respectively) representing 22 local and multinational companies that have employed graduates from our B.Eng. and B.Eng./B.Pharm.Sci.degrees were interviewed during summer 2016/17. Verbatim transcripts and accompanying notes were analysed manually at the sentence level.

Sentences were classified against the CT cognitive skills suggested by Facione (1990) and the CT intellectual criteria of Paul and Elder (2008). A sentence was classified only where the interviewee indicated that the cognitive skill or intellectual criteria was used by, or desired to be used by recently employed graduates.

Transcripts were then reanalysed to find emergent themes regarding the CT behaviours or traits of graduate students. After thematic regression, another 21 themes were identified, falling into five broad categories; *actions*, *traits*, *good business-sense*, *problem-solving approach*, and *employability outcomes*.

RESULTS

Tellingly, when asked to define CT in relation to the work expected of graduate employees, industry respondents largely did not mention or discuss the formalised concepts of Facione (55% of companies mentioned or implied one or more skill), and Paul and Elder (36% of companies mentioned or implied one or more criterion). When asked about day-to-day use of CT, those formalised concepts were mentioned even less (28%, and 33% respectively). Most respondents (numbers here?) instead defined graduate's CT in terms of 'a systematic problem- solving approach' (82% mentioned), especially when graduates are working within business- or industry-constraints and contexts (64% mentioned). Although not directly asked, most responding companies (91%) indicated that graduates are not entering employment sufficiently equipped with these skills.

CONCLUSIONS

Our research appears to indicate those industries hiring our graduates either require a more pragmatic approach to CT than academia or that they interpret CT in a more unidimensional manner (i.e. problem-solving, rather than analysis, synthesis etc.).This may indicate a need for greater, and/or more explicit, development of industry-aligned CT skills in our students. Failure to do so may adversely affect the employability of our graduates.

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CULTIVATING CREATIVE THINKING IN SCIENCE STUDENTS

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KEYWORDS: science education, creative thinking, authentic assessment, employability

We often hear complaints that University does not prepare graduates adequately for the workforce or that our education system has not caught up to the "real-world" problems. Work-integrating learning approaches are gaining momentum to address some of these issues, but they still focus mostly on providing internship experience to limited number of students. In regular classes, academics are caught between having to provide enough discipline-based knowledge and skills, while being required more and more to foster soft (transferable) skills, such as interpersonal communication, effective team work and presentation skills, in increasingly shorter amount of time. On the other hand, students cling to formulaic approaches to learning and assessment, looking for a "safe zone" before they step into the competitive "real-word" of the workforce. Is there a way to meaningfully incorporate all these requirements?

Authentic assessment can cultivate creative thinking, resourcefulness, ambition and curiosity in our students, which are highly valued employability skills. However, academics are often concerned that non-formulaic forms of assessment are much more complex to construct marking scheme for. How can one assess equally an assignment in the form of a board game, a short movie, a poem, or a letter written to a family member? I will present examples of authentic, open-ended assignments which have allowed students to present accumulated and non-linear understanding of the discipline knowledge (astronomy in this case), which a "regular" form of assessment (an essay or a report) cannot. I will discuss possible marking rubrics that can be used to communicate the requirements of the assignment to the students, as well as to assess their work. Finally, I will argue that authentic assessment teaches our students to be solution-driven, not mark-driven.

PROMPTING UNDERGRADUATE STUDENTS' METACOGNITION OF LEARNING: IMPLEMENTING 'META-LEARNING' ASSESSMENT TASKS IN THE BIOMEDICAL SCIENCES

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KEYWORDS: metacognition, biomedical science, assessment

BACKGROUND

To succeed at post-secondary education and become lifelong learners (Boud and Falchikov 2006), it is essential that students develop an understanding of their own knowledge and learning processes. This metacognition of learning, or 'meta-learning', helps students to become more effective learners, as they become more aware of their self-regulatory processes and recognise the effectiveness of their study strategies (Biggs 1985, Jackson 2004). As meta-learning relates to students self-awareness regarding their learning processes, it is closely aligned to the self-regulation of learning (Zimmerman, 2002; Winne 2010).

METHODS

To increase biomedical science students' self-awareness we have designed and implemented meta-learning assessment tasks (Colthorpe et al. 2015) and have deployed them across a number of undergraduate courses in the biomedical sciences, on each occasion incorporating them as part of course assessment. In this study, we evaluated the impact of the meta-learning tasks using students' perceptions of the value of those tasks. We also investigated students' responses regarding their self-regulatory behaviour in two successive courses to identify longitudinal changes in strategy use and the impact that may have had on academic achievement.

RESULTS

Most students (85%) reported that meta-learning tasks had a positive impact on their learning, as they prompted self-regulatory processes of forethought and self-reflection (Zimmerman 2002). Students were equally likely to change or not change their study strategies across subsequent semesters.

Those students who did not change (49%) believed their study approaches were already effective, and performed well in the second semester (exam scores 78.3+/-1.4%), but their exam performance did not improve across semesters. In contrast, students who adapted (51%), mostly by modifying how they transformed records or improving their planning and time management, performed significantly less well than those who did not change strategies in the second semester exam (71.5+/-1.8%; p<0.01), but showed significant improvement across semesters, increasing their marks on average by almost 5% (p<0.01).

CONCLUSIONS

Students perceived the meta-learning tasks to be a valuable starting point to becoming more reflective in their own learning, and considered them as a tool to challenge their knowledge and learning processes. The tasks may be particularly beneficial for poorer achieving students whose self-regulatory behaviours are less well-established, as prompting such students to reflect on the effectiveness their learning strategies may provide impetus for them to seek more effective learning behaviours. These findings suggest that meta-learning tasks may prompt students to become more self-reflective and independent learners, and may enable the development of lifelong learning skills.

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STUDENT CREATED NOTES PAGES AS AN EXAM AID: A CROSS DISCIPLINARY CONTENT ANALYSIS

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KEYWORDS: Cheat sheet, Crib sheet, Content Analysis

BACKGROUND
The use of student-constructed notes as a testing aid is seen as a happy compromise between closed book examinations and unrestricted open book examinations (de Raadt, 2012; Larwin, Gorman and Larwin, 2013). We use the definition of Harmouda and Shaffer (2016) - "a small collection of notes that students are sanctioned by the instructor to create during their exam preparation and bring to the exam session as a reference" (p.1).

The establishment of Federation University Australia in 2014 and subsequent opportunity to review and redesign the curriculum and structure of the full suite of Science degrees has resulted in the widespread use of student constructed notes across a range of science courses, particularly at first year. Previous research has established a link between improved student grades and decreased exam anxiety and the use of student constructed notes (de Raadt, 2012, Edwards & Loch, 2015, Harmouda & Scaffer, 2016; Larwin, Gorman and Hamouda, 2013) but also some contradictory findings. Content analysis of student constructed notes pages is promising new analysis technique to recently emerge in the literature.

AIMS
The aim of this research is to establish a template for qualitatively analysing the structure and content of student created notes pages across a range of science disciplines in order to describe the similarities and differences between students' notes pages.

DESIGN AND METHODS
Using a content analysis approach originally suggested by de Raadt (2012) and later further developed by Edwards and Loch (2014; 2015) as a basis, a small voluntary sample of students notes pages developed as an exam aid were examined to establish a non-discipline specific template for analysis of factors related to the structure and content of these sheets. This sample included notes pages developed for first year mathematics, statistics, chemistry and biology. A triangulated enumeration technique involving multiple analysts was used to define a list of factors for both structure and content which could be applied across disciplines.

RESULTS
A list of generic factors relating to the structure and content of student created notes pages will be presented as well a template which can be used to conduct a content analysis.

CONCLUSIONS
It is possible to analyse the content of student created notes pages across a large spectrum of the science disciplines by looking at content as higher level abstract skills and techniques rather than as subject specific content. The template created may be applied to a broader range of subjects to further validate its usefulness.

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OPEN-NOTE EXAMINATIONS AS OPPORTUNITIES FOR MEANINGFUL LEARNING AND ASSESSMENT

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KEYWORDS: open-note assessments, meaningful learning, distributed revision practice

BACKGROUND

Problem solving and critical thinking are critical 21st century graduate attributes, particularly in STEM fields. Development and evaluation of these skills can be supported by open-book and/or open-note assessments. While open-note assessments have been used in science education, the related literature is rather controversial, and guidelines are lacking in terms of their optimal implementation.

AIMS

Overarching goal of the project is establishing guidelines, for students and educators, for effective implementation of open-note examinations.

Aim 1 – to investigate students' and educators' perspectives on open-note assessments
We are interested in how such assessments are perceived to influence approaches to learning, motivation and engagement, ability to manage students' mental/cognitive load, higher order cognitive skills development, ability to manage stress and anxiety, ability to manage study time, and overall learning experience.

Aim 2 – to investigate impact of open-note assessments on students' academic achievements
We are interested to determine whether the development and use of open notes modifies students' learning behaviour and affects students' learning outcomes. Specifically, we are investigating whether there is a correlation (i) between students' regular development of their notes during the semester and examination performance and (ii) between the type, amount, and organisation of information on the notes and students' achievement outcomes.

DESCRIPTION OF INTERVENTION

For the last four years, students' enrolled in physical chemistry coursework have been assessed via open-note examinations, using self-prepared notes constructed during the semester. Similar arrangements are implemented in a range of units of study across the university, with majority coming from Science, Engineering, and Business and Economics faculties.

DESIGN AND METHODS

First year students (Bachelor of Pharmaceutical Science, Monash University) took part in this study (common enrolment 100-130 students). A convergent parallel mixed method design was used to investigate the impact of the open-note assessments on study strategies and academic achievements. Quantitative scores from the open-note coding and examination results were combined with qualitative feedback from students' reflections and focus groups and triangulated by incorporating input from academics' interviews from a range of disciplines.

RESULTS

Quantitative results demonstrated a range of student choices for material selection and organisation. Qualitative analysis demonstrated that regular note construction leads to successful study strategies of distributed revision and to meaningful learning. Drawing on the views of educators who have implemented open-note assessments across Monash University, we established that, while methods of implementation vary between units, common trends relate to positive influence of the practice of self-constructed notes on student engagement and learning in a range of subjects.

CONCLUSIONS

Note construction promotes meaningful learning, and students' study techniques are positively influenced when expert guidance is provided.

'YOU THOUGHT YOU DID REALLY WELL?' EXAMINING THE RELATIONSHIP BETWEEN SELF-EVALUATION, ATTRIBUTIONS AND CONFIDENCE IN ANATOMY PRACTICAL EXAMS

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KEYWORDS: academic failure, causal attribution, self-efficacy

BACKGROUND
The academic demands of university can be challenging for new students, especially for those experiencing failure (Turner and Husman 2008). The self-regulated learning cycle describes the thoughts, feelings and behaviours that students use during learning (Zimmerman 2002), and provides a framework for investigating how failing students can adapt their learning to improve performance.
Specifically, the self-reflection phase includes efforts to evaluate one's performance, adapt learning strategies and attribute success or failure. This study compares the self-regulated learning traits of failing students in anatomy.

METHODS
Participants were first year physiotherapy (n=107) and occupational therapy (n=83) students studying anatomy. As part of course assessment, students completed two practical examinations and four summative meta-learning tasks. The meta-learning tasks consisted of open-ended questions designed to encourage students to reflect on their learning (Colthorpe, Sharifirad, Ainscough, Anderson and Zimbardi 2017). The answers to meta-learning questions were coded using either inductive or deductive thematic analysis to determine students': a) self-efficacy regarding anatomy practical examinations; b) degree of perceived understanding of mid-semester exam material; c) attributions about their understanding of the mid-semester exam material; and d) intention to adopt new learning strategies for the end of semester practical exam.

RESULTS
Forty-six students failed the mid-semester practical exam. Out of these 46 students, 15 passed the end of semester practical exam and 31 failed. Students who failed both practical exams were more likely to believe they had a thorough understanding of course content (74%) compared to student who passed the end of semester exam (53%). Students who failed the end of semester exam were also more likely to attribute their understanding (or lack thereof) to extrinsic (45%), uncontrollable (51.6%) factors compared to students who passed (20% and 26.7% respectively). Students who failed both practical exams were also more likely to report the intention to spend more time using the same strategies in preparation for the end of semester practical exam (23%) rather than modifying or adopting new strategies compared to the students who passed the end of semester practical exam (7%). Self-efficacy regarding performance on the practical examinations was not significantly different between the two cohorts.

CONCLUSIONS
Students aiming to improve academic performance need to take ownership of their learning by attributing success or failure to internal, controllable factors. In addition, struggling students may need to change their approach to study by exploring new learning strategies, as spending more time using existing learning strategies may not be effective. Interventions should therefore aim to encourage students to identify and explore new learning strategies.

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LABORATORY AIMS AND EXPECTATIONS – MEASURING THE GAP BETWEEN STUDENTS AND TEACHING STAFF

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KEYWORDS: Student perspective, Quantitative/Qualitative, Large scale, Staff/student comparison, International

The aims of undergraduate teaching laboratories are a contentious topic, even in 2017. It is important that we understand how both students and teaching staff perceive these aims, as any major discrepancies could potentially lead to either student dissatisfaction (and subsequent failure to learn) or continuing frustrations for teaching staff.

To investigate the student held beliefs about the purposes of teaching laboratories, alongside their expectations of the experience, a modified literature instrument[1] was utilised. The survey contained several demographic questions as well as an open question about the respondent's perception of the aims of teaching laboratories. The instrument also included 30 Likert questions that focused on the respondent's expectations and practices that either contributed to, or detracted from, the student's meaningful learning experience.

This survey was delivered to all students enrolled in chemistry at Monash University (>1600 students), the University of New South Wales (>1600 students) and the University of Warwick (>350 students). Response rates were 40-80% and the results have been fully analysed, which will be discussed during the presentation.

The survey was also modified to ascertain the perspectives of Teaching Associates (or Demonstrators) and Academic members of staff. Between all three sites, over 150 TA and over 100 Academic responses were gathered. These results have been fully analysed and show startling differences between teachers and students. These findings will also be discussed during the presentation.

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REDESIGNING THE LAB COMPONENT OF A BRIDGING CHEMISTRY UNIT

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KEYWORDS: laboratory learning, active learning, chemistry

PROBLEM

Since 2015 sweeping changes have been made to our bridging chemistry unit, with cessation of lectures being the most controversial. Classroom lectures have been replaced with a limited number of recordings, an online learning platform called 'Mastering Chemistry' (Pearson publishing) adopted, and a customised textbook developed. Weekly tutorials (1 hour) were replaced with a series of five workshops (2 hours), and structured learning activities on key concepts were developed for these. No assessment weighting for workshop participation was allocated, so the majority of students did not attend. The traditional laboratory component, consisting of five classes (3 hours), was not changed during the first two years of the revised unit format and assessment weighting (15 %) continued to be allocated to participation in labs. The majority of students attend lab classes.

PLAN

The broad plan was to remove poorly attended workshops from the timetable and merge the structured learning activities developed for them with well-attended lab classes, shifting the focus from experimental work to enhanced understanding of chemistry fundamentals. Five new learning activities for the lab classes were developed, and the timetabled sessions for each lab increased from three to four hours. Assessment weighting for the lab component (15 %) would be allocated to participation (12.5 %) and online quizzes (2.5 %) assessing the learning outcomes of each activity to be completed in the lab at the end of every session.

ACTION

The existing workshop activities, which applied some principles of POGIL (process oriented guided inquiry learning) (Moog & Spencer, 2008), were adapted to write the new lab activities. All information required is embedded in the learning activity and any resources needed, such as a periodic table or molecular model kit, are provided in the lab. The following POGIL principles2 were the main ones considered in the design:

- Learning activities are completed during class with a facilitator present
- Instruction is not lecture based, the instructor facilitates student learning
- No preparation is required or expected

A demonstrators' manual and demonstrator orientation/training sessions for each lab were also developed. The presentation will outline all aspects of the action and gaps identified.

REFLECTION

Evaluating the effect of the revised lab classes on student learning is difficult because the assessment structure of the unit was changed concurrently, with removal the mid semester test and allocation of assessment weighting to completion of online tutorials in 'Mastering Chemistry'. The impact of the lab classes will be evaluated through a survey of all students who participated in the first iteration. A targeted study involving interviews with students who were repeating the unit during the first semester of the new lab component is also planned. The authors' experience demonstrating the new lab classes was with largely engaged students who were learning the fundamental concepts and not experiencing the anxiety commonly observed in chemistry lab classes.

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ENCOURAGING STUDENTS' SELF-REGULATED LEARNING SKILLS THROUGH THE USE OF DISCUSSION BOARDS

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KEYWORDS: Self-regulated learning strategies, Discussion boards, Meta-learning

BACKGROUND
The academic success of secondary and tertiary students has been linked to how one regulates their own learning (Nota, Soresi & Zimmerman, 2004). Self-regulated students are proactive learners, using self-generated thoughts, feelings and behaviours to achieve their goals (Zimmerman, 2002).
These students direct their efforts towards acquiring knowledge and skills by obtaining, modifying and employing various learning strategies (Zimmerman, 2002), with a positive correlation between self- regulated learning and academic achievement (Nota et al., 2004). Prior intervention studies show that underperforming students can be taught self-regulated learning strategies to improve their success in education (Zimmerman, Moylan, Hudesman, White & Flugman, 2011). However, these interventions are often time and resource intensive. Technology-assisted peer learning may provide a more efficient tool to enhance students' knowledge of self-regulated learning strategies.

AIMS
This study investigated the incorporation of peer learning using online discussion boards to improve university students' self-regulated learning skills.

DESCRIPTION OF INTERVENTION
Meta-learning tasks were embedded into a first-year biomedical science course to encourage students to develop their self-regulated learning skills, and to reflect on their knowledge and academic performance (Colthorpe, Sharifirad, Ainscough, Anderson & Zimbardi, 2017). Students were allocated into small groups, and as part of their meta-learning tasks, were required to post their responses to specific questions on their respective group discussion board.

DESIGN AND METHODS
Participants in this study were first-year allied-health students (n=192) who completed four meta- learning tasks as part of course assessment. Each task consisted of five to six open-ended questions. Meta-learning responses regarding study strategy usage were analysed to determine if use of the discussion board improved students' understanding of self-regulated learning strategies. To identify the strategies that students employed, responses were coded against Nota et al. (2004) categories of self-regulated learning strategies, using deductive thematic analysis.

RESULTS
Student responses revealed that 92% of students identified and considered using a new strategy from the group discussion board. Students frequently identified planning and environmental structuring as strategies they considered using. Of these students, 23% indicated that they had adopted a new strategy from those identified on the discussion board for mid-semester exam preparation.

CONCLUSIONS
This study demonstrated the potential benefits that collaborative discussion of self-regulated learning strategies can offer to students. Exposing them to new learning strategies was effective in persuading a quarter of students to use their peers' strategies. Importantly, it gave all students the opportunity to reflect on their learning, and therefore encouraged self-regulation.

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DEVELOPING TEAMWORK SKILLS IN UNDERGRADUATE SCIENCE STUDENTS: THE ACADEMIC PERSPECTIVE AND PRACTICE

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KEYWORDS: Teamwork, undergraduate, science, employability skills, curriculum

ABSTRACT

Learning to function as an effective team member is an important skill for science graduates. A science curriculum that   supports the development of teamwork skills ensures graduates are equipped with workplace skills that are required both in research and other professional careers. In this study, we investigated the academic perspective of teaching teamwork within Australian universities. We undertook a survey of science academics investigating how the development of teamwork skills is currently practiced in the undergraduate science curriculum. Our findings suggest science academics across all disciplines are positive about the importance of developing teamwork skills in graduates. Current approaches for teamwork were varied, with the majority of respondents favouring approaches integrated into the curriculum for developing teamwork skills. There was a variable response to professional development about teaching teamwork, with some academics wishing to expand their understanding of teaching teamwork and others who cited time and other curriculum pressures as reasons for not seeking further professional development. With a greater understanding of the academic perspective of teaching teamwork, those involved with developing science undergraduate curriculum can better understand how to foster these valuable skills in science graduates.

REMOVING THE CLOAK OF INVISIBILITY: DEVELOPING SCIENTIFIC WRITING PRACTICES FOR COMMENCING SCIENCE STUDENTS

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KEYWORDS: academic writing, blended learning, communication skills, first year, scientific report

PROBLEM

First year (FY) students are expected to write scientific reports to demonstrate their understanding of the scientific method and are also assessed on their communication of the results, writing style, and adherence to scientific writing formats. Although students are taught how to conduct experiments, they are not explicitly taught scientific writing conventions and often have limited exposure to what is expected in a university report. Numerous guides on scientific writing are available but these are not tailored to FY novice writers. Not surprisingly, FY students' unpreparedness can lead to low confidence and many students continue to find scientific writing challenging.

PLAN

The ability to communicate research findings is fundamental to scientific practice. Our aim is to support FY science students in building their capacity and confidence around writing, through analysing the structure of a scientific report. We have designed online interactive modules and workshops focusing on:
1. Introducing the conventions of scientific writing,
2. Developing the students' scientific report writing practices, and
3. Building students' confidence in their scientific writing.

ACTION

Since mid-2016, we have embedded our scientific writing resources into a core FY first semester inquiry-oriented science subject. This work builds on reading strategies modules and workshop that develop students' critical reading practices (Davila & Griffiths, 2016). We use a scaffolded, blended learning approach; students complete interactive online modules prior to applying their scientific writing practices in workshops, in preparation for their report assessment task. Our learning design incorporates recommendations for flipped and active learning approaches supporting an authentic task in science education (Overton & Johnson, 2016).

We evaluated our intervention over two semesters through tracking online module completions, a paired comparison survey to gauge students' levels of confidence in their writing practices in weeks 1 and 12, and an anonymous survey evaluating students' experiences and perceived value of the learning activities.

REFLECTION

The majority of students completed the online modules in preparation for the workshop. Students commented on how useful it was to have modules dedicated to unpacking each report section and identifying the language used. Their confidence increased in several areas particularly around their understanding of the structure and correct placement of information into each section of a scientific report. They also indicated that they had a clearer understanding of the university's expectations and of the conventions of academic scientific writing. Students commented that the workshop enabled them to receive timely actionable feedback to improve their writing for the task and helped them learn to write collaboratively. Our blended learning approach to scientific writing and presenting skills in an authentic context means students see these skills as an integral part of their learning and careers.

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PERCEPTIONS OF MATHEMATICS AMONG UNDERGRADUATE BIOMEDICINE STUDENTS

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KEYWORDS: mathematics, biomedicine, relevance, attitudes, perceptions

ABSTRACT

Mathematics plays an important role in 21st century biology, but is its importance recognised by students? How do students of the biological and health sciences view the role of mathematics in these disciplines, and the relevance of mathematics in their courses? These considerations may be important as undergraduate biology and biomedicine curricula increasingly incorporate specialised biology-oriented mathematics subjects. In this paper we investigate perceptions amongst undergraduate biomedicine students of the role of mathematics in biomedical science, and the relevance of mathematics in the undergraduate biomedicine curriculum. Student attitudes were found to be generally positive regarding the role of mathematics in biomedical science and its relevance in the curriculum, and persisted throughout the degree programme. Themes arising from student survey responses included whether mathematics is relevant to all or only to some disciplines or careers, and the value of specific mathematical content versus generic skills.

PERSPECTIVES ON EQUITY IN MATHEMATICS EDUCATION AT AN AUSTRALIAN UNIVERSITY

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KEYWORDS: equity, mathematics education, university mathematics, learning support

ABSTRACT

It is widely accepted in the Australian university system that students who meet certain 'equity' criteria need special attention in the form of study and transition support. These criteria are typically drawn from a list of demographic factors including gender, home language, indigeneity, geographic location (remote or regional), sexual identity, socio-economic, first in family and disability status. There is also an increasing accumulation of evidence pointing to the learning challenges faced by Australian university students of mathematical subjects, and the extent to which this is caused by upstream imbalances in secondary school mathematical participation and achievement. This presentation attempts to bring these issues together in examining perspectives on equity in mathematics education as it applies to students at Western Sydney University (WSU), an institution that enrols above average proportions of students in many of the equity categories mentioned above.

GETTING THE FUNDAMENTALS RIGHT: CASE STUDIES IN HOW TO CONFRONT STUDENTS' MISCONCEPTIONS

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KEYWORDS: Active learning, conceptual change, student-centred learning

For 21st Century employment, graduates need to have the high-level skills of application in order to confidently apply their knowledge to unfamiliar and in many cases unprecedented future scenarios. This sort of knowledge cannot be gained by rote-memorisation or detail-led surface learning, but rather requires deep conceptual knowledge of the subject (Markauskaite & Goodyear, 2016).

However, many students bring misconceptions into their science degrees, whether from their high school courses, or from the public domain. Misconceptions can come from common lay beliefs about science, from incomplete understandings, or from intuitive but incorrect observations, but no matter how they arise, they make it difficult to reach a deeper understanding (Chinn & Brewer, 1993, Chi 2013). As educators, we want our students to develop the correct conceptual understandings that allow them to apply their knowledge to more complex problems. However, it is hard in many higher education settings to carry out intensive teaching, especially in large classes. We will present four case studies in which we have trialled methods to confront misconceptions in a range of STEM disciplines, year levels and teaching modalities: a First year psychology written assessment, Masters level computing tutorials, and large class tutorials in 2nd year Biochemistry and Molecular Biology.

Common themes that allow conceptual change in these different situations have emerged:

- Make use of social constructivism. Students can be harnessed as peer teachers as student discussion is a potent mechanism for students to realise the incompatibility of their beliefs with the concept presented in the question or task (Armstrong, 2007).
- Great expectations. Asking students to carry out application questions, or conceptually advanced tasks, is a great way to reveal to them the inadequacy of their current knowledge. While it could be expected that students would simply shut down when presented with advanced challenges, instead they often rise to the challenge, and in so doing reset their fundamental misconceptions.
- Surprise! Strongly held misconceptions can be hard to break, and students will only remember a correct concept if the inconsistency of that concept with their current erroneous belief is central to the task. This inconsistency generates surprise and 'cognitive dissonance', leading to the student replacing their misconception with the correct understanding, and hopefully remembering this into the long-term (Cottrell, Berzinski & Lodge, 2015).

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MOTIVATIVATING GREATER STUDENT ENGAGEMENT IN LEARNING

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KEYWORDS: active learning, flipped classroom, student response systems, live polling

There is widespread concern about decreased engagement in learning by university students (*1–4*). Two common symptoms of disengagement are declining lecture attendance and lack of preparation for classes. We evaluated whether changes to the assessment and mode of delivery of a third-year Science subject, *Animal Behaviour*, improved a) students' preparedness for class; b) class attendance; c) in- class participation and d) student feedback. We also assessed whether behavioural changes in students were purely strategic or reflected changed attitudes to learning or motivation. We motivated students to prepare for class by inviting them to access the course text via an online social annotation platform (Perusall). This platform enabled discussion with peers in the class about upcoming topics (intrinsic motivation), but students were also graded on the quality of their annotations and discussion, using an automated (machine learning) grading system (20% of final mark), and could be randomly selected in an upcoming class to discuss aspects of their learning. We also provided further extrinsic motivation for students to attend class by conducting live polls in class, which contributed another 20% of the overall mark for the subject over the semester. Our changes resulted in high levels of preparation for class, with students spending on average >2 hours per week on pre- reading and annotation of the prescribed text; increased attendance (>90%) in classes, and active participation in class discussion. At the time of submission of this abstract, data on student feedback, behavioural change and exam performance were not yet available, but these will also be presented.

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PHYSICAL BIOCHEMISTRY: EMBODYING THE AMINO ACIDS

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KEYWORDS: performance, creativity, conceptual change, student engagement

PROBLEM

Students learn about the structure of amino acids in 1st year Chemistry, but their understanding is often superficial and not well retained by the time they progress to Biochemistry in 2nd year. When commencing a course in Biochemistry it is challenging to re-engage students with what they often see as a "dry" topic, best addressed by rote learning.

PLAN

The plan was to surprise, amuse and engage 2nd year Biochemistry students with a performance in the first week of class where the amino acids were represented via the medium of the human form. The performance was designed to make students reconceive their prior learning about amino acids and to "breathe life" into the distorted, static, two-dimensional textbook imagery. The aim was to help students integrate multiple concepts to build a more holistic understanding of biomolecular structure, while at the same time providing a memorable conceptual framework that can be readily re-invoked later, with or without props.

ACTION

Each of the 20 amino acids was scripted in terms of physicochemical features, such as size, geometry, valance, resonance, reactivity and flexibility. The order of the performance was dictated by structural similarity and ease of the actor's transition from one amino acid to the next. A physical glossary was developed that communicated the similarities and differences between structures (e.g. "I am the side chain… my feet are on the alpha carbon" and the colour of clothing and props indicated atom types according to the Corey-Pauling-Koltun (CPK) colour scheme that is familiar to Chemistry students. Students interacted with the performance thorough real-time online polling (Polleverywhere.com) to vote on which amino acid was being presented. This gave immediate feedback to students and the instructor. Whenever there was a significant frequency of incorrect response, this prompted useful discourse e.g. "Yes, most thought this was arginine, but some indicated lysine. Look at the geometry of my hands…" etc.

REFLECTION

Classroom observers reported high student engagement and participation. Many students self-reported enthusiasm for the performance and individual students said that, for the first time they really understood amino acid structure, when before, they just didn't "get it". An unexpected and unprompted outcome was that some students approached the instructor and showed how they personally engage with their Science studies through other creative arts.

ENHANCING STUDENTS' ENGAGEMENT AND CONCEPTUAL UNDERSTANDING THROUGH ACTIVE LEARNING TUTORIALS

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KEYWORDS: biochemistry, molecular biology, misconceptions, conceptual change, student- centered

BACKGROUND

One of the risks of large class teaching is that students go through the class with uncorrected misconceptions (Finn & Achilles, 1999). Misconceptions can impede the students' learning process because they are firmly believed by students and they can be hard to rectify by traditional teaching methods (Hughes, Lyddy, & Lambe, 2013). They also affect the students' acquisition of new ideas (Kuhle, Barber, & Bristol, 2009), impairing the learning process (Chinn & Malhotra, 2002; Hughes, Lyddy, & Lambe, 2013). Active learning methods designed to break misconceptions have been shown to improve the conceptual understanding of students (e.g. Mevarech & Kramarski, 1997; Loertscher, 2009). Active learning is also one of the most important means of ensuring that activities lead to long term learning.

AIMS

This study explores the effectiveness of an active learning tutorial compared with a didactic tutorial, in enhancing students' engagement and conceptual understanding. It seeks to find out if students are more engaged and have higher conceptual understanding through the active learning or the didactic tutorials.

DESCRIPTION OF INTERVENTION

In the active learning tutorial, students discussed a piece of writing that contains misconceptions, while in the didactic tutorial the lecturer explained how to answer questions that the students were given in advance. The active learning tutorial is a combination of ideas gathered from the interview with academics and students and from selected review of literature*. It was implemented by following the metacognitive steps in Mevarech and Kramarski's (1997) IMPROVE method. The active learning tutorial utilised a lot of peer discussion.

*this paper deals with one aspect of data collected in a wider project

DESIGN AND METHODS

This study used a standard cross-over design in which students carried out one active learning tutorial and one didactic tutorial. Conceptual pre- and post-tests measured conceptual understanding while a student self-report measured students' engagement.

RESULTS

An independent samples t-test showed that the conceptual post-test scores of students in the active learning tutorial (n=79, M=2.56, SD=1.31) were significantly higher than in the didactic tutorial (n=141, M=1.72, SD=1.13), t(218)=4.94, p=.000001. The average learning gain of students even show that the active learning tutorial (20.7%) is higher than that of the didactic tutorial (5.465%). However, in the second trial, there was no significant difference in the conceptual post-test mean scores of the active learning (n=134, M=2.77, SD=1.07) and didactic (n=80, M=2.87, SD=1.04) tutorial, t(212)=-.781, p=0.218. The average learning gains of students in the active learning tutorial (26.8%) is lower than that of the didactic tutorial (48.1%). The results appear to be highly context specific.

A Mann-Whitney U-test of the student self-report indicated that the engagement of students in the active learning tutorial (n=78, Mdn=3.2) and didactic tutorial (n=141, Mdn=3.13) are comparable, U=4958, p=.113. The same was observed in the second trial, no significant difference in the engagement of students taught using the active learning (n=132, Mdn=3.2) and didactic tutorial (n=75, Mdn= 3.2),

U=4838, p=.393. However, the two independent classroom observers agreed that students are more engaged in the active learning tutorial than in the didactic tutorial.

CONCLUSIONS AND FUTURE DIRECTIONS

The first trial of the intervention was successful in enhancing students' conceptual understanding, whereas the second was not. Based on the self-report of students, the intervention was not successful in enhancing students' engagement. The comments of the two independent classroom observers, however are saying otherwise. We will trial the intervention again in the 2nd semester of 2017.

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EXPLICIT TEACHING OF SKILLS FOR FIRST YEAR BIOLOGISTS: REFLECTING ON OUR IMPACT

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KEYWORDS: graduate attributes, skills, transition, biology

PROBLEM

Students graduating from research-intensive institutions are expected to have obtained research skills as a core part of their graduate attributes. Many of these skills are also required to succeed at higher levels of tertiary education but are not explicitly taught in first year. This may be because of large cohort sizes or a lack of space in a curriculum that aims to give a broad appreciation of a discipline.

Our first experience of explicitly introducing skills into our practical program in 2012 highlighted that first year biology students, despite their previous science schooling, lacked many of the basic skills required for success in science such as forming hypotheses, designing simple experiments, data presentation and communication (O'Neill *et al.* 2012). This was of concern, not just to the first year teaching staff but to coordinators of higher year subjects.

PLAN

At The University of Melbourne, the recent merger of three departments into one large School of Biosciences provided an opportunity to review the curriculum. A recommendation of this review was to move from implicit to explicit teaching of generic skills to undergraduates. This recommendation aimed to ensure students were being adequately prepared to meet the expectations of higher years of study and the attributes of an employable biological science graduate (e.g. see Ross *et al.* 2013).

ACTION

In response to the review's recommendation and our past experience, we designed five hours per semester of explicit skill development which we have called "Skills Workshops". The five workshops included data presentation and visualisation, asking scientific questions, designing experiments, critical analysis and evaluating resources, and communication. These skills were taught using content that is linked with the lecture and practical material to help students see their relevance. In Semester 1 2017, Skills Workshops were held in a refurbished space that holds 52 students sitting in groups of up to six. A tutor led the group, but there was a strong emphasis on student activity and participation. The workshop commenced with stimulus material, usually an activity which engaged the students in the skill and with each other. This was followed by a series of discussion questions or group activities. The impact of these classes was measured through student performance in practical class assessments, a written report, targeted questions on the final exam, and responses on the student questionnaire.

REFLECTION

Although there was evidence of improvement, at the end of semester, most students still struggled with basic scientific skills such as writing hypotheses and explaining the purpose of a simple controlled experiment. As an example, an analysis of assessment tasks across the semester demonstrated that graphing skills may take a full semester and require at least two feedback cycles to be acquired. At time of submission, student questionnaires had not yet been analysed, however, anecdotal feedback suggests students missed the relevance of these classes despite our attempts to link the material to course content and assessments. Students may also bring misconceptions and/or over-estimate their skill level and it is possible that limited metacognition may hamper acquisition of skills. In semester 2 we propose to more explicitly link assessment tasks to the workshops and tighten the connection between content knowledge and the development of these skills.

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CURRICULUM TRANSFORMATION - CREATING AN ALTERNATIVE PATHWAY IN FIRST YEAR CHEMISTRY

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KEYWORDS: Hybrid Learning, Assessment Literacy, Collaborative Learning.

PROBLEM

We design our first year curriculum so that chemistry fits seamlessly into Chemistry major and non-Chemistry science degree programs, preparing the students for courses with chemistry as prerequisite as well as adding to and supporting the course learning outcomes of those degrees. Furthermore we tell students that Chemistry is generally applicable, and as an enabling science, will support whatever context they end up working in. Students know they are likely to change occupations, careers, disciplines and thus concepts and skills fundamental to all applied sciences are very valuable. However, with increasing student numbers, diversity of the cohorts and with no additional resources we have had to look at ways of transforming our curriculum to deliver for all students and those teaching it.

PLAN

Over the past 10 years we have planned to transformed the first year Chemistry curriculum to a dual stream pathway featuring hybrid learning, collaborative learning environments and development of assessment literacy. Our learning designs are based on widely accepted pedagogical principles and informed by our own extensive research-led approaches to learning and teaching practice and experience. We have used a student centred approach that is founded on knowing and understanding our students and on accommodating and supporting them in their academic pursuit, whilst making clear our expectation of intellectual effort and rigor. Our intent is to design and provide programs at appropriate levels of challenge, accounting for each student's background learning and circumstances, and that take into account cognitive, affective and behavioural dimensions.

ACTION

The transformed curriculum is the culmination of several major and minor action research cycles funded internally and externally over a decade of SOTL. The new curriculum takes into account growing student numbers, with reduced resources, but delivers:
1. Distinctiveness, coherence and clarity of purpose.
2. Addressing Equity and Diversity.
3. Influence on student learning and student engagement.

The impact of these curriculum reforms has been evidenced in many ways. But perhaps most significant is the outstanding results for students who enter without a HSc background in chemistry, but who complete this first year and then go on to be successful in the second year of their course.
- Baseline: 61% Pass (P or PS) grade or higher over the year (n = 451)
- Cycle 1: 83% Pass (P or PS) grade or higher over the year (n = 476)

This clearly demonstrates that we have generated an appropriate alternative pathway.

REFLECTION

We are greatly encouraged by increasing numbers of students committing to completion of the full three semester foundation stream, even when it is not necessary for their program. Finally, it is appreciated by us both that this significant body of work carried out over the course of some 10 years has been recognised by the University of Wollongong with the overall Vice Chancellor's Award for Outstanding Contribution to Teaching and Learning in 2017.

PATTERNS OF STUDY OF THE FIRST YEAR CHEMISTRY COHORT.

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KEYWORDS: Transition pedagogy; patterns of student behavior; first year chemistry courses

Students making the transition from high school to university are often concerned about how they will manage their time once they are free to decide for themselves whether they will attend classes that are not tagged as compulsory. Many first year students appear to struggle to adjust to the smaller number of high stakes assessment tasks compared to the regular monitored homework more often found in the high school environment. This is apparent in the pattern of lecture attendance in our first trimester, 100 level courses where the sharp drop in numbers towards the end of the first term mirrors the cycle of tests and assignments that most courses schedule half way through the trimester. Over the second half of the course, lecture attendance often stabilises, with the numbers being considerably lower than the numbers sitting the final examinations.

In order to gather information about student learning behaviour in first year chemistry we have collected data from a number of different sources. We have monitored lecture attendance, we have surveyed students about their chemistry learning activities and their perception of how these affect their learning gains, we have surveyed students about their lecture expectations, attendance and attitude, and we have looked at the data from the learning management system about student engagement with resources over time. As patterns of student behaviour emerge, we are be able to make better informed choices about the timing and nature of the assessment tasks. Student choice of learning resources, alongside survey and focus group comments provides insight into the transition from high school to university learning expectations.

Transition pedagogy principles for first year of university study (Kift, Nelson & Clarke, 2010) suggest that curriculum design should take into account students' background, needs and patterns of study. At high school, patterns of study are developed in response to the National assessment regime that dominates teaching and learning at this stage of schooling. By investigating patterns of student behaviour throughout the first year of university study, we will better understand the way they go about their learning and hence be able to design curricula to facilitate successful transition through their first year of study.

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EVALUATING THE METACOGNITIVE SKILLS OF FIRST-YEAR ALLIED HEALTH STUDENTS IN ANATOMY

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KEYWORDS: metacognitive skills, anatomy, first-year students

BACKGROUND

First year anatomy courses are challenging and often confronting for students commencing their university experience (Schutte, 2016). Students must develop learning processes appropriate to the study of anatomy. Fundamental to these processes is their metacognition and self-regulation of learning (Zimmerman, 2002). Established frameworks of self-regulation have not yet been applied to the challenging context of anatomy study.

METHODS

To investigate the learning experience and strategy use of first-year physiotherapy (n=99) and occupational therapy (n=105) students, we integrated a series of meta-learning questionnaires at key time points in their anatomy courses. Meta-learning tasks have been shown to be of value to students, as a tool to support the development of their learning behaviours and processes (Colthorpe, Sharifirad, Ainscough, Anderson & Zimbardi, 2017).

The meta-learning questionnaires initially explored the students' prior experience and intended study strategies; then the students' perceptions of their performance during the mid- semester exams, to what they attribute their success and errors, and intentions for future study. A final meta-learning task asked students to reflect on their performance during the course, the strategies they used and the effectiveness of those strategies. Using deductive and inductive thematic analysis we identified the types of strategies used, according to the framework developed by Zimmerman (2002), and the quality of those strategies, according to the model by Hattie and Donoghue (2016). To identify the most effective strategies we compared strategy use and academic performance.

FINDINGS

Students commencing their first anatomy course use a wide range of learning strategies. Meta-learning responses showed that students favoured strategies such as time- management and use of visual tools to overcome the challenges that they associated with anatomy study, including the large workload and limited access to cadaveric specimens. Importantly, it seems that students identify self-evaluative learning strategies as particularly effective, following feedback from both theory and practical assessment. By linking this data with the students' overall course performance we will be able to show which strategies are least effective and which are most effective for 1st year anatomy study.

IMPLICATIONS

Understanding the varying ways students approach anatomy study is important for educators to effectively support the development of students' learning strategies. In addition, this study will help us to identify characteristics of students at risk of poor performance. Potentially, the meta-learning tasks may serve as a valuable tool to prompt students to use more effective learning strategies for studying anatomy.

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ADDRESSING GENDER DISPARITY IN THE UNDERSTANDING OF PROJECTILE MOTION

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KEYWORDS: physics, gender gap assessment, projectile motion

BACKGROUND

A common real life experience is catching and throwing a ball or other object. However, the underlying conceptual understanding of this phenomenon is surprisingly different in male and female students. Gaps in performance on questions involving projectile motion have frequently been observed. Attempts to reduce the gender gaps by modifying the questions, for example by changing the *context* or *presentation* of the questions have generally not been successful although gaps can be reduced by replacing diagrams with words. The remaining gap is likely to be due to the *content* of the questions.

AIMS

The aim of this study is to investigate the effectiveness of a teaching intervention that has been introduced at UNSW Canberra to help students develop an understanding of projectile motion.

DESCRIPTION OF INTERVENTION

In an attempt to address the common (predominately female) misconception that the speed of a thrown ball is zero at the apex of a projectile's trajectory, students undertook a short hands-on activity. A tennis-ball launcher was used to project balls in a parabolic arc, parallel to a wide expanse of windows. Students used whiteboard markers to draw velocity vectors on the windows at five points in the motion: just after launch, halfway up, at the apex, halfway down, and just before impact on the ground. They then resolved those five vectors into horizontal and vertical components, and were asked to summarize (in words) how the ball's speed varied during the motion.

DESIGN AND METHODS

A total of 153 students completed pre-instruction, immediate post-instruction, and delayed post-instruction tests. Each of these tests included the question shown in Figure 1. The pre-instruction test was held in the first week of semester before any instruction, the immediate post-instruction test was held at the end of the tutorial with the intervention, and the delayed post-instruction test was held several weeks later. Transition matrices were constructed to analyse how students' answer choices changed between tests. Facility, gap and changes in facility by gender from pre-instruction to immediate post-instruction and delayed post-instruction tests were calculated.

RESULTS

The analysis shows that 69% of males but only 34% of females are answering this question correctly pre-instruction, giving a gap in facility of 0.35. Following instruction, and immediately after the intervention, the facilities increase dramatically. The female facility rose to 86%, and male facility to 96%, which gives a gap of 0.10. These facilities remained consistent for both genders on the delayed post-instruction test some weeks later. Hence their learning was retained.

A ball is thrown into the air, and it moves in the path shown below.
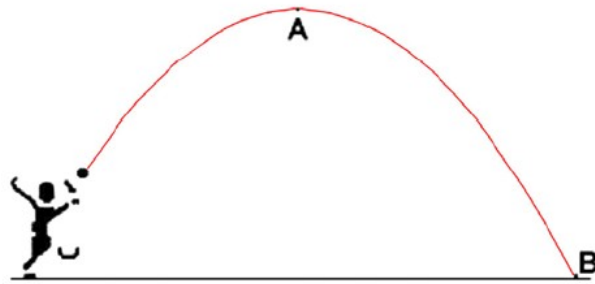
At position **A** the ball is at the highest point in its path; position **B** is just before it hits the ground. Ignoring air resistance, which one of the following statements is true?

A. The speed of the ball at **A** is zero; and the acceleration of the ball at **A** is the same as at **B**.

B. The speed of the ball at **A** is the same as the speed at **B**; and the acceleration of the ball at **A** is lower than at **B**.

C. The speed of the ball at **A** is lower than the speed at **B**; and the acceleration of the ball at **A** is higher than the acceleration at **B**.

D. The speed of the ball at **A** is lower than the speed at **B**; and the acceleration of the ball at **A** is the same as the acceleration at **B**.

E. The speed of the ball at **A** is higher than the speed at **B**; and the acceleration of the ball at **A** is the same as at **B**.

Figure 1. Projectile motion question used in tests.

CONCLUSIONS

The hands-on activity benefited both male and female students. The learning gains by the female students, who started at a very low base, were such that the gender gap in performance was reduced by more than two thirds. This learning was retained, at least over several weeks.

DO OUR STUDENTS HAVE A WEIGHT PROBLEM?

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KEYWORDS: Physics, Weight, Conceptual Understanding, Applied Knowledge

THE WEIGHT PROBLEM
The concept of weight is problematic in physics teaching, due to the lack of consensus over how 'weight' should be defined, taught, and applied. Weight can be defined either as the gravitational force acting on an object (the "gravitational" definition), or as a normal force applied to (or by) an object by (or to) a supporting surface (the "operational" definition). These two definitions are conceptually different, and give different numerical values for weight in many situations. Students enter university with a variety of understandings of weight, which may or may not agree with our own.

AIM
This study examines how our incoming first year students *define* and *apply* the term weight. Are students consistent in their answers to different types of questions? Does their consistency vary with the definition to which they subscribe?

DESIGN AND METHODS
Incoming students were given a pre-instruction test in which they were asked the following question:

Which, if any, of the following define "weight"? Circle all that apply.
1. *the gravitational force exerted on an object.*
2. *the normal-contact force exerted by a scale on an object.*
3. *the normal-contact force exerted by an object on a scale.*
4. *the normal-contact force exerted by a surface on an object.*
5. *the normal-contact force exerted by an object on a surface.*

Later on the same test, students were asked to calculate the weight of a block at rest on the ground under three scenarios: (i) with no other forces acting; (ii) with a force of unspecified origin acting vertically downwards on the block; and (iii) with a second block (of weight equal to the downwards force applied in (ii)) sitting on top. We explored which definition students *applied* in each scenario, compared to the definition they *chose* in the first question.

RESULTS
The main results are summarised in Table 1. Students who nominated a gravitational definition of weight were more consistent in applying their definition than were the students who subscribed to an operational definition. Students who accepted both definitions were more likely to apply a gravitational definition in their calculations. Also, students who chose the operational definition were more inclined to use the operational definition when a force of unknown origin acted (saying that weight changed in such a scenario), compared to when an equivalent load was applied.

Table 1. Results of pre-instruction test (*n* = 189): how students both define and calculate 'weight' in the presence of additional forces. The columns headed "Bad" indicate the number of students whose calculation of weight was erroneous (neither gravitational nor operational).

Scenario:	Applied Force			Added Load		
Definition applied → **Definition chosen (#) ↓**	*Gravitational (119)*	*Operational (49)*	*Bad (21)*	*Gravitational (134)*	*Operational (40)*	*Bad (15)*
Gravitational (84)	58	14	12	62	17	5
Mixed (45)	29	14	2	31	10	4
Operational (60)	32	21	7	41	13	6

CONCLUSIONS
Students enter university with an existing set of ideas and concepts, not all of which are consistent. Weight is one such problematic concept. Even in apparently trivial questions, this can lead to difficulties for students.

As educators we need to be aware of this, and ensure that we know what existing concepts are students arrive with, and ensure that they reach a consistent understanding.

TRANSFORMATION OF RECORDS USAGE IN HIGHER EDUCATION

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KEYWORDS: Self-regulated learning, organising and transforming, meta-learning

BACKGROUND

Learning has been conceptualised as the integration of new information into previously acquired knowledge that is stored and organised in long term memory (Kalyuga, Ayres, Chandler & Sweller, 2003). Given the complexity of information students must assimilate in biomedical sciences, and the high expectations of tertiary education, students must rapidly develop skills in managing their own learning. This is referred to as self-regulated learning (Zimmerman, 2000). While all students are capable of self-regulating their learning, the quality and quantity of strategies used differs between learners. One of the key self-regulatory processes that students undertake to enhance their learning is the transformation of information into different forms, referred to as 'transformation of records'. Organising and transforming refers to the overt or covert rearrangement of learning material that is self-initiated by a student in efforts to improve learning (Zimmerman, 2000). This study investigated the extent, purpose, type and quality of transformation of records that students performed.

DESIGN AND METHODS

The participants of this study were second year students in the Bachelor of Physiotherapy (n=128), and Bachelor of Speech Pathology (n=105) programs studying physiology. As part of the course, students completed meta-learning assessment tasks to prompt the self-regulation of learning (Colthorpe, Sharifirad, Ainscough, Anderson & Zimbardi, 2017). Responses to the meta-learning questions "*What learning strategies have you employed in the past?*" and "*When and how do you utilise study tools?*" were coded using inductive and deductive thematic analysis to determine frequency of strategy use across the cohort. These results will be triangulated using semi-structured interviews and examples of transformed records submitted by students.

RESULTS

Students (n=189) reported a variety of strategies, including summarising, rewriting notes, making concept maps, utilising flash cards, drawing diagrams, listening to lecture recordings, seeking social assistance, rehearsing and memorising, environmental structuring and watching YouTube videos. The most frequently reported strategy was the transformation of records which encompassed diagrams, concept maps, flash cards and any form of summaries or rewritten notes. The second most frequently reported strategy was reviewing notes, followed by environmental structuring. When prompted further, more than half of the students reported creating more than one type of transformation.

CONCLUSION

The majority of our students transformed records, and did so in a variety of ways. While students are free to choose their own strategies and study tools that suit them best, it appears that students who actively undertake transformations are more cognitively engaged in the learning process, which may be correlated to a higher academic success (Fredricks, Blumenfeld & Paris, 2004). The different types of transformations may have different levels of effectiveness in learning, and methods to evaluate the quality of transformations needs to be developed.

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PATHWAYS TO CREATING INCLUSIVE LEARNING ENVIRONMENTS THROUGH ADAPTATION OF MULTIMODAL EXTERNAL REPRESENTATIONS USED IN CHEMISTRY LECTURES

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KEYWORDS: Multiple external representations, chemistry concept construction, visual resources

BACKGROUND

In recent years, inclusive learning and teaching strategies have promoted pedagogies and practices that widen participation in learning. To enable this approach, potential barriers to learning must first be identified and addressed through the provision of multiple ways for students to access their learning. A critical process in learning chemistry is the development of internal mental models of concepts, hence instructors adopt multiple external representations (MERs) in their teaching to support students construct their understanding. Instructors often intentionally combine MERs to provide complementary information, however more strategic scaffolding can be achieved when MERs are deliberately combined to promote construction of understanding. In this study, the existing lecture content for a first year chemistry course has been analysed to categorise each representation and its role in terms of supporting student learning of chemistry concepts. The aim was to identify the critical combination of representation(s) that build deeper understanding and then to convert these representations into alternative modes, thereby widening participation for blind and visually impaired students in particular.

METHODS

Every representation used in each lecture slide, across a single first semester, general chemistry course, has been categorised according to three separate, but complementary, frameworks: (i) Johnstone's (2000) domains of thinking in chemistry (macroscopic, submicroscopic and symbolic); (ii) Gilbert's (2005) modes of external representations in science and (iii) Ainsworth's (2006) designs, functions and tasks (DeFT) framework for learning with multiple representations. The relationships between these categorical data have been statistically analysed to construct a dendrogram, this has revealed five clusters of related topics and provided insight into the critical combinations of representations that may enable construction of understanding. Preliminary analysis of the associated lecture recordings for three parallel lecture sections has also enabled identification of how different lecturers adopted these representations into their teaching practice, including additional verbal, gestural or concrete modes.

PRELIMINARY FINDINGS

Through the correlation between combinations of external representations and topics that construct understanding, alternative representations that can be accessed by visually impaired students have been identified. Providing access to these resources for all students represents an increase in access to development of 3-dimensional mental models, the effectiveness of these resources (including tactile models) are currently being explored further.

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CAN SPREADSHEETS BE USED TO ENGAGE STUDENTS WITH OPEN INVESTIGATIONS IN SCHOOL SCIENCE?

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KEYWORDS: open inquiry, investigations, spreadsheet, student engagement

While investigations in science can often be used to engage students with open inquiry, constructing an investigation that does so is not trivial. This is particularly so in the topic of electricity which is concept laden and formulaic. We designed an investigation on electrical power with a catchy title, 'Vampire Power', requiring not just some understanding of electricity, but also mathematical skills. We utilized Excel spreadsheet making it more challenging for students. We ran this investigation in NSW and the Northern Territory with Primary school students, Year 5 to Senior Secondary students, Year 12. Here, we examine if the inclusion of Excel was successful in engaging students with open inquiry. The specific questions are:
- How did the students engage?
- What were the student experiences of the investigation?
- What were teacher perceptions of the investigation?

METHOD
The investigation was developed as an open inquiry investigation according to the 'Australian Curriculum: Science'. The students were provided with devices, ranging from microwaves to laptops and requested to design and carry out an open inquiry regarding the amount of power consumed. First they were asked to select a device, take a measurement and enter it into a pre-constructed spreadsheet. The students were then asked to design and carry out their own open investigation inquiry regarding power consumption.

DATA COLLECTION
The data collected consisted of (a) field notes, (b) spreadsheets generated by students and (c) surveys. Data were collected from 35 teachers and 118 students were involved at different workshops in Sydney, Borroloola and Katherine. These studies were conducted in workshops as part of the 'ASELL Schools' program.

RESULTS
Students engaged with the spreadsheet, understanding trends in numbers and cost of electricity. Survey data indicates good engagement and the students were interested. Teachers indicated that the investigation was at the appropriate level, indicating they would implement it in their classes.

CONCLUSION
We conclude that, in this case, investigating a concept laden topic was aided by incorporating a spreadsheet together with maintaining the 'openness' of the investigation

THE ASELL SCHOOLS NATIONAL PROJECT: PROFESSIONAL DEVELOPMENT WORKSHOPS FOR HIGH SCHOOL TEACHERS. OUTLINING THE BACKGROUND OF THE PROJECT AND INTRODUCING SOME OF THE PEDAGOGICAL TOOLS OF THE TRADE

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KEYWORDS: Inquiry based learning, practical work, professional learning

While the notion of inquiry in the field of science education has been implicit for a millennia or more, it was in the 1960's that inquiry took shape in a form suitable to be incorporated into curriculum documentation. In considering "some of the materials and methods by which the curriculum can serve the needs of teaching science as inquiry", Schwab wrote:

> "The laboratory is easily converted to inquiry ... The laboratory ceases to be a place where statements already learned are merely illustrated and where perception of phenomena occurs within the restrictive structuring of terms and concepts already laid down. It ceases, too, to be preoccupied with standardized techniques. It becomes, instead, a place where nature is seen more nearly in the raw and where things seen are used as occasions for the invention and the conduct of programs of inquiry. The laboratory manual which tells the student what to do and what to expect is replaced by more permissive and open material." page 187 Schwab (1960).

However, simple as it may sound, shifting the stance towards more inquiry in the laboratory required a novel perspective on how students made sense of science in view of their interpretation of the world in the everyday sense. Their understanding of the world was valid, and had to be acknowledged in the teaching of science (Driver 1978). Instead of mistakes and misunderstandings to be corrected; students' alternative frameworks and conceptual models were to be maneuvered; student understandings guided to those more congruent with science understandings. The collection of papers by prominent scholars titled, "Children's ideas of Science" (1985), captures how this can be achieved in a laboratory or in an environment using hands-on activities or equipment.

ASELL Schools is an AMSPP funded project that implements professional development for school teachers, with the majority of the workshops focused on Yr7-10 high schools teachers. The workshops run a unique format that includes teachers working with students while doing investigations, and separate pedagogical sessions for the teachers. The key pedagogical tool provided to teachers is the 'Inquiry Slider'. This tool is designed to allow teachers to easily identify the essential features of inquiry, what level of inquiry they are currently employing in their own investigations, and how they might increase the level of inquiry. This presentation will give a brief outline of how the ASELL Project was shaped and present data that has been collected on the effectiveness of the workshops and the inquiry slider.

INVESTIGATING STUDENTS' EXPERIENCES OF UNDERGRADUATE SCIENCE EXPERIMENTS ACROSS 5 DISCIPLINES: ARE STUDENT EXPERIENCES REALLY THAT DIFFERENT?

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KEYWORDS: undergraduate science education, practical work, evaluating laboratory learning

BACKGROUND

Over a 15 year period, Advancing Science and Engineering through Laboratory Learning (ASELL) has contributed to this endeavour by investigating student perceptions of undertaking individual experiments. In 2015, a paper published in IJSE by the ASELL team presented the findings of a survey capturing 3153 students' perception of chemistry experiments. The survey had fourteen questions asking students to respond to a Likert scale with the options *Strongly Disagree, Disagree, Neutral, Agree, and Strongly Agree.* The survey also included five open- response items to probe the best and worst experiments students experience during the semester, as well as suggestions students have for improvement of the laboratory program.

The development process for constructing this survey is described in detail previously (Barrie et al, 2015). Using exploratory factor analysis, three factors were extracted: motivators, resources and assessment.

THIS PRESENTATION

This presentation outlines a follow up survey which aimed to investigate if the factors persist across different disciplines. The same survey was administered to 2691 students in 5 different disciplines: biochemistry, biology, chemistry, physics, and pharmacology. We find that the factor, 'motivators' is maintained while 'assessment' and 'resources' combine into a single factor. We propose 'experiment-based motivators' and 'course-level resources' as better suited names for these two factors. The results were remarkably similar across the different disciplines. In this presentation we will discuss in detail the factor analysis methods that were used in the analysis and the implications of the results for teaching and learning.

SUPPORTING DECISION MAKING IN LABORATORY CLASSES.

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KEYWORDS: Decision-making, chemistry, laboratory

BACKGROUND

Knowing that there are a number of ways to do something can unnerve students. As we all do, students will have devised techniques to make their lives easier. Many will have ways of making sure they get the best answer. Others will focus on obtaining an answer that just gives them an OK mark. Very few students have developed ways of considering multiple possibilities and working out which might be the best option to take forward. However, the skills at play in decision-making such as initiative, critical thinking, thinking on their feet, and being flexible, are all key criteria for a student making a successful transition into the workforce (Deloitte Access Economic, 2014; Sahkar et al, 2016). As such, we should be supporting students in learning about and experiencing decision-making.

LABORATORY ACTIVITIES

Two examples of how we attempted to manage this experience within our Materials Chemistry laboratory class will be discussed. One example uses the synthesis of newly commercialised metal organic frameworks, a candidate for hydrogen fuel storage and a new generation of filtration technologies. The second gives students an opportunity to use scant literature sources to write a method to make a magnetically active pigment and an analogous material. After the laboratory class the students were asked "whether the lab experience was open enough to allow me to make decisions?" They were also asked, "if they made a significant number of decisions during this lab, what effect did that have on your lab experience?"

The prompt to develop this approach came when trailing the laboratory activities and observing students having difficult starting activities that were more open than they were used to. Students preferred to start with the part of the activity that they were more familiar with (generating a calibration curve), even though this in itself is often a very unpopular task.

ISSUES TO CONSIDER

If activities are structured to both support students (i.e. not too many decisions at once) and provide information for them to use in the decision-making before class the students will be more successful in their decision-making. Decision-making is also very difficult while processing a lot of content so the design of activities should take account of cognitive load on the students.

Students can be supported in speedy decision-making by designing activities in which it is "safe" to "fail" and the "failure" can be rectified, or at least reflected on and understood. Students will often see these as failures initially, but once they meet the challenge of reflecting, re-planning and achieving success, they are more able to see it as a learning experience.

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TRENDS IN LEVEL 1 CHEMISTRY STUDENTS' LABORATORY ANXIETY AND SELF-EFFICACY

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KEYWORDS: Undergraduate Laboratories, Chemistry Anxiety, Science Self-Efficacy

BACKGROUND

At the University of Western Australia there are three chemistry units offered at level 1. Of these, two (CHEM1001 and CHEM1002) are offered to students who have completed year 12 chemistry. The third unit is for students who have not completed year 12 chemistry (CHEM1003). In semester 1 of 2017 data was collected to probe current anxiety levels. It is known that anxiety and self-efficacy are correlated [1], therefore, students were also asked about their confidence in their laboratory skills.

AIMS

The primary aim of this research is to provide a snapshot of the current levels of chemistry laboratory anxiety and self-efficacy of level 1 chemistry students. Additional aims include:

- Confirming the correlation between anxiety and self-efficacy
- Identifying and commenting on the differences between students with different chemistry backgrounds
- Analyzing trends in the factors which contribute to chemistry laboratory anxiety

DESIGN AND METHODS

A voluntary, online survey was distributed to the students at the beginning (Week 4) and end (Week 12) of the first semester of 2017 (with n = 271, 33% of the cohort and n = 195, 24% of the cohort respectively). This corresponds to the weeks that students had their first and last labs of the semester. The survey was based on Bowen's 1999 Chemistry Laboratory Anxiety Index (CLAI) (Bowen, 1999), which had been widely used in the existing literature (Galloway, & Bretz, 2015; Kurbanoglu & Akim, 2010).

Modifications were made to the survey to probe the impact of additional factors (demonstrators, interpreting data and being assessed). Furthermore, for each factor relating to anxiety students were asked about their self-efficacy. Results were collected on the website Qualtrics and data analysis was completed in excel using linear regression to analyze the correlation between anxiety and self-efficacy across contributing factors.

RESULTS

As expected, areas in which anxiety was high self-efficacy was low. There were similarities between CHEM1001 and CHEM1002, where: social factors were the lowest in anxiety and highest in self- efficacy, practical skills were ranked in the middle and tasks relating to cognitive load were higher in anxiety and lower in self-efficacy. The absolute highest-ranking factor for anxiety was time and being able to complete the work in the time given was ranked lowest in self-efficacy. Both cognitive load and the time needed to complete the laboratories are related to students' experience and mastery.
For students in CHEM1003 time was less of an issue and the areas students had the highest anxiety and lowest self-efficacy in were interpreting data and being assessed which, given that they also had lower self-efficacy in these areas, may be due to a lack of experience in chemistry.

Comparing the data from the beginning and end of semester showed that generally anxiety decreased, the strength of the relationship between anxiety and self-efficacy also weakened. This could be due to a shift in priorities at the end of the semester, in which results may become more pressing and the perceived impact on students' grades may be a greater cause of their anxiety than just lower self-efficacy.

CONCLUSIONS

Given the relationship between anxiety and self-efficacy, interventions to reduce chemistry laboratory anxiety should aim to increase self-efficacy. Additionally, knowing which factors contribute most to students' anxiety can also inform the design of curriculum for efficient laboratory learning.

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USING IPADS IN A FIRST YEAR CHEMISTRY LABORATORY TO ENHANCE STUDENT LEARNING.

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KEYWORDS: iPad, Undergraduate Chemistry Laboraotries

Our first year chemistry laboratories use iPads as the interface with our data loggers. As we have increased the number of iPads available in the laboratory we have looked for ways to use them to enhance the learning experience of students in this part of their course.
In many NZ High Schools, digital learning devices are used extensively in all disciplines. In our University courses, we expect students to access course materials and complete on-line quizzes through our learning management system, and we make some use of digital devices through a student response system in lectures. However, there has only been limited uptake of digital technology in the laboratories.

Initially, specific experiments were selected for modification for the iPads. However, a fundamental change to the paperless delivery of the laboratory materials was identified as a first step in shifting the culture of the laboratory programme to embrace digital technology. To this end, the traditional printed laboratory manual was not provided, instead students could access the laboratory notes and instructions, safety data, report sheets on-line prior to each experiment. In the laboratory, iPads were used for instructions, access to data and safety notes. These were easy to make available on all the iPads using DropBox. Throughout the course there was flexibility to add other applications and resources to meet student needs. For example, when students were struggling to remember how to balance a redox equation or even to write formulae, they had easy access to the notes to remind them of the procedures. Two experiments were modified to include simulations and animations to help students make better connections between the theoretical and practical aspects of the course.
For first year students, this was their first experience of university chemistry laboratories. Some of them were unfamiliar with iPad technology most of them were working entirely form the iPads by the end of the course. Some students brought printed notes to their laboratory classes, mostly so that they could annotate them before they came. Students are, at this stage still required to keep a written record of their laboratory results but their laboratory reports are mostly submitted on-line. This has vastly improved the efficiency of the administration of the laboratory marking, although some of the markers took time to adjust to on-line marking.

Student and staff feedback will help determine the future direction of this project

TRANSITION INTO TERTIARY STEM STUDY – DEVELOPING STRATEGIES TO ENGAGE INDIGENOUS STUDENTS

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KEYWORDS: Community of practice, Indigenous students, Transition to Tertiary study, enabling study

AIMS

This contribution seeks to establish interest in developing a community of practice to support collaboration and further sharing of good practice between universities who are developing, implementing and refining their approaches to increasing the participation of Indigenous students in tertiary sciences, technology, engineering and mathematics, STEM, courses.

SOURCES OF EVIDENCE

Indigenous students are underrepresented in tertiary education and this is particularly acute in STEM education (Behrendt, 2012 and references cited therein). Many factors influence current differences between the tertiary STEM participation rates of Indigenous and non-Indigenous students. Many strategies also are being employed and recommended in efforts to diminish these differences (Milroy, 2013; Paige, Hattam, Rigney, Osborne & Morrison, 2015).

Some strategies aim for sustained impact by focusing on encouraging students to retain their interest in STEM study throughout secondary schooling, and fostering their success. There remains however a lack of parity in STEM preparation of Indigenous and non-Indigenous student cohorts as they complete secondary schooling. This means that strategies at tertiary as well as secondary levels are required to meet the commitments made by the universities in the Universities Australia Indigenous Strategy 2017-2020 (Universities Australia, 2017).

MAIN ARGUMENT

Alternative entry pathways, including enabling courses, form one component of this landscape. Enabling courses commonly provide students with a semester or a year of study, located between secondary and tertiary education, and may also be available to non-school-leavers who are seeking an alternative pathway into tertiary study.

The enabling course approach has been adapted at the University of Melbourne to provide entry to its Bachelor of Science through a four-year extended degree in which students complete all of the requirements of the BSc, and can access all of its graduate outcomes. The Extended degree includes transition subjects whose proportion tapers across the first three semesters. These transition subjects offer discipline-specific and broader academic skills.

Development of this degree has been shaped by the institutional context and previous experience in developing a Bachelor of Arts (Extended). It is also being informed by the practices of other institutions and the growing literature on effective strategies for Indigenous education in Australia and elsewhere. However, development of the Bachelor of Science (Extended) would have benefitted from opportunities to learn more from others who had implemented, or were about to embark on interventions with similar objectives. A community of practice approach would have aided the team's consideration of the balance between discipline-specific, interdisciplinary and generic knowledge and skills for this cohort; how to engage effectively with Indigenous communities to support curriculum development and student experience; how to effectively integrate understanding and valuing of Indigenous perspectives in the curriculum.

CONCLUSIONS

Universities across Australia are committed to increasing the participation and success of Indigenous students in STEM study. While there is a growing literature documenting the initiatives being implemented

and individual conferences, academic and professional staff responsible for these initiatives would benefit from a community of practice to support an evidence-based approach to the many considerations that impinge on success in achieving these goals.

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ACADEMIC ATTITUDES TO SERVICE TEACHING

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KEYWORDS: Service teaching; academic attitudes

The nature of academic work is changing rapidly. The expansion in the number of profession specific courses and a decline in enrolments in traditional generic courses such as Arts and Science. Student staff ratios have increased and academics are expected to devote more time to teaching, especially if they are not meeting research metrics around publishing and funding. Service teaching, teaching basic science to non-science students such as nursing students, is increasingly important to maintain science academic positions.

Many published research papers report that nursing students are dissatisfied with the science courses in their degree, often describing them as content heavy, frightening and neither enjoyable nor valuable. However, at CQU, we have found that nursing students are highly satisfied with their science courses (Clifton and McKillup, 2016). We suspected that many science staff involved in service teaching might not value it and even regard it as a tedious chore, and this may be contributing to students' perceptions and experiences. We have surveyed academics from 13 universities to investigate whether this attitude is widespread throughout the discipline.

We received responses from 126 academics. Most belonged to departments or schools that conduct service teaching, but only approximately half personally undertook service teaching. 60% of respondents were male but only 42% of male respondents do service teaching. From our survey, academics consider that it is more difficult to teach science to students who are not science majors ($t = 7.23$; $p < 0.00001$) but that such service teaching is less well regarded for promotion ($t = 2.70$; $p < 0.01$).

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WHO ARE WE? THE IDENTITY OF STEM EDUCATORS

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KEYWORDS: Concerns, identity, STEM, teaching

BACKGROUND

High attrition rates of up to 50 % (in the United States) in the initial years of a teaching career lead to a high level of disillusionment in teaching as a desirable and rewarding profession (Hayes, 2014; Jacques, Behrstock-Sherratt Parker, & Bassett, 2017). This situation is not new, and nations commit billions of dollars to dissuade newly qualified teachers from leaving the profession. Despite changes to initial teacher education programs, there have been few inroads into the problem and so attrition rates remain high. An important factor in becoming a member of a profession is the development of a sense of identity to both a particular group of people and a set of established practices (Trede & McEwen, 2012). This presentation paper examines the developing science STEM identity of pre-service teachers in both primary and secondary initial education programs at Curtin University, Australia. It considers how the developing professional identity of pre-service teachers (PSTs) maps with their concerns upon entering the teaching profession (Hall & Hord, 1987), and it makes recommendations for reform.

AIMS

This research sought to answer the following questions:
1) How do pre-service teachers in primary and secondary initial teacher education courses envision themselves as science and mathematics educators?
2) What are the concerns of these pre-service teachers as they progress along their journey to becoming science and mathematics educators?
3) What are the characteristics of effective science and mathematics teachers that pre-service teachers identify, and how do these characteristics compare with the characteristics identified by experienced science educators?

DESIGN AND METHODS

Research has indicated a link between students' free-hand drawings of their possible selves and the development of their professional identities as educators (eg Beltman, Glass, & Dinham (2015); Bennett, 2013; Garnesh, 2011; Mitchell, Theron, Stuart, Smith, & Campbell, 2011). One hundred and sixty three undergraduate (primary and secondary) and graduate PSTs were asked to draw themselves as a STEM (science or mathematics) teacher, to describe their future selves, to list three attributes of effective teachers, and to describe their major concerns as pre-service teachers on the threshold of becoming teachers.

RESULTS

All students were asked what three attributes described effective teachers of science/mathematics. Their responses were coded into the following categories and tallied and cross checked by colleagues. At this stage the neither the majority of the PST's in secondary (the graduate diploma PSTs) and the primary PSTs had not yet been on a practicum so could be compared at the same rate. It should be pointed out, however, that the secondary cohort (grad dip students) were at the beginning of only a 12 months teaching course and therefore would be in classroom in 12 months. The primary cohort still had a further two and a half years before they would be qualified as teachers. When comparing the attributes the primary cohort rated confidence and enthusiasm much lower that the secondary cohort. Knowledge rating 18% for the secondary cohort and only 8% for the primary and passion and enthusiasm rated 19% for the secondary cohort but only 10% for the primary group. Both groups rated communication equally at 6% primary and 7% secondary. Most of the difference occurred in interpersonal skills or soft skills where the primary cohort expressed these as important attributes 35% of the time whilst the secondary cohort nominated these soft skills only 18%. The primary cohort indicated that patience was the attribute most commonly names as well as caring, considerate and confidence.

When examining their concerns initial findings determined that both cohorts shred many of the same concerns in relatively similar proportions. For example self-concerns, including individual concerns (for example 'burning out' or 'losing my passion' and teaching concerns (for example 'coping with workload' and

'time management') were stated as a concern for 49% of secondary preservice teachers' responses to 52% of the responses by primary preservice teachers. This trend continued with concerns around behavior management; 26 % of secondary preservice teachers' responses to 21 % of the responses by primary preservice teachers, and impact concerns at 13% of secondary preservice teachers' responses to 12 % of the responses by primary preservice teachers.

CONCLUSIONS

Although the diverse group of PSTs included both undergraduate and graduate students, many of the characteristics and concerns expressed were similar across the participant group. Pre-service teachers felt that effective educators were passionate, patient, knowledgeable and confident, and they used the descriptors approachable, fun and engaging when describing themselves in their own classroom. Pre-service teachers from all cohorts expressed a range of concerns including personal concerns (for example, will I get a job?) to concerns about managing the behavior of students and interacting effectively with their colleagues parents.

It was determined that as both groups of students had not yet been out on a practicum and therefore had little to no classroom experience that this may explain the similarities in both around concerns. Further research will examine the concerns of the secondary cohort to determine whether these had changed after their classroom practice.

In conclusion the majority of PSTs also saw themselves in a teaching or a teacher leadership role in 10 years after graduating, suggesting that they planned a mid- or long-term career engagement in teaching. These findings led us to ask what prevents this from occurring in so many cases

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THE IMPACT OF GENDER ON THE CAREER PLANS OF UNDERGRADUATE CHEMISTRY STUDENTS IN AUSTRALIA, NEW ZEALAND AND THE UK

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KEYWORDS: Gender, Career plans, learning experiences

BACKGROUND
One of the primary roles of higher education institutions is to provide quality education to students that have been enrolled in such institutions. Several factors believed to affect student learning outcomes in STEM-based courses one of them being gender. The present study attempted to identify the influence of gender on career plans of undergraduate chemistry students between universities in Australia, New Zealand and the UK. Having a knowledge of gender and career variations between institutions in different countries may help educators develop interventions that can enhance provision of program quality.

AIMS
The aim of this study was to investigate how gender and career plans of undergraduate chemistry students varied within and between universities in three different countries namely Australia, New Zealand and the UK.

DESIGN AND METHODS
The study took part in the form of a cross-sectional study. Data was collected in 2016 via a questionnaire survey that targeted year 1 chemistry students in Australia, New Zealand and the UK. The questionnaire was made up of three sections,- career plans, reasons for choosing to study chemistry, and career planning help sections. Before the actual data collection the scale was tested and validated. Data was collected from over 1300 undergraduate chemistry students then then analyzed using SPSS data analysis software.

RESULTS
The results obtained showed that gender made statistically significant differences to undergraduate chemistry students' career plans. The results also showed that country of origin had an effect on career plans of male and female students. Female students in the UK University were planning a career in chemistry to a significantly greater extent than female students in the Australia University. Within the institutions, it was found that gender made statistically significant differences on career plans of male and female students.

CONCLUSIONS
One of the main findings is that career plans of undergraduate chemistry students vary by gender and also by country of origin. The differences in career plans of undergraduate students between Australia, New Zealand and the UK indicate that the students in the institutions in these countries have different learning experiences due to different educational systems.

WE BUILT IT, WHERE ARE THEY?

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KEYWORDS: mathematics support, statistics, support modes

BACKGROUND

Western Sydney University (WSU) is a large multi-campus university covering Western Sydney. The region includes approximately 9% of Australia's population and 44% of the population of Sydney (Western Sydney Profile, 2015). WSU has high proportions of low socio-economic and first in family students, together with many with non-English speaking backgrounds. About 50% of those taking a first-year mathematics or statistics subject in 2015 had no senior high school mathematics prior to attending university.

The Mathematics Education Support Hub (MESH) at WSU is a central unit tasked with supporting students in their mathematics and statistics at all levels and providing curricular support to the schools within WSU.

AIMS

This study aims to evaluate the effectiveness of, and engagement with, the two main forms of face-to-face mathematics and statistics support and the interactions between these forms of student support.

DESCRIPTION OF INTERVENTION

Because of the multi-campus nature of WSU there is no MESH drop-in centre. Instead, MESH staff are available in six campus libraries at advertised times to help with mathematics, statistics and numeracy problems from any course of undergraduate study. This service is known as Library Roving. In addition, the MESH team offer topic specific workshops in most first year mathematics and statistics subjects on a just in time basis before major assessments in these subjects. These workshops are designed to help students understand the concepts being taught in the subject and are not focused on assessment questions.

DESIGN AND METHODS

Student identifiers for those attending workshops or Library Roving are collected. We also have access to results and demographics of students attempting the subjects supported by MESH workshops. Our analysis has involved comparing results for students making use of both forms of support, their levels of engagement with the support, and key demographic characteristics.

RESULTS

Overall we have found that there is a positive correlation between student results and the level of engagement with student support workshops. Engagement with Library Roving provides a further boost of approximately 3 marks on average to students' final marks in their mathematics or statistics subjects independently of their engagement with workshops. While a significant proportion of students who utilise MESH support services make use of both forms of support, there are also significant numbers of students who use only workshops or only Library Roving. Overall, approximately 30% of students studying a mathematics or statistics subject make use of the available support facilities.

CONCLUSIONS

Despite evidence that students utilising MESH support perform better than those who don't, the proportion of students making use of the service is very low.
It is not surprising that there are large numbers of students using only Library Roving as this service provides assistance to all undergraduate students, not just those studying mathematics and statistics. There are, however, a significant number of students within these subjects who choose to use only one of the two forms of support, suggesting that the different forms of support may appeal to students with different learning preferences.

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DEVELOPMENT OF AN INSTRUMENT TO INVESTIGATE AFFECTIVE FACTORS IMPACTING STUDENTS' MATHEMATICS SUCCESS IN AN ENABLING PROGRAM

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KEYWORDS: affective factors, academic numeracy, enabling program

BACKGROUND

Academic numeracy is essential in various disciplines at the university. However, many students lack the necessary mathematical skills required in their undergraduate studies (Kent & Noss, 2001; Tariq, 2008). The implementation of government policies to widen the participation of young adults in tertiary education has resulted in the intake of a diverse cohort of students, which in turn affected the level of mathematics preparedness for university education (Dalby, Robinson, Abdulla, Galligan, Frederiks, Pigozzo & Wandel 2013). While it is known that cognitive ability influences students' achievement in mathematics, many research findings have shown that affective factors, such as attitudes toward learning, initiative to access support for learning, learning strategies, anxiety and motivation influence success in learning mathematics (Bol, Campbell, Perez, & Yen, 2016; Guy, Cornick, & Beckford, 2015).

To ensure students in an enabling program at UniSA College are adequately prepared for their undergraduate studies in the university, it is crucial to develop the students' academic numeracy effectively. This requires the consideration of the role and impact of affective domain on learning mathematics.

AIMS

The aims of this paper are to discuss the development and reliability of a questionnaire, and a pilot test to measure the effect of affective factors on enabling students' mathematics success.

DESIGN AND METHODS

We began by conducting a systematic review of literature encompassing the use of questionnaires in assessing affective factors affecting students' learning success. This review led to the development of 5-point Likert scale items based on seven factors: self-efficacy, active learning strategies, perceived usefulness of mathematics, learning environment, achievement oriented goals, enjoyment of mathematics and mathematics anxiety. To create a more robust instrument, the items were adapted and modified from standardized questionnaires developed by Tuan, Chin and Shieh (2005) and Lim and Chapman (2012, 2013). The developed instrument was reviewed by two academics in mathematics to assess its face validity and refined following the comments by these experts leaving 51 items. A pilot test ($n = 31$) was then conducted to preliminarily assess the suitability of the items for the participants, particularly students enrolled in the UniSA College. Data from the pilot test were used to determine the reliability of the instrument.

RESULTS

Thirty one participants completed the questionnaire voluntarily. Among them, 68% were female and 29% were male participants aged 18 to 57 years In terms of their mathematics preparedness level, a majority (76%) of the participants only completed Year 11 and below.

The results from the pilot test indicated that the internal consistencies of the seven factors, estimated by the Cronbach alpha reliability coefficients ranged between 0.71 and 0.93, which met the minimum reliability threshold of 0.70 set by Nunnally (1967).

CONCLUSIONS

Results show that the instrument has satisfactory validity and reliability suggesting a promising and appropriate instrument to be used on the enabling program students in a full survey. The result also indicates a large proportion of the participants' level of mathematics are below Year 12, revealing the

necessity to elevate their academic numeracy in preparation for their undergraduate studies in the university.

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SUPPORTING STUDENTS WITH DISABILITIES IN OUR UNDERGRADUATE CLASSES

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KEYWORDS: Disabilities, mental health, laboratory classes, studio learning environments.

AIM
I will discuss the strategies we have implemented in the School of Physics & Astronomy to foster an inclusive environment for students with physical or mental health conditions, in the context of the laboratory classes and studio-style teaching approaches we use in our School.

SOURCES OF EVIDENCE
As society becomes more inclusive of people who have physical or mental health conditions, we are seeing an increase in people with such conditions pursuing studies in higher education. In the Faculty of Science at Monash University, the number of students registered with Disabilities Services has increased by 50% over seven years (with 100 students in 2007, and 150 students in 2014), while the number of all students enrolled in the Faculty has increased by only 30%.

MAIN ARGUMENT
Laboratory classes and studio-style teaching approaches introduce additional challenges for students with physical or mental health conditions compared to traditional didactic lecture environments.
Although teaching staff are typically prepared for increasing class sizes in general, catering for the necessarily individual requirements of an increasing number of students with disabilities can easily become unmanageable without careful planning.

CONCLUSIONS
We have implemented support strategies in our School which allow for individualised approaches to providing students with reasonable adjustments to their learning, while at the same time managing aspects of the process in a uniform manner so that this process is sustainable for the staff involved.

STRUCTURED MATHEMATICS SUPPORT WITH FLEXIBLE LEARNING MODES– WHO, WHAT, WHY, WHERE, WHEN AND HOW?

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KEYWORDS: mathematics support, mathematical skills, structured support, flexible modes of learning, first year mathematics, mathematics confidence

ABSTRACT

Mathematics support takes on many guises, each encapsulating a particular approach and method of delivery. Yet they all under the one umbrella of "support for the mathematics underprepared student". Dissecting the diversities, the pros and cons, and the approaches, of different support programs, relevant to particular subjects or disciplines, is essential when creating a support program. Support delivery should optimize student success within a subject and aim to be relevant and enlightening.

Sometimes support is via drop-in sessions only, with feedback, guidance and help, personally given. However, this type of support can degenerate into urgent pre-assignment support and not expose, nor heal, the underpinning lack of skills burdening a student. Sometimes support takes on a more structured, detailed delivery, tailoring to student needs within subjects or disciplines, designed to delve into the underlying problems behind a student's lack of understanding. This presentation   considers structured mathematics support with flexible learning modes and discusses the following questions. Who needs such support? What precisely is structured support? Why should we offer it?

Where do students access it? When should we offer it? How do we present it? Structured mathematics support, with flexible learning modes and tailored programs relevant to subjects, or disciplines, has been the approach of La Trobe University's *Maths Skills Program* for the College of Science, Health and Engineering, since 2010. It is a set of individual programs, each tailored to suit a specific discipline, and each created under the same model (see Jackson & Johnson, 2013; Jackson, Johnson & Blanksby, 2014). The *Maths Skills Program* has grown to support subjects for Chemistry, Physics, Biology, Statistics, Psychology Statistics, Mathematics, Biochemistry, Biotechnology, Nursing and Engineering. This presentation discusses the data analysed over the seven years (14 iterations) of the program's delivery, showing the program helps students with their mathematical skills, maths confidence and subject grades.

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LOOKING FOR INNOVATIVE AND EFFICIENT TEACHING METHODS FOR FIRST YEAR UNIVERSITY MATHEMATICS

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KEYWORDS: bridging unit, digital technology, interactive online exercises, problem solving, learning from examples, conceptual learning

BACKGROUND

The University of New England is a regional university with a large percentage of students studying online, and students lacking the traditionally expected mathematical background. The newly created bridging unit aims to bring students with a weak background in mathematics to a level of mathematical competence that is adequate for an increasing number of degrees. The existing constraints in the available teaching time due to shorter trimesters poses an additional challenge. This forces us to look for innovative, more efficient teaching methods.

Teaching mathematics in this bridging unit uses both conceptual and example-based teaching methods. The conceptual method is based on providing a definition and explanation of a new concept, which develops students' deep understanding and abstract thinking. The example-based method is based on problem solving and on providing examples to illustrate the concept, and it engages students' ability to apply the concept in similar situations and other applications (Xinming Zhu at al.1987). Thus, both approaches are needed for a complete understanding of mathematics, which requires both the understanding of abstract concepts and the ability to apply this understanding to solve real-world problems.

AIMS

The aim of our research project is to determine the right balance between the two methods in order to make the learning process most effective. To this end, we created worksheets which we gave to students on a weekly basis. These either contained conceptual or example-based explanations, as well as questions tapping the students' understanding of the abstract concept and their ability to solve similar and more conceptual questions.

DESIGN AND METHODS

Each week, students received worksheets that introduced new concepts that were to be explored in more detail in the following week's lecture. Subsequent short questions in this worksheet tested their understanding of the concept. For half of the students the concept was introduced by a formal definition, for the second half it was demonstrated by using a few examples and applications of the concept. We also asked if the concept was new to the student.

The students' responses will be described qualitatively and quantitatively. The qualitative aspect will be concerned with evaluating to what extent the participants' responses to the open-ended questions reflect conceptual and generalised understanding. The quantitative aspect will compare the number of correct responses across the concept-based and example-based groups, using Bayesian hypothesis testing (Rouder et al., 2009).

RESULTS

Our observation shows that the students whose test mark is above average achieve better results if the concept was introduced by a definition. The same is true for students with a mark less than the average, if they had been exposed to the concept before. Only students with marks less than average, and unfamiliar with the concept, did better if the concept was demonstrated by using examples. The latter group of students was the largest cohort in this bridging unit. The final results will be presented in the talk.

CONCLUSIONS

The result of this research will help us to find the right balance between studying theory and solving problems, which allows students to learn more efficiently.

TRANSITIONING TO THE FLIPPED CLASSROOM: IMPACTS ON STUDENT SATISFACTION

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KEYWORDS: blended learning, technology, flipped classroom, online, videos, active learning, case-based learning, animal health, veterinary science

BACKGROUND

The flipped classroom approach to teaching arose from a pedagogical ideal to utilise face-to-face class time for active learning activities. In flipped classrooms, preparatory materials are provided before class and commonly utilise technology-based approaches to content delivery including video. The approach requires students to engage in independent self-regulation of their learning by reviewing subject content before attending class. For this reason, a transition to the flipped classroom does not always lead to enhanced student satisfaction.

In this study, established introductory animal health subjects delivered to second year undergraduate students were transitioned from a traditional didactic lecture delivery mode to a blended 'flipped classroom' delivery mode. Preparatory materials were delivered online through the learning management system, and consisted of short videos and learning activities packaged into weekly learning modules. During weekly live classroom sessions students engaged in case-based small group collaborative learning activities.

METHODOLOGY

This study compares two cohorts of students; those that experienced the traditional lecture format and those that experienced the blended delivery format of the same subject in the subsequent year. The learning outcomes and assessment plan for the subjects remained the same for both delivery modes, with the overall cognitive load of the two approaches considered equivalent. Student satisfaction was evaluated using an online survey and focus groups which were recorded and transcribed.
Distributions of responses to the survey items (5 point Likert scale) were compared between the two cohorts using a two-tailed Mann-Whitney U test; and focus group transcripts were analysed using inductive thematic analysis to identify key emergent themes.

RESULTS

Analysis of the satisfaction items within the student survey showed that there were largely no significant differences between the cohorts experiencing the different delivery modes. The mean response (4.19) for the item '*Overall, this subject has been supported by useful learning resources'* was higher in the cohort receiving the flipped classroom delivery mode. The focus groups revealed several key themes relating to student satisfaction including enhanced flexibility and convenience, the opportunity to self-pace, and the availability of rapid formative feedback.

CONCLUSIONS

This study found that a transition to a flipped classroom delivery mode enhanced specific aspects of student satisfaction, however others remained unchanged. The outcomes of this study have implications for educators considering a transition to the flipped classroom approach

STUDENT PERSPECTIVES OF PEER PARTNERSHIPS FOR LEARNING

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KEYWORDS: Peer-assess, Peer-review, Student partnerships

BACKGROUND
The current trend of mass participation in Higher Education has led to an increase in size and diversity in our classes. One strategy of responding to mass participation is to engage students as partners in their learning (The University of Queensland, 2017). Students as partners is defined as harnessing student and staff creativity via collaborative partnerships to enhance teaching and learning1. Healey et al (2014)2 identified four key areas where both stakeholders share the responsibility of designing an engaging student learning experience: learning, teaching and assessment; subject-based research and inquiry; scholarship of teaching and learning; curriculum design and pedagogic consultancy. While partnerships is a shared endeavor between students and staff learning and enacting change together it is also a relationship based on respect, reciprocity, shared responsibility.

AIMS
This study investigates third year students' perceptions of their peers as partners in their learning through a peer-assessment and peer-review activity.

DESCRIPTION OF INTERVENTION
This study was carried out in a class of 387 final year Bachelor of Biomedical Science students, mentored in 20 small groups, participated in a summative assessment activity designed to develop students' metacognitive and evaluative judgement. This co-learning activity emulated the peer review process that takes place when publishing in journals. It required students to work in teams (4-5) to peer-assess, construct feedback to others' work, respond to feedback and return improved submission for tutor assessment. The activity used Moodle Workshop module to automate and streamline the process of student submissions, randomize distribution for peer assessment and review anonymously, return feedback, re-submit for tutor assessment (Mostert & Snowball, 2013).

DESIGN AND METHODS
The study (semester 1, 2016) scoped student perspectives on peer-review and assessment before commencing the activity through a questionnaire. At the end of the four week activity student experiences were explored via questionnaires and focus groups. Results from questionnaires were entered into an Excel spreadsheet and analysed using GraphPad Prism 7.0 while Focus group data was de-identified and transcribed before analyzing according to themes.

RESULTS
The mixed methods approach confirmed the positive aspects of working in student partnerships such as collaboration, learning from others, exposure to a variety of perspectives, benchmarking themselves all of which students identified as being valuable to their learning and the workplace. The study also revealed a complex and negative behaviour encouraged by anonymity. Trust, respect and confidence were challenged by a highly driven cohort of students who considered their peers to be competitors rather than a resource in their learning journey.

CONCLUSIONS
Despite the literature supporting the advantages of student partnerships in learning (Healey, Flint, & Harrington, 2014; The University of Queensland, 2017), this study has revealed its limitations. Ensuring that partnerships enhance student learning is challenging because working and learning within partnerships is not automatic, and requires transforming existing ways of being, doing and thinking. This study highlights a contemporary higher education context that promotes competition and therefore the importance of diffusing tensions between participants, power differentials if we are to provide an engaging learning experience through partnerships.

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DIGITAL LITERACY AND SELF-EFFICACY IN STEM EDUCATION

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KEYWORDS: digital literacy, self-efficacy, online learning

BACKGROUND

Science, Technology, Engineering, and Mathematics (STEM) courses in higher education institutes rely on technological tools and online learning to support deliverance of concepts to students (Ng, 2012). Digital literacy, the ability to utilize and effectively engage with information technologies, is an essential skill to access and comprehend the information delivered (Ng, 2012). However, students may not be conversant with new and emerging technologies for online learning (Kennedy, et al. 2008). Studies have also identified self-efficacy as an important learning behavior for successful online learning (Prior, et al. 2016).

HYPOTHESIS

This study hypothesizes that digital literacy and self-efficacy levels of students enrolled in STEM courses are enhanced with increasing number of semesters completed at universities.

AIMS

The technological skills and knowledge possessed by STEM students will be investigated to understand if they are adequate for effective engagement with online learning activities and assessment. Secondly, self-efficacy and digital literacy levels of students across different levels of courses will be measured. Next, technological problems encountered by instructors when delivering online learning activities in STEM courses offered at The University of Queensland (UQ) will be identified.

DESIGN AND METHODS

After obtaining gatekeeper approval and informed consent (UQ Human Research Ethics Approval #2016001757), 545 of the 3500 undergraduate students, 18 years and older, enrolled across multiple levels of STEM courses at UQ in 2017 completed the online survey. Survey questions from previously published studies were used for this survey (Ng, et al. 2012; Prior, et al. 2016; Shen, et al. 2013), which were analyzed with the Statistical Package for Social Science (SPSS) program to identify significant differences between groups (Artino & Stephens, 2009; Ng, 2012; Prior, et al. 2016). Additionally, individual face-to-face interviews were conducted with 44 of these students and 7 course coordinators of the STEM courses targeted, obtaining their in-depth experiences with online learning activities. Each interview was manually transcribed into written text before analysis with the NVivo program to elucidate themes present in the responses (Starks & Trinidad, 2007; Ulin, et al. 2005). This mixed methods design allows data triangulation and corroboration of findings from each analysis (Ng, 2012; Creswell, 2013).

RESULTS

Analyses of survey responses revealed that students who completed more semesters in university had scored significantly higher on digital literacy than new undergraduates who have not completed any semesters. Interviews with students also reported significantly higher volumes of online learning activities in university than in high school. Moreover, students who completed more semesters were exposed to increasingly specialized online tools for their learning. Students irrespective of experience would first try to solve any problems on their own before approaching the course coordinators or other avenues for support. The course coordinators agreed that most students were digitally literate, and could easily comprehend the information delivered using technology.

CONCLUSIONS

Though self-efficacy levels were similar between students of varying study experience, students who completed more semesters at The University of Queensland were more digitally literate with online learning activities and tools than students who were in their first semester of study.

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STUDENT PERCEPTIONS OF TEAMWORK IN UNDERGRADUATE SCIENCE DEGREES

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KEYWORDS: Teamwork, groupwork, employability, science, assessment

BACKGROUND

Innovation and disruption are rapidly changing the nature of work in all fields of STEM (Science, technology, engineering and maths). Transferable skills, such as problem solving, creative thinking and communication, will be more integral than ever to successfully navigating STEM fields. Among these skills, learning to function as an effective team member, is one of the most important for science graduates given the increasingly collaborative employment landscape. A science curriculum that supports the development of teamwork skills ensures graduates are equipped with workplace skills that are required both in research and other professional careers.

AIMS

This study aimed to determine science undergraduate's perceptions of teamwork and approaches used to foster it. This was broken down into three focal questions: Do undergraduate science students value teamwork skills? What are student's experiences of teamwork during their studies? What are students' views on assessment format for the development of their teamwork skills?

DESIGN AND METHODS

A 'mixed methodology' approach was used, which included the analysis of both quantitative and qualitative (open response) online survey data (n = 201). Questions were designed to examine perceptions of team assessments as well as the value of teamwork skills and how well they   perceived their science degree had prepared them with those skills. The data collection was undertaken between May and July 2016. Qualitative data was analysed using open coding to identify and analyse the prevalence of different themes. Quantitative data was analysed using summary statistics and ANOVA.

RESULTS

The findings showed that although students recognised the importance of developing teamwork skills for their future, a substantial proportion did not feel sufficiently prepared with these skills by their science degree. More students' valued working in groups during a laboratory, team sports, and informal study groups than formal assessment for developing teamwork skills. The most cited factors contributing to poor teamwork experiences were unequal contribution among team members and difficulties scheduling meetings.

CONCLUSIONS

The findings of this study suggest that science students are willing to develop teamwork skills within their undergraduate degree and can recognize their importance for their future whether in science or not. This study provides some indication of approaches, from the student perspective, that can be used to support science students in the development of their teamwork skills.

READY FOR WORK: HELPING UNDERGRADUATES RECOGNISE THE TRANSFERABLE SKILLS DEVELOPED DURING THEIR DEGREE

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KEYWORDS: transferable skills, employability, badges,

BACKGROUND

Employers of graduates are seeking a range of transferable skills from job candidates in addition to discipline knowledge and skills (Deloitte Access Economics 2014; Rayner & Papakonstantinou 2015; Sarker, Overton, Thompson & Rayner 2016); and academics are increasingly seeking to build employability skill development into the undergraduate curriculum. However, past studies suggest students may not recognise such skill development without prompting (Tomlinson 2008; Whittle & Eaton 2001).

Badging is a potentially valuable tool for enhancing skill recognition, and making the explicit links between the curriculum and employability called for in the literature (Lowden, Hall, Elliot & Lewin 2011; Saunders & Zuzel 2010).

We have created a set of transferable skill badges/icons for highlighting where undergraduates can build their employability and research skills in science units. Despite much recent interest in badging, there is a lack of research literature in this area (Frederikson 2013), with research typically focused on badges as learning incentives and/or a means of recognition or communication of student competency (Bowen and Thomas 2014; Kim 2014; Hurst 2015; Hensiek, DeKorver, Harwood, Fish, O'Shea & Towns 2016; Seery, Agustian, Doidge, Kucharski, O'Connor & Price 2017). It is believed that the impact of badging course materials on student awareness of the skills the curriculum is designed to develop, has not been reported to date.

AIMS

The project aim is to determine the impact of adding skills badges to course materials and tasks on student recognition of skill development opportunities in their units, and the importance of transferable skills.

DESCRIPTION OF INTERVENTION

Ten transferable skills badges / icons have been developed, representing transferable skills sought by employers from science graduates. These icons will be applied to student-facing online and hard copy course materials in five science units at Monash University and three modules at the University of Warwick. The icons will be displayed on documents related to any aspect of the course identified by the unit coordinators as providing students the opportunity to develop the relevant transferable skills. This may include practicals, tutorials, assignments, essays, group tasks, problem solving tasks, quizzes, assessments, discussions, field trips, assessments etc.

DESIGN AND METHODS

The study employs an exploratory mixed method design. Quantitative surveys have been administered to students completing the relevant units before badges have been added. These surveys will be repeated after the addition of skills badges in the subsequent semester, and results analysed for statistical differences. In addition, focus groups have been carried out amongst students completing the units prior to badging, enabling collection of detailed qualitative data on current student views of skill development opportunities in these units. After the addition of skills badges, further qualitative data will be collected amongst students and the academic staff facilitating the units. The qualitative output will be coded for themes with comparison of themes arising before and after the inclusion of skills icons in the course.

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APPLYING LEARNING ANALYTICS: APPROACHES AT COURSE/UNIT-LEVEL TO DEVELOP A TARGETTED INTERVENTION

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KEYWORDS: learning analytics; integrating concepts; short answer question

BACKGROUND, AIMS AND METHODS

Factors affecting student academic performance are multifaceted and are often context-specific (Entwistle & Peterson, 2004; Vermunt, 2005). The Learning Analytics paradigm can be utilised to identify course-specific factors that impair student performance, which can be subsequently addressed through targetted interventions (Clow 2012). The current study aimed to utilise such a paradigm and design an intervention to improve student performance in a large first year biology course. Data from students enrolled in the previous iteration of the course was analysed to identify factors that impair student performance. Performance of students that passed and failed the course in the various course assessment tasks was analysed and compared. Findings were then used to design an intervention that was implemented in the semester 1 2017 iteration of the course.

RESULTS AND DISCUSSION

Students who passed the course (Pass, n=588) performed significantly better than those who failed the course (Fail, n=159) in every assessment task (p<0.001 for all comparisons). Data analysis also revealed specific aspects of student performance in the course. For example, both Pass and Fail students performed relatively well in the Skeletal Muscle practical (p<0.001) compared to other course assessment tasks, while relatively poorly in quiz 1, which focusses on cell biology and biochemistry lecture modules. While this data is valuable, our primary focus shifted towards assessment tasks or skills that are affecting all/many students in the course, not just at-risk students. One such example was a required underlying skill to demonstrate in-depth understanding of concepts covered in the course, particularly in the Short Answer Questions (SAQ) of the End Of Semester (EOS) exam (p<0.001 compared to all other assessment tasks, including the multiple choice questions' part of the EOS exam). The SAQs required students to integrate their understanding of concepts across different course modules and various organ systems within the human body. This data subsequently formed the basis for the development of a targetted intervention this year, which focused on improving student abilities to generate specific, integrated and complex responses to the SAQs. The activity, conducted during lecture time, exposed students to questions that were similar to the SAQs of the EOS exam, and was directed towards concepts that students generally found challenging. During the intervention, students were further exposed to structural variations in the understanding of these concepts, which was generated by utilising the answers from students to similar questions in previous semesters. Along with this, the instructor provided specific guidelines on what was expected in the best answer as well as point out the flaws in all the other answers provided to students. This presentation will focus on the methods we employed to develop course-specific data using a learning-analytics approach and the intervention that followed. The effect of the intervention on overall student performance (pass vs. fail rates) will also be analysed at the conclusion of semester exams, and will be presented at the conference

EVALUATION OF STUDENTS' ATTITUDES TOWARDS WRITTEN AND VIDEO FEEDBACK FOR THEIR LABORATORY REPORTS

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KEYWORDS: Feedback, student engagement, assessment

BACKGROUND

Practical classes are considered an integral part of undergraduate pharmacology curricula. Individual students' written practical reports form a primary method of assessing their understanding of theory, and developing their skills in written communication, data presentation and interpretation. Although we aim to provide constructive written feedback on these reports, our suggestions for improvement are not always incorporated into future reports. This observation suggests that we are not sufficiently engaging students in the feedback process. Interestingly, several reports have indicated that students might better engage with novel feedback methods such as audio and / or visual.

AIMS

The current study aimed to evaluate student perceptions of our current feedback practice for laboratory reports, in order to assess what factors might influence their uptake of this feedback.

DESIGN AND METHODS

Respondents were undergraduate students undertaking third year pharmacology units in semester 1 (n=79) or semester 2 (n=34), 2016. Each unit included several assessed practical reports that contributed to the student's overall mark for that unit. Feedback for reports in the semester 1 unit was provided in written format only, whereas feedback for reports in the semester 2 unit was provided via several modes including peer, written and video. At the conclusion of each unit's practical teaching program, students were invited to complete an anonymous survey that asked them about their perceptions of the feedback they received.

RESULTS

In semester 1, the majority (57%) of students indicated that they always reviewed the feedback provided to them on their practical reports, irrespective of the mark received. Furthermore, students overwhelmingly agreed (>90%) that the feedback was useful for improving their future reports, and could be applied to other units of study (78%). Nearly 50% of students disagreed that they pay less attention to written feedback than when it is provided in person. However, of the semester 2 respondents who received multiple feedback formats, 74% indicated that the video feedback was the easiest to understand, and 71% agreed that this format gave the clearest indication of where improvements were needed. 85% of students indicated that they would be willing to receive feedback via this format for future assessment tasks.

CONCLUSIONS

Although students do appear to value written feedback they receive, their response to the novel format of video feedback was overwhelmingly positive. This raises the question of whether better engagement with feedback increases the likelihood of students acting on it. Thus, we are currently investigating whether the format of feedback influences whether students incorporate it into future assessment tasks.

DOES (ONLINE VERSUS TRADITIONAL) ASSESSMENT METHOD IMPACT ON EXAM PERFORMANCE?

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KEYWORDS: peer assessment, WileyPLUS, online learning, statics, dynamics

ABSTRACT

This paper identifies and describes the effects of online versus traditional assessment activities on student performance when incorporated into a large first year Engineering topic. Due to higher workloads, high failure rate and limited teaching academic assistance, we looked at developing more efficient assessment methods without compromising student performance and consequently reduce our workloads. This topic consisted of Statics and Dynamics parts. For the pilot study in 2015, students were assessed using traditional methods for the Statics part i.e., students handed-in five assignments that have problems relating to the content for marking. Their competence in the Dynamics part was assessed through weekly online WileyPLUS tasks. The WileyPLUS system provided students with self-paced tutorials in an individualised coaching mode and instant feedback. We found that the correlation between the exam results was the same for both Statics and Dynamics exams. In 2016, we used similar assignments [1] for the Statics part, but introducd peer assessment [1] to place more emphasis on student-centred active learning, engagement, performance assessments and to move away from traditional lecturer/tutor grading [2]. Overall, the exam results didn't shift significantly between 2015 and 2016 there was evidence to suggest students that actively engaged in the peer assessment performed better in the exam. Even though the level of student engagement improved with the introduction of peer assessment, there were some critical issues (plagiarism, over inflated confidence etc.). Our findings/observations are in agreement with the results of [3]. It is also clear from the study that whatever mechanisms students use in their own time do not transfer their knowledge. This presentation will discuss challenges and the results of our approach/project.

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A CASE FOR LIMITING WRITTEN EXAMINATIONS

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KEYWORDS: Examinations; Online Learning; Student outcomes, Assessment for Learning

ABSTRACT

In 2016 the new blended mode version of Principles of Physics A, a first year, first semester physics course, was developed and delivered at La Trobe University. Regression analysis of the student results was used to build a model which predicts the final results of individual students based on performance during semester. This was then compared with actual student attainment. The analysis showed a large variation between expected and actual student outcomes mostly due to underperformance in the mid-semester and final examinations (total weighting of 65%). We hypothesise that this is due to anxiety relating to many examinations taking place in quick succession, English literacy skills, and for some students not being trained in written examination technique.

We use the results of this analysis to argue for radically decreasing the percentage weighting for mid-semester and end of semester examinations in the course assessment structure. The change in the distribution of marks from examinations to continuous assessments throughout the semester should, we argue, increase the engagement, learning, and outcomes of students. This argument emphasizes assessment for learning over assessment for evaluation. An example assessment for learning regime is proposed in the case of Principles of Physics A, which weights weekly online quizzes at 4-5% each. We argue that higher weighted quizzes coupled with immediate usable feedback encourage students to better learn from their mistakes. We hypothesise that successful student completions and retention in physics will increase due to an increase in self-confidence increase in the students.

ASSESSING THE ASSESSMENTS: WHAT HAVE WE LEARNED?

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Higher education in Australia is in a phase of rapid change due to significant regulatory changes, with the new Higher Education Standards Framework in effect since January 2017. In preparation for this change the Australian chemistry community has come to a consensus on common Chemistry Threshold Learning Outcomes (CTLOs) that every Bachelor level chemistry graduate from an Australian university will have attained. The CTLOs will inform the standards used to accredit institutions and degrees, and the RACI has changed its accreditation process for chemistry degree programs and now uses these CTLOs as the basis for accreditation. Therefore, it is paramount to ensure that assessment items used allow students to demonstrate attainment of the CTLOs for a chemistry major (Elmgren, Ho, Åkesson, Schmid & Towns, 2015).

The "Assessing the Assessments" project, funded by the Australian Government's Office for Learning and Teaching (OLT ID14-3562) has used an iterative process to develop an evaluation framework to assist academic staff at tertiary institutions to determine the alignment of their assessment items with the CTLOs (Schmid et al., 2016). In conjunction with professional development workshops in which attendees explored the alignment of assessment items with the CTLOs, a user-friendly tool has been developed which can be used to evaluate assessment items. The tool yields ratings for both Task Design and Assessment Criteria for each CTLO within the assessment task evaluated, highlighting areas of potential improvement in current assessment practices. Comparison of self-evaluations of tasks submitted to the project with evaluations conducted by the project team shows that in the majority of cases, academics (including project team members) over-estimate the ability of their assessment items to confirm achievement of CTLOs, as the new regulatory environment requires. Recommendations to increase the coverage of CTLOs through changes to assessment procedures will be presented.

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MONASH ROCKS – THE FIRST STEP IN AN AUGMENTED REALITY JOURNEY THROUGH DEEP TIME

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KEYWORDS: Augmented Reality (AR), innovative teaching space, student engagement

Monash's magnificent Earth Sciences Garden is a "living" geological map of Victoria collating nearly 500 rock specimens, laid out, as they are *in situ* with local flora. This garden, the first of its kind in Australia and the most comprehensive worldwide, establishes Monash as a world leader in creating an innovative, immersive teaching and learning experiences.

This presentation will outline the development of the "Monash Rocks" app that brings a virtual environment into the user's hands and facilitates independent learning in an experiential context. The ubiquitous incursion of mobile devices opens up a new avenue of teaching and learning opportunities for educators and we have seized this opportunity to create an AR experience for the Monash Earth Sciences Garden. Our purpose was to use Augmented Reality and the virtual environment to enhance the engagement of a visit to the Garden heightening the opportunity to develop high-level cognitive skills of exploration, analysis, interpretation and reflection.

THE PROJECT

With funding from the Monash University - Office of Learning and Teaching we developed a proof of concept (Phase 1) to demonstrate the capabilities and relevance of the app for teaching and learning. The initial project proposal was to build a full App to act as a guide for the MESG, incorporating one complete environmental reconstruction of the Devonian seafloor 410 million years ago. We consulted with academics in the School of Earth, Atmosphere and Environment (EAE), who are leading palaeontology and palaeoecology reconstructive artists, and experts in the field of Augmented Reality and 3D animation.

This project aimed to bring a new dimension to learning and teaching at Monash. It showcases a unique learning environment and demonstrates the possibilities to faculty members across the University. A key outcome will be the development of templates and protocols for development of similar resources in faculties other than Science.

CONCLUSION AND NEXT STEPS

Augmented Reality situates the learning about deep time in a present-day context. Learners are able to see 3D fossils come to life and watch them moving as they hover over the authentic background of the rock in which they are buried. This visualisation heightens the learning experience making it memorable. It also enables the learner to develop a deep understanding of how our environment was formed and our place in it.

CHANGING YOUR MIND ON THE INTERNET: CAN A YOUTUBE AUDIENCE THINK CRITICALLY?

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KEYWORDS: Thinking Critically, YouTube, Multimedia, Online Learning

ABSTRACT

The public is increasingly engaging with educational videos through YouTube. While one of the goals of educational videos is to introduce viewers to new concepts it is also to shift viewer's understandings towards those more congruent with science. This paper focuses on two videos by Dr Derek Muller of the popular YouTube channel Veritasium (4 million subscribers, 345 million total views). Derek uploaded a video with four riddles and 6 days later, a video with the solutions to the four riddles. Data was collected from the comments on the first video, and via a survey link in the second video. This data was analysed to answer the questions of "After watching a YouTube educational video, do viewers self-report a shift in their understandings? If not, why not?". The answer to the   first research question is yes – most people changed their answers, and hence reported a shift in their understanding. The ones that   did not cited reasons of "Almost" – they reported their answer was almost correct, "Possible with something else" – the solution   presented is not unique, and some reported a negative emotional response. We propose that this shift has a reflective element which aligns with a part of critical thinking.

USING SOCIAL MEDIA IN A SCIENCE COMMUNICATION COURSE

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KEYWORDS: science communication, social media, blogs, assessment

Science communication is a diverse, interdisciplinary activity. It is seen as a core skill for scientists as well as being a field of specialisation with its own career pathway to work in areas such as journalism, non-formal science education and outreach, museums, science policy, and science advocacy. In addition to 'traditional' skills such as written and oral communication and working with the traditional media, the use of social media to communicate science is increasingly seen as a core skill for science communicators (Bik & Goldstein 2013).

The University of Adelaide's Communicating Science course began as a Masters-level postgraduate offering in 2012, with one of its goals being the use of social media alongside other forms of communication within the course. The course has a particular focus on the use of blogs as a specific genre of science communication. The course is run in intensive mode over two weeks in the University's Winter School period. Each student makes 9 blog posts for the course, which combined make up 50% of their final course grade. From 2012-2014, students set up their own blog using Wordpress. All students now produce their blog posts within the University's online learning management system (Blackboard in 2015 and 2016 and Canvas from 2017). Other assessment tasks include two oral presentations (20% of final course grade) and a writing assignment (30% of final course grade). In addition, students create Twitter accounts and are invited to use the course hashtag #cs7020 to share posts and other items of interest with the instructors and each other. Since 2015, third year undergraduate students have been enrolled in their own version of the course, which is co-taught with the postgraduate students.

Marking rubrics for the blog posts were constructed carefully so students would know exactly what was expected of them. Marking criteria cover categories such as credibility, content, clarity, creativity and personality. Different rubrics were constructed for the postgraduate and undergraduate versions of the course, reflecting the difference in expectations for each cohort. Each blog post initially receives formative feedback within 24 hours of it being posted, allowing students to incorporate this feedback into subsequent posts. At the end of the course, each student's entire collection of blog posts is marked summatively as one body of work, allowing the markers to see students' progression and development.

This presentation will describe the course development process, construction of the blog marking rubrics and their implementation as well as student reaction to the course and its use of social media.

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ONLINE INTERACTIVE TEXTBOOK USE IN ANATOMY AND PHYSIOLOGY: "TEACHING AN OLD DOG (ACADEMIC) NEW TRICKS"!

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KEYWORDS: E-Texts, Adaptive Learning, Learning Analytics, Data Mining, Big Data

We remember a time when A&P textbooks were a sole source of truth, carefully read and reviewed (never touched by highlighters) after a hard day taking hand written notes in chalk and talk didactic lectures. No this is not the 19th century, but just 20 years ago. The advent of online course materials,   YouTube, MOOCs, Khan Academy…..etc has made prescription and marketing of modern textbooks challenging for academics and publishers alike, and created what is an expansive content source list combined with a fragmented learning environment for our students.

After a soft launch in 2016, this year (Semester 1, 2017) we intensively pitched Tortora and Derrickson's Principles of A&P 1st Asia-Pacific Edition Online Interactive Textbook (no hard copy) to two co-taught subjects/units at JCU for a) first year Pharmacy students (n=50) and b) 2nd year Biomedicine students (n=45). Both subjects had independent LMS sites under Blackboard©, and were   delivered in traditional face-to-face lecture-lab-tute mode over 13 weeks on a single campus location.

And so we can hear you thinking:
Students won't buy it: 90%+ purchase rate in both cohorts (affordability for 2 consecutive subjects of A&P unmatched).
Students won't use it: over 9000 practice questions attempted by Pharm students with 64% correct, 6000 for Biomed students with 72% success. Individual students with over 100 hours of access time (thru LMS, personal online reading time untracked).
Students prefer hard copy texts: Surprisingly minimal requests. Co-semester subjects had hard copy texts prescribed.
Equity of access: No requests received, hardship access made available (library access code also made available).
Too much work for academics: very easy set up and actually saves academic time (reduces requests for practice materials). Engage as little or as much as required.
No support from publisher: timely and comprehensive back up for both students and academics.

While end of semester results are not in, and not all students have engaged with the textbook heavily, the correlation between the online interactive textbook use (time on task and adaptive questions attempted) versus summative quiz results is strong and provide improved student engagement tracking over other analytics sources such as; lecture attendance, lecture recording views and content download statistics. Students themselves have rated the online textbook and associated resources strongly via formative survey, with portability, interactivity and ability to practice questions highlighted.

The learning analytics and outcomes of using an online interactive textbook are compelling as they are confusing for an experienced A&P educator, but in this presentation we aim to provide some tips, dispel some myths and allay some fears for any old or new dogs (academics) thinking of moving into this resource space and re-unifying their content sources.

AUSGEOL.ORG – A NEW RESOURCE FOR EARTH SCIENCE EDUCATION

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KEYWORDS: earth science, virtual geology, immersive visualization, 3D models, UAV, photogrammetry

PROBLEM

Fieldwork is a fundamental component of Earth science education that teaches a range of important observational and analytical skills in an experiential learning context. However, it is not possible to expose students to a fully comprehensive range of field experiences in undergraduate units since important localities are widely dispersed and many significant sites are in inaccessible or dangerous locations, where student visits are not practical. Financial, safety, legislative and logistic issues, as well as trends towards increased flexible content delivery, motivate the development of new digital resources to complement conventional field-based teaching programs.

PLAN

Interpretation of a geological outcrop is a complex cognitive task that requires integration of three-dimensional information at multiple scales and from different viewpoints. Recent advances in enabling technologies such as digital photogrammetry, high pixel-count imaging and Unmanned Aerial Vehicles (UAV) now facilitate rapid, inexpensive, generation of interactive geological visualisations.
We have used these new methods to create the AusGeol Virtual Library of Australia's Geology (AusGeol.org). AusGeol delivers a range of intuitive, immersive digital content and associated learning objects that illustrate the diverse geology of Australia.

ACTION

The AusGeol library was developed at the University of Tasmania during 2015 and 2016 with funding from the Australian Government Office for Learning and Teaching, eleven Australian universities, four government geoscience agencies and the Teacher Earth Science Education Program.
The AusGeol library delivers digital geological content for over 3000 sites across the continent. Visualisations include: photo-realistic, geo-located, three dimensional models derived from terrestrial and aerial photogrammetry; full spherical panoramas; multi-resolutional (gigapixel) imagery; and virtual tours of selected sites. All virtual content is available for interactive display and free download from the AusGeol website and is accompanied by comprehensive geological metadata. Teaching and learning resources that utilize the AusGeol visualisations are also available to registered educators.
We have developed new open-access software (GeoVis3D) that provides intuitive visualization and enables quantitative geometric analysis of three dimensional virtual objects. GeoVis3D allows students to replicate, on virtual models, the range of standard geological observations and measurements that are conducted on real outcrops.

REFLECTION

AusGeol digital resources and GeoVis3D software have been trialed in undergraduate Earth science units at several universities during 2016 and 2017 with positive feedback from staff and students. Students particularly appreciate the interactive measurement and analysis functionality provided by GeoVis3D.

The AusGeol library and associated resources provide an expanding and evolving virtual repository for Earth science education. We will continue to enhance the utility of the existing digital resources by development of new teaching and learning activities and additional virtual tours.

We have developed and refined techniques for high-resolution 3D digitization of small-scale geological samples. Generation of 3D models for significant archival specimens from university and public collections will be an AusGeol priority if funding for this initiative can be secured.

DO ACCELERTED STUDENTS IN NURSING BENEFIT FROM FACE-TO-FACE SUPPORT WHEN ONLINE SUPPORT IS AVAILABLE?

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KEYWORDS: accelerated nursing students, bioscience, face-to-face support, online support, pharmacology

ABSTRACT

We have demonstrated that the diploma-entry accelerated students in a nursing program need additional support at the start of their studies in bioscience and pharmacology to prevent high rates of attrition. This support consists of a formative, online activity of resource notes and quizzes covering key concepts in bioscience and pharmacology, and a face-to-face workshop addressing academic skills and reviewing bioscience material, presented to the students in orientation week. Subsequently, we developed an online eBook: Getting Started in Bioscience, Pharmacology and Microbiology; https://sites.google.com/site/gettingstartedinbioscience/ The aim of the present study was to determine whether it was necessary to provide both the face-to-face workshop/review lectures and the eBook, as support for nursing students undertaking the biosciences and pharmacology. In order to do this, firstly, we evaluated the eBook showing it was well received by the both accelerated and traditional students. Secondly, we evaluated the face-to-face workshop/review lectures in 2016, when the students had access to the eBook, and this showed high appreciation by the students. Finally, we compared the analysis of the face-to-face workshop/review lectures in 2016 with the analysis in 2011, which was prior to the eBook, and showed that the students' appreciation of the face-to-face workshop/review lectures was not altered by the introduction of the eBook. Thus, continuing face-to-face support for nursing students prior to studying bioscience and pharmacology, despite the introduction of an eBook, may be worthwhile.

UNDERSTANDING STUDENT MOTIVATIONS AND HOW THEY CHANGE IN A PEER- LEARNING PROGRAM

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KEYWORDS: Peer Learning, STEM Learning, Support for learning

BACKGROUND

Support for learning in STEM is a growing area due to underprepared students (Xue and Larson, 2015) with Peer Assisted Study Sessions (PASS) and similar programs being implemented in Universities around Australia and the world (Zammit et al., 2017). Queensland University of Technology has implemented a program (called STIMulate) based upon student volunteers, called Peer Learning Facilitators (PLFs), who provide one-on-one learning support to visiting students.
There is a significant lack of knowledge around what motivates PLFs to volunteer for the role and why they choose to stay on in the role over multiple semesters of service. Understanding volunteers' motivations to stay with the program can be used to inform practice and professional development for the volunteers.

AIMS

The ability to support campus-wide student learning in diverse areas of science, maths and IT underlies the scalability of the program. However, to ensure program delivery is both quality assured and sustainable, and that participation enriches the university experience of the PLFs, it is essential to establish better practices to support our volunteers in their roles. On this basis, this research aims to identify if and how motivations driving participation change after a semester of service.

DESIGN AND METHODS

To understand the motivations underlying student volunteerism, a survey instrument was adapted from the Volunteer Functions Inventory (VFI) (Clary et al 1998) by Devine et al. (2016) to make the survey more contextually relevant to the volunteers. The survey was administered to all of the new volunteers in the program (n = 89) before the start of semester 1, 2016. The same survey was again administered at the end of the semester (n=35) to allow for changes in motivations to be tracked. The respondents used an individualized anonymous code to provide traceability to their responses.

The data was then analyzed according to the purpose, mastery and autonomy scales put forward in the adapted survey, along with multi-criterion decision making (MCDM) assessment using PROMETHEE-GAIA, and data reduction methods such as Principal Component Analysis (PCA) and Hierarchical Cluster Analysis (HCA). These methods were used to cross-validate the assumptions of the survey instrument.

RESULTS

The initial survey results reported by Devine et al. (2016) found that student motivations included "relationships and experiences," "intrinsic motivators" and "extrinsic motivators". The follow-up surveys found that student motivations changed to "Network and leadership," "Engagement and confidence with STIMulate" and "Engagement with other students" through the PROMETHEE-GAIA analysis, while the PCA analysis identified six motivators which can be reduced to the same three motivators identified in the PROMETHEE-GAIA. These results show that volunteer motivations change and become more complex with service.

CONCLUSIONS

The pre-service surveys previously revealed that motivators driving participation could be described as "relationships and experiences," "intrinsic motivators" and "extrinsic motivators." The post-service surveys conducted at the end of semester reveal that volunteer motivations have become more complex, focusing on "networking and leadership," "engagement with STIMulate" and "engagement with other students." These findings demonstrate that positive interactions with staff and students of the University, coupled with

opportunities to network and take leadership positions motivate students to stay with the program. These deepening motivations can be used to drive opportunities for students to develop their graduate capabilities.

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STUDENT ENGAGEMENT, LEARNING AND PERCEPTIONS IN A FLIPPED CLASSROOM

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KEYWORDS: Flipped classroom, student engagement, active learning, student experience

Over the past three decades, we have been teaching human bioscience to allied health cohorts using a traditional approach that is content heavy, primarily didactic in its delivery and consequently, tends to be teacher-centred. Although these units rank well in the student evaluation of teaching and units (SETUs), it is difficult to engage students in the content and there is limited time to provide active learning opportunities for students to meaningfully apply their knowledge in class. In an attempt to address the issues surrounding student learning and engagement, we completely flipped two human bioscience units in 2016.

In order to 'flip' our units, we removed the didactic delivery of content from lectures and placed it instead, in short online lessons (pre-work) that students were required to complete prior to coming to class. The pre-work we created consisted of a series of short videos (recorded by the teaching staff), conversational text and formative quizzes to allow students to check their understanding. The pre- work was made available to the students via an online platform within the university's learning management system (Moodle lesson). By transforming our lectures into online pre-work, we had more time available to engage students in a highly collaborative and active student-centred learning environment. During these sessions, students applied their understanding in case-based tutorials, explored and evaluated information in our investigative workshops and worked together in pre- determined teams to complete activities that aimed to promote transferrable skills.

We will present qualitative and quantitative data from surveys, reflective journals, focus groups, Moodle analytics and assessment results. This data will allow us to detail the learning experiences and academic outcomes of our cohort, with emphasis on how our approach increased student engagement and student learning. We will discuss the techniques used to motivate the students to become active and engaged participants in all aspects of their learning, leading to a ten-fold decrease in fail rates and an increase in the average unit grade. We will also discuss the students' perceptions of the flipped approach and demonstrate that, although students were initially resistant to the approach, they later embraced the flipped classroom and felt "better prepared for exams". Our presentation will be concluded by a brief discussion of some of the possible mechanisms underlying the success in our flipped classroom.

PRE-LECTURE VIDEOS AND QUIZZES AS EFFECTIVE TOOLS TO PROMOTE STUDENT ENGAGEMENT AND ACHIEVEMENT

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ABSTRACT

This presentation reports on our investigation into the efficacy of pre-lecture resources, including key content videos and mastery quizzes, to promote student engagement with first and second year chemistry courses.

Learning outcomes for second year students studying core chemistry improved significantly in terms of academic performance, with a decrease in failure rate of around 10 % compared to the previous year. The most substantial change was noted for the mainstream level students, whose mean theory marks also showed significant improvement. Student results in the advanced unit improved as well, although not to a significant level. These results emphasise the benefit of our approach for student learning outcomes.

Student perceptions of the partially flipped course were positive overall. When surveyed, the vast majority of students responded that the pre-lecture materials had improved their learning and that they had found the online videos and quizzes useful. In addition, the use of worksheets and active learning for the in-lecture portion was most frequently cited by students as their preferred method of learning.

Interaction tracking data were used to determine student engagement with the online modules. On average more than 80% of students accessed the modules when they were available for lecture preparation. An Engagement Index (EI) was developed using the online tracking data, then correlated with students' exam results to determine whether there was any relationship between engagement and academic achievement. It was found that students who were engaged with the modules performed significantly better in the final exam than students who were unengaged.

DESIGNING BLENDED LEARNING IN STEM

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KEYWORDS: Blended learning, Moodle, educational design, science communication, online learning, higher education

PROBLEM

Making material available through learning management systems is standard practice in most universities, but this is generally seen as an adjunct to the 'real' teaching that takes place in face-to- face classes. The default format of Moodle, our Learning Management System (LMS), is linear and applied across the university. Thus, without any recognition of learning theory to inform their decisions, academics use their online teaching space as a repository for their lecture slides and reading lists with a few forums thrown in.

Our paper (Gleadow, Macfarlan, and Honeydew. 2015) described the redevelopment of a large course in scientific practice and communication that is compulsory for all science students studying at our Melbourne and Malaysian campuses, or by distance education. The re-development changed the pervasive paradigm of learning and teaching and promoted blended learning, to seamlessly integrate the face-to-face and online delivery, and maximize the learning opportunities presented to the students.

PLAN

The plan was to apply the Monash University–Office of Learning and Teaching (MU-OLT) Unit Enhancement agenda to ensure effectiveness through high quality design of learning outcomes and assessment regimes, multifaceted activities, and optimal delivery methods. The course chosen to spearhead a program for enhancing teaching across our university was *SCI2010 Scientific Practice   and Communication.*

The collaboration between the educational designer and the academic led to the development of a blended learning methodology and converted the environment provided by the learning management system into a teaching space.

Drawing on the work of Laurillard (2012, 2013), Dalziel (2009), Sims et al. (2002), Al-Samarraie et al. (2013), and Goodyear (2015) we applied a design for learning approach. This meant that we made obvious what had previously been buried. A logical design and clear learning pathway were implemented to make obvious to the student the actions required to achieve specified learning outcomes.

ACTION

The content of the course did not change, but by restructuring the delivery using educationally relevant design techniques, and contextualising the learning activities and assessments into an integrated learning experience we found that students were more engaged intellectually, and lecture attendance improved.

The learner is guided through scaffolded activities, discussions, opportunities for reflection, self-test quizzes, and extension activities if needed or desired. We believe that an altered learning landscape motivates the learners to engage with the prescribed materials and activities at a deeper level and reflectively participate in the learning experience.

REFLECTION

Getting buy-in from time-poor academics can be challenging. The pain is more in taking time to   rethink what it is that you want to teach rather than the implementation. Making design explicit and shareable delivers consistency and makes implementation straightforward.
The design we have described here used a consistent thread as a strategy within which we could   create learning opportunities for a diverse group of students. In this presentation, we will describe   what has happened in the two years since this first iteration and give examples of the take-up of designing for learning in other schools in the Faculty of Science.

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POSTER 1

AN OPEN ACCESS ETEXTBOOK TO SUPPORT STUDENTS TO BECOME SCIENTISTS

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KEYWORDS: open access resources, student-centred, STEM, research skills

ABSTRACT

Science experts are asking educators to teach science in authentic, engaging, inquiry-driven and relevant ways to prepare graduates to be scientifically literate citizens who can contribute to society in the 21st century (American Association for the Advancement of Science 2011; Office of the Chief Scientist 2014). This means that it is essential for student scientists to experience the activities that practicing scientists carry out in their jobs, from designing and conducting experiments, analysing and presenting data to communicating their results to different audiences via different platforms. Traditional teacher-centred approaches and resources are not appropriate to support students in learning how to be a scientist, particularly in increasingly large student cohorts.

As we introduced curriculum designed to support student scientists through taking on the role of a scientist, we realised that while there is a lot of support available for students learning scientific facts, it was harder to find resources to support students to become scientists. This led us to write a student guide that provided an innovative and flexible way of helping students along their journey of scientific discovery and allowed students to interact with the material in the guide in an appropriate context, rather than when a class is scheduled on a particular topic. We wanted our guide to be as valuable, user friendly, accessible and engaging for students as possible and while the content of the guide was contemporary, it was still in a relatively conventional form and available only to our students. We decided to transform our guide into an etextbook that was optimised for viewing online and allowed some interactive elements to be included. This made sense as the move away from teacher-centred teaching is happening at the same time as more teaching and learning is occurring in blended and fully-online contexts (Johnson, Adams Becker, Estrada & Freeman 2015) and students entering university today have access to and use devices including smartphones, laptops and tablets (Farley, Murphy, Johnson, Carter, Lane, Midgley, Hafeez-Baig, Dekeyser & Koronios 2015). La Trobe University has a proud tradition of enrolling and retaining students from low socio-economic status (SES) backgrounds with participation rates higher than the state and national averages and plans to increase this population (La Trobe University 2015). Students from low SES backgrounds are particularly burdened by the high price of traditionally published textbooks. One response is the growing trend towards creation of open access resources that are able to be freely used or re- purposed by others, contain educational costs and widen distribution of high quality educational resources. Therefore, we made our etextbook open access.

Students will use the etextbook, How to Do Science: a guide to researching human physiology, for the first time in semester 1 of 2017; it is freely available via the La Trobe Bureau. We will present (1) a reflection on the process of creating an open access etextbook, (2) preliminary data on student views on how well the etextbook has contributed to learning success in subjects where the etextbook is embedded and compare student perceptions with grades on assignment tasks related to etextbook content, and (3) our plans for future editions of the etextbook.

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POSTER 2

EMBEDDING EMPLOYABILITY INTO THE FINAL YEAR OF A NON-VOCATIONAL HEALTH SCIENCES COURSE

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KEYWORDS: connected learning, connectedness capabilities, connectedness pedagogies, digital career literacy

Although it is clear that the higher education sector places a high value on graduate employability, research and practice in this area are under-developed (Bridgstock 2016). Recent research suggests that universities should be promoting connectedness learning and a networked approach to promote connectedness capabilities and graduate employability (Bridgstock 2016). Individuals that have high functioning connectedness capabilities have the ability to make, nurture and reinforce professional connections, and interact with them strategically and successfully (Bridgstock 2016). Connectedness capabilities are supported by connectedness pedagogies such as work integrated learning, student partnerships, co-curricular activities, and social media and eportfolios (Bridgstock 2016). La Trobe University's Bachelor of Health Sciences is a non-vocational 3-year course with over 1000 students and is the stepping-stone to at least 30 identified career pathways. The course currently has a sparse and haphazard approach to the development of students' connectedness capabilities and employability, and this may be leading to under-prepared graduates with low functioning levels of connectedness capabilities and employability.

Our intent is to design and introduce a scaffolded course-wide employability curriculum which will be embedded into targeted core subjects at each level and semester of the course. The curriculum will have an integrated approach, and will draw on the connectedness pedagogies presented in the Graduate Employability 2.0 Connectedness Learning Model (Bridgstock 2016), and will focus on authentic student-centred, connected, and networked learning activities. In the first year, the development of connectedness capabilities will be supported by a highly scaffolded curriculum, moving progressively towards more authentic and student-led activities. Specifically, the curriculum is intended to enable students to graduate with (1) a functioning professional social network and the ability to form and maintain professional relationships, (2) digital career literacy, and (3) the ability to apply their connectedness capabilities in the innovation economy and society.

In advance of introducing a course-wide approach to graduate employability we have recently embedded an employability module into the core curriculum in the third and final year of the course in the Human Physiology and Anatomy major. The module is comprised of research into future study and careers which is assessed via an oral presentation, creation of a LinkedIn profile, networking with professionals in the field via the LinkedIn profile, reflection and evaluation of employability strengths and weaknesses, and a goal setting exercise designed to enhance employability. We will present preliminary data on student performance in the module, as well as student feedback and staff observations.

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POSTER 3

EVALUATION OF AN INTERACTIVE E-BOOK AS AN EFFECTIVE RESOUCRE FOR STUDENT ENGAGEMENT AND LEARNING IN ANATOMY

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KEYWORDS: e-book, Anatomy, engagement, learning

BACKGROUND

Use of E-books (or electronic textbooks) is increasing in tertiary education, and are starting to replace conventional paper textbooks. E-textbooks have several advantages over conventional paper textbooks, including portability and being able to incorporate interactive mediums (sound and videos). Additionally, if academics develop their own E-books, they can only include material that is very specific for their subject, have links to relevant websites, and include practice tests (Alkadi & Johnson 2009). However, it is very time consuming for academics to generate their own e-books, and there is limited evidence on the effectiveness of using E-books as a teaching resource in tertiary education.

Thus, it comes as no surprise that current literature shows little uptake of e-books in tertiary education (Chong 2008). Empirical data is needed to demonstrate the effectiveness of E-Books in tertiary education.

AIMS

To determine if using an E-book providing resources for 5 Embryology systems improves student engagement and learning in Anatomy - a challenging and under-resourced subject.

DESCRIPTION OF INTERVENTION

James Cook University (JCU) health students were given access to either a textbook OR an E-book and textbook on Embryology that covered 5 systems: cardiovascular, respiratory, digestive, urinary and reproductive.

DESIGN AND METHODS

In 2017, weekly 3-hour Anatomy practical classes on each of the 5 Embryology systems, a non- randomized, cross-over trial design compared JCU Biomedical Sciences & Medical student (n=85) learning when using the textbook resource only to their learning when using both E-book AND textbook resources.

The practical class was split into 2 groups. For the first 20 minutes, each group used either just the textbook OR the E-book + textbook resources to study a component of the embryology teaching for that week, then completed a 5-minute survey on their learning experience. Students then 'crossed over' and swapped resources with the other group, and similar to the first 20 minute session, they continued to study the embryology teaching materials for 20 minutes using the available resources, then filled out an identical 5-minute survey.

Survey data was entered into SPSS version 22, and analyzed using 2-sided paired T-tests.

RESULTS

Male students found using both the E-book and textbook resources significantly enhanced the quality of their learning experiences ($p<0.001$), their level of engagement with the resources ($p<0.001$) and their overall enjoyment of learning the Embryology systems ($p<0.001$), compared to when they just used the textbook resource. Female students found using both the E-book and textbook resources significantly enhanced the quality of their learning experiences ($p<0.004$), and their overall enjoyment of learning the Embryology systems ($p=0.024$), compared to when they just used the textbook. Findings are summarized in the Table 1.

Table 1: James Cook University health student perceptions (a total of 179 female and 118 male students over the 5 weeks) of the learning environment across 4 weeks of system Embryology when using 'textbook only' or 'E-book AND textbook' resources, as rated out of10 between 0 ('nonexistent') to 10 ('fantastic')

	Textbook only mean ± (S.D.*)	E-Book and Textbook mean ± (S.D.*)	p-value[#]
Overall quality of learning experiences from resources provided in the Embryology of the system topic Male Female	6.9 ± (1.5) 7.4 ± (1.6)	7.7 ± (1.4) 7.7 ± (1.6)	**<0.001** **0.004**
Overall level of interaction with peers using the resources given (e.g., discussion of ideas, etc) Male Female	7.0 ± (2.0) 7.2 ± (2.1)	7.3 ± (1.9) 7.2 ± (2.1)	0.126 0.871
Level of engagement in using the resources provided Male Female	6.9 ± (1.8) 7.4 ± (1.7)	7.7 ± (1.6) 7.7 ± (1.7)	**<0.001** 0.056
Your overall enjoyment of the Embryology system topic over the last 20 minutes of practical class Male Female	6.9 ± (1.8) 7.6 ± (1.6)	7.7 ± (1.5) 7.8 ± (1.6)	**<0.001** **0.024**

CONCLUSIONS

Use of Embryology E-books significantly improved students' learning experiences in the Anatomy practical class across 'overall quality', 'level of engagement with the resources' and 'overall enjoyment of learning Embryology' (though not 'level of interaction with peers'). In particular, the E-book resource made most difference to male students' quality of learning experiences, engagement with resources, and overall enjoyment in learning across the weekly Embryology topics.

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POSTER 4

EVALUATION OF CURRENT TEACHING PRACTICES AND APPROACHES TO TEACHING IN THE SCHOOL OF BIOMEDICAL SCIENCES AT MONASH UNIVERSITY

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KEYWORDS: teaching practices, lectures, barriers

BACKGROUND

The traditional teaching style in higher education is didactic. However, the current literature states that student learning improves when students are active players in the process, triggering the move to implement active learning (AL) within the curriculum. Accordingly, Monash University introduced the "Better Teaching Better Learning" (BTBL) agenda to deliver a more student-centred learning experience. However, its implementation has been inconsistent within the School of Biomedical Sciences (SOBS).

AIMS

With the current literature supporting the benefits of AL within higher education lectures and the inconsistent adoption and implementation of the Monash University's BTBL agenda within SOBS, this study aimed to evaluate current SOBS academics teaching practices and approaches, identify barriers that prevent academics from incorporating AL within lectures and identify strategies to help academics overcome these barriers and implement the BTBL agenda within lectures.

DESIGN AND METHODS

The study design consisted of surveys (57 participants) and interviews of SOBS academics. Both surveys and interviews examined current teaching practices in lectures and identification of strategies to support incorporation of AL in lectures. Semi-structured interviews were conducted with four academics who were, representative of the survey data and of different academic levels, to obtain deeper insight into teaching approaches and practice.

Survey respondents were stratified based on: academic position, number of years teaching in higher education and number of lectures delivered per year. The survey quantitative data were coded and two-tailed t-tests were used to determine if there were significant differences between the academic stratifications. The coding process was used to thematically analyse the interview transcripts to identify major themes.

RESULTS

The results focused on the two main teaching groups within SOBS: Teaching and Research (T&R) academics and Education-focused (EF) academics. EFs generally incorporated more AL practices into lectures compared to the T&Rs. Many academics were in the process of changing their teaching practices, mainly to increase student engagement, learning, and active participation. Complex barriers such as lack of time and recognition for teaching efforts were identified from the interviews. Several strategies such as more recognition for teaching efforts and assistance from education designers were identified that would help academics incorporate more AL practices in their teaching in lectures.

CONCLUSIONS

Academics within SOBS at Monash University use a variety of teaching styles in lectures, with EFs employing more AL practices than T&Rs. Many academics were in the process of changing their teaching style, mainly to improve the overall student learning experience. However, complex barriers prevent them from doing so. Possible strategies were identified that would help academics adopt a more student-centred teaching style and align with Monash's BTBL Agenda.

POSTER 5

DO STUDENTS AND STAFF SEE ASSESSMENT THROUGH THE SAME EYES?

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KEYWORDS: Assessment, Feedback, Students

BACKGROUND

The Biomedical Science degree at Monash University recently became a pathway for entry to graduate medicine. This has had an effect on assessment in the course. Students have become strategic in their learning, focusing on assessment and challenging staff about grading. The situation has tested the student-staff relationship and suggests that we do not have a good grasp of what students and staff expect with respect to assessment.

AIMS

The aim of this research was to evaluate staff and students' conceptions of assessment to determine if there is a mismatch which may serve as a starting point for assessment reform.

DESIGN AND METHODS

A Conceptions of Assessment Questionnaire (Brown, 2011) consisting of 27 items using a 4 point Likert scale was administered to staff and final year Biomedical Science students via SurveyMonkey. Responses were analysed using SPSS. A Mann-Whitney U Test was used to determine significant differences between staff and students responses.

RESULTS

The response rate for staff (n=18) was 55.5% and for students (n=92) was 69.6%. Students gave a significantly higher rating than staff to all items on the survey that related to assessment as an indicator of institutional quality (2.92 versus 2.27). Students also gave a higher rating to the item "assessment is assigning a grade to student work" (3.25 versus 2.72, $p<0.021$). Staff and students were in agreement with the role of assessment in ranking students and determining if a student has met qualification standards.

Students and staff conceptions were similar for items relating to the integrity of assessment. There was a significant difference in the views regarding the use of assessment in modifying ongoing teaching practices. Fewer students agreed that ongoing teaching was modified by assessment information (2.75 and 3.18, $p<0.040$) and more students agreed with the statements that "Assessment is unfair to students" (2.06 and 1.64, $p<0.017$), and that "Lecturers should take into account the errors and imprecision in all assessments" (3.20 and 2.82, $p<0.013$).

CONCLUSIONS

There was general alignment of students and staff with respect to their conceptions of assessment. Areas of discrepancy related to the use of assessment as an indicator of institutional quality and its use to modify ongoing teaching. Students did not think that assessment information impacted on teaching or modified ongoing teaching practices. This data indicates a need for staff to better articulate the use of assessment in shaping teaching practices.
Another area of discrepancy included items associated with the fairness and accuracy of assessment. Data from these items contrasts that given by students on the trustworthiness, consistency and dependability of assessment results. Further research is needed to clarify this aspect. The data presented here is a pilot study. Further quantitative and qualitative data from students across the degree program is currently being gathered. The results of this study may be used to inform assessment practices in higher education.

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POSTER 6

SCIENCE INQUIRY IN UNDERGRADUATE PHYSICS LABORATORIES: COMPARING STUDENT EXPECTATIONS AND EXPERIENCES

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KEYWORDS: Inquiry learning, graduate attributes, assessment

BACKGROUND

Scientific inquiry is fundamental to scientific progress, enhancing the development of vigorous evidence-based thinking and analysis which is applicable in all areas of life. As part of their undergraduate degrees, university science students are expected to encounter and develop scientific inquiry skills (Familari et al., 2013). In particular, the undergraduate laboratory program is placed as one of the main vectors through which students acquire these skills.

How, then, do we evaluate the development of these scientific inquiry skills? As the focus on the quality of STEM education and workplace-ready graduates intensifies, tools must be developed in order to evaluate students on scientific inquiry skills. While studies have been conducted in biology on these aspects (Salter & Atkins, 2014; Varsavsky, Matthews & Hodgson, 2014), the area of undergraduate physics education in Australia has had minimal evaluation of the development of scientific inquiry skills in students.

AIMS

Our work focused on the development and refinement of a survey instrument that explored the following aspects:

- What were the student's expectations of the undergraduate physics laboratory program from the perspective of scientific inquiry as they entered university?
- What were their experiences after partaking in the program during their first year of the undergraduate science degree?
- How did it compare to their expectations?

DESIGN AND METHODS

Two prototype survey instruments, containing 34 Likert-scale questions based on the Advancing Science by Enhancing Learning in the Laboratory (ASELL) Laboratory Program Evaluation survey were developed in early 2015; focused on the Science Threshold Learning Outcomes. One was developed focusing on student expectations of undergraduate physics laboratory programs; the second focused on student experiences of the program in that semester.

First year physics students at the University of Sydney were given the surveys in three instances:

- The expectations survey at the beginning of Semester 1 2015, before starting the laboratory program, with 924 responses;
- An experiences survey was conducted at the end of Semester 1 2015, with 872 responses; and
- A second experiences survey was conducted at the end of Semester 2 2015, with 336 responses.

Exploratory factor analysis was conducted on the expectations survey instrument, using Principle Component Analysis and Varimax orthogonal rotation in SPSS.

PRELIMINARY RESULTS

From the expectation survey results, a potential base for a model of student expectations was developed, with a focus on generic graduate attributes (Cronbach alpha =.812) and science-specific skills (Cronbach alpha =.777).

In general, the surveyed students outlined optimistic expectations of the undergraduate physics laboratory program, including:

- The development of science-specific skills; and
- The development of more general skills, such as teamwork and communication.

Preliminary results from the experiences survey in Semester 1 indicate that student expectations were not matched by their experiences in the physics laboratory. The results of the validation of the survey instrument and the comparisons between student expectations and experiences in both semesters will be presented.

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POSTER 7

USING INTERACTIVE SIMULATIONS TO ENHANCE STUDENT ENGAGEMENT IN MATHEMATICS AND PHYSICS

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KEYWORDS: Active Learning, Simulations, Interaction

BACKGROUND

Students learning physics and mathematics at university level must develop an understanding of complex concepts underpinned by equations that form part of a physical model. In the past students have been expected to develop a 'mental picture' using diagrams and images in textbooks. Interactive simulations are one way that we can take the learning process beyond these traditional approaches. A good simulation allows a student to deeply engage with concepts in an interactive manner. Advances in internet technology and devices mean that such simulations can be easily delivered to students wherever they are conducting their study.

AIMS

This project examines the use of interactive simulations in teaching mathematics and physics to students across a range of undergraduate year levels. In particular we aimed to
•   Develop simulations and associated teaching packages targeted as specific learning activities in relevant classes in mathematics and physics
•   Implement these activities in our own classes and classes of our colleagues
•   Evaluate the effectiveness of the approach.

DESCRIPTION OF INTERVENTION

We have previously utilised interactive simulations as preparation for active learning classes (see Drinkwater et al, 2014, and McIntyre and Wegener, 2014). Here our team aimed to enhance the learning process by developing and implementing simulations supported with associated teaching packages leading to students completing an assessment task.

The simulations themselves were developed by team members using Javascript and Geogebra programming languages and were made available to students via the internet. Each simulation has a set of controls that students can manipulate. Students observe the outcomes in a visual display. They can also make quantitative measurements of relevant parameters in the simulation.

The associated teaching package was developed partly to provide guidance to students in how to use the simulation. The instructions generally suggest a number of exercises to become familiar with the simulation. This then led to an activity that was assessed, allowing students to demonstrate their understanding of the concepts involved.

DESIGN AND METHODS

In Semester 1 of 2017 we implemented simulations in a range of courses across mathematics and physics (see McIntyre et al, 2017). Each implementation was evaluated by using surveys completed by students after they had attempted the activity. The survey consisted of a set of statements to which students indicated the level to which they agreed or disagreed, along with a number of free-response questions. We also used Google Analytics to monitor access to the simulations.
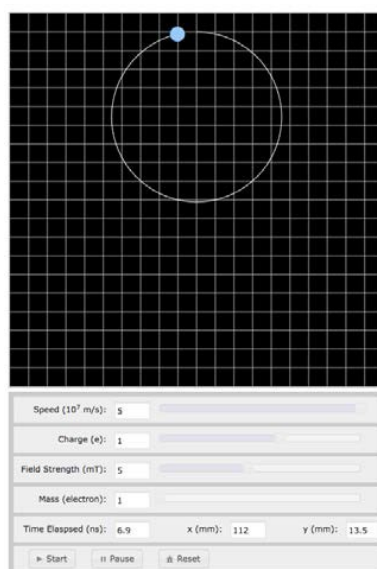
Figure 1. Simulation of motion of a charged particle in a magnetic field.

RESULTS

We report here results from the first-year course covering electromagnetism and modern physics. The simulation in this case dealt with the relationship between electricity and magnetism, investigating the motion of a charged particle in a magnetic field. A screenshot is shown in Fig. 1. Students were able to control parameters including the speed and mass of the charge as well as the strength of the magnetic field in which it moved. For the situation they set up, they could measure the elapsed time of motion and the position of the charge. The associated assignment asked students to discuss concepts and make particular measurements. In the advanced section of the question, students conducted a virtual experiment using the simulation.

The feedback received from students about their experiences with the simulation and teaching package was generally extremely positive. Over three-quarters of the class agreed or strongly agreed that the simulation 'helped me learn the concepts' and 'helped me to better visualise the concepts'. A similar percentage stated that they would like to use more simulations in courses in the future. Written feedback from students included comments such as 'It was good because Icould see what actually affected what in what way physically, instead of just reading about it' and 'Having an animated visual aid helped to convey key points related to the learning goals'.
The full presentation will cover results for implementations in Semester 1, 2017 in courses across mathematics and physics.

CONCLUSIONS

We have successfully introduced simulations and associated teaching packages in our courses to enhance student learning. Since its original inception, the project has expanded and is now used in classes taught by colleagues outside the immediate project team. Feedback from students indicates that the approach is successful in aiding understanding of the concepts involved. 'Visualisation' and 'interactivity' are indicated as important aspects that aid learning in both physics and mathematics. There are still improvements that can be made, including enhancing the interface and better targeting the teaching package to the student cohort on which it is used.

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POSTER 8

ASSESSMENT PRACTICES OVER A WHOLE DEGREE PROGRAM: WHAT DO STUDENTS' SEE?

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KEYWORDS: Assessment, Feedback, Students

BACKGROUND

Increasing student numbers and the need to be work ready or complete further study upon graduation have changed the assessment landscape in higher education. In the Biomedical Sciences students have become more strategic in their approach to learning, focusing on their assessment in order to meet the demands of further graduate study. The assessment environment significantly affects the learning environment of students, determining the quantity and quality of student learning. An important aspect of this environment is the quantity and quality of feedback received by students. National data from Australia has highlighted the dissatisfaction that students feel about the feedback that they receive during their undergraduate studies.

AIMS

The study aimed to explore undergraduate Biomedical science students' experiences of assessment and feedback across their whole degree.

DESIGN AND METHODS

An Assessment Experience Questionnaire (Gibbs and Simpson, 2004) was administered to final year Biomedical Science students. The questionnaire contained 27 closed and 6 open-ended questions relating to assessment and feedback experiences within the whole degree program. Closed questions used a 5 point Likert scale (1-strongly disagree, 5-strongly agree) and formed 9 categories; i) quantity of effort, ii) coverage of syllabus, iii) quantity of feedback, iv) use of feedback, v) appropriate assessment, vi) clear goals and standards, vii) surface approaches, viii) deep approaches and ix) learning from exams. Thematic analysis was used to group open-ended responses into broad themes.

RESULTS

The questionnaire was completed by 189 students. Students gave highest rating to "quantity of effort" (3.81) indicating that consistent work was required of them across the course. Lowest rating was given to "clear goals and standard" (2,44) where only 42% of students agreed that they knew what was expected of them. An average of 46% of students agreed that they received hardly any feedback and that feedback came too late to be useful. Surprisingly 67% of students stated that they learnt from exam preparation.
Five major themes with sub themes emerged from the qualitative data. Themes included: amount and timing of assessment (too many assessments), quality of assessment (good quality, more guidance wanted, relevance to course content), quantity and timing of feedback (too late), quality of feedback (more detail wanted), student response to feedback (generally helpful).

CONCLUSIONS

This pilot study provided a snapshot of final year Biomedical Science students' experiences with assessment and feedback. The results illustrate a need for academics to better communicate to students to goals and standards expected and to improve the quantity and timing of feedback provided. These findings were supported by the qualitative data obtained. An unexpected finding of the study was the positive rating given by students for their learning from examination preparation.

The findings of this study provides guidance for improvements in assessment practice and initiatives to meet the needs of students. Further research involving a broader sampling across multiple degree programs would help to identify and confirm positive and negative emerging trends in higher education assessment and feedback.

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POSTER 9

ONLINE LESSONS: AN EFFECTIVE AVENUE FOR CONTENT DELIVERY

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KEYWORDS: Online learning, Moodle Lesson, pre-work

Tertiary educators are progressively increasing their use of online lessons to deliver all, or some of, their content prior to face-to-face classes. Online lessons, run through university learning management systems (e.g. Moodle Lessons), offer a number of benefits including an avenue for educators to bring the necessary material together   in one easily accessible place. In providing content online in this way, students are encouraged to increase their responsibility for content acquisition, allowing educators to increase active learning opportunities during class. In addition, there is now a new generation of learners that are more techno-savvy (they just love their electronic devices), allowing educators to utilize this space for learning. Finally, timetable constraints and decreases in availability of lecture theatres provide additional reasons to investigate alternate modes of delivery of material, particularly online.

During 2016 and 2017, we have actively been working to incorporate content delivery via Moodle Lessons, to a range of student cohorts. This poster focuses on staff experiences of the use of online lessons and their reflections of their value and obstacles.

In general, Moodle lessons appear to be worthwhile and helpful for students to organise their learning. They offer a learning package, which not only allows educators to deliver content via text, but also via the inclusion of short videos and animations. The lessons can be constructed to break up student learning into short digestible chunks, which can formatively be assessed via the inclusion of MCQs.

In using Moodle Lessons, staff have commented that students appreciate the shorter videos (compared to full lecture recordings) as it allows them to easily revise specific content; students can easily revisit individual short videos as often as they like.

Students also seem to appreciate the MCQs, Mix and Match questions and True/False questions, allowing them the time needed to consolidate their understanding before moving onto the next chunk of information. From an educator's point of view, the use of Moodle Lessons to deliver all, or part of the content, provides valuable time within lectures/workshops/tutorials to involve students in greater amounts of active learning, including application of material, collaborative peer discussions and problem solving. It also frees up the curriculum to enable educators to provide greater amounts of feedback.

However, Moodle lessons can have some issues. They can be time consuming to create. At least in the first instance, academics find it time consuming to re-think their content, so that they can develop appropriate recourses, e.g. videos of a short duration; conversational text. There are also challenges associated with the logistics of navigating Moodle Lessons and learning how to establish the appropriate settings, however, most of these difficulties were easily overcome with help from IT and/or educational designers, and were most often only an issue until educators became familiar with the platform.

POSTER 10
EFFICACY OF WORKBOOKS IN FOUNDATION CHEMISTRY

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KEYWORDS: Resources, engagement, foundation, confidence, chemistry

BACKGROUND
The University of New England (UNE) Foundation Chemistry unit (CHEM100) is designed as a bridging unit for students undertaking science-based programs which have first year chemistry as a core requirement. Students at UNE come from varied backgrounds and many, having never studied chemistry before, find it challenging and intimidating. These students are also typically enrolled in applied life science degrees such as agriculture, animal science and zoology, and struggle to see the relevance of chemistry. Consequently, effective student engagement in Foundation Chemistry is a continuing challenge. CHEM100 has traditionally been taught online, but in 2016 an on-campus stream was introduced to cater for students who are mainly school leavers and have an agricultural science background and have not developed the confidence or ability to study a conceptually difficult unit online.

AIMS
The aim of the intervention was to enhance the learning experience through the use of Workbooks, leading to improved student engagement, attendance and confidence.

DESCRIPTION OF INTERVENTION
To address poor student engagement and attendance, the on-campus version was 'flipped' in 2017 and learning resources included a purpose-made Workbook to promote a supportive and active learning environment. The Workbook is a hardcopy resource containing a short summary of concepts, worked examples and exercises aimed at reinforcing the students' understanding of that topic. The exercises begin with questions similar to the worked examples before increasing in level of difficulty. A different Workbook was used for each module of a unit and they are all structured similarly. Our approach incorporated a 'mini-tutorial' at the beginning of each class (10-15 min), and following the mini tutorial, the students are asked to complete a set of focused questions linked to a learning objective. The Workbooks were designed as an accessible resource and reference guide that aimed to deliver core concepts, build confidence, and allowing the student to quickly identify the task at hand and engage with the topic, thus providing students with a clear framework of what they 'need to know.'

DESIGN AND METHODS
An online questionnaire was administered at the end of Trimester 1, 2017. Participants were the on- campus foundation chemistry students enrolled primarily in applied life sciences. The questionnaire contained Likert scale questions regarding the efficacy of the Workbooks in relation to engagement, confidence and attendance. Quantitative research methods will be employed to analyse the results.

RESULTS
There is a general agreement that Workbooks are useful resource to have in class. For first year undergraduate students with little to no prior knowledge of chemistry, having structured lessons guided by the lay-out in the Workbooks enabled students to quickly identify what they are being taught, and encouraged students to give problem-solving a go using worked examples. The ability tOsolve simple questions in the beginning gave students the confidence to continue working on more problems. Students felt encouraged to come to class knowing what to expect.

CONCLUSION
The incorporation of Workbooks improved student engagement with the unit through higher confidence in problem-solving, and an improvement in attendance.

POSTER 11

TEACHING-INTERESTED SCIENCE ACADEMICS: SCHOLARLY ACTIVITY ACROSS A RANGE OF ROLES

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KEYWORDS: academic role, education-focus, dissemination

BACKGROUND

University science academics who are involved and interested in teaching have a variety of roles (and corresponding viewpoints and priorities). To best advance science education, we need the greatest collective impact of scholarly work that investigates and develops science education. We should engage and support all who are interested in teaching, whether a person in an education-focused position, expected to be productive in SoTL, a Teaching-and-Research staffer interested in fulfilling teaching duties with optimal efficiency, an early-career academic who has been given some teaching responsibility and is willing to try new things, or some other position.

In recent times, emphasis on scholarly activity in science education has increased noticeably for some, with the professionalisation of university teaching (Ross et al, 2016). There have been efforts to encourage projects nationwide that develop science tertiary teaching, through substantial and seed funding (see, for example, Kirkup, 2013). The dissemination of the outcomes of such education projects has been recognised as problematic, but effective strategies have been identified (Gannaway et al, 2013).

AIMS

In a case study of the discipline of physics, we aim to explore the prevalence of scholarly practices and the range of experiences of those involved in university teaching. What factors, besides interest, affect the extent of involvement in a scholarly approach to teaching? How do physics academics come to an understanding of the principles of education? How do they become aware of and take on board teaching innovations? How is their scholarly work in physics education supported? We seek to identify effective practices that can be used more widely in helping to progress science education.

Our research questions are motivated by the following observations:

- Induction – Academics generally move into science education research from their "home" discipline, rather than training in it.
- Isolation vs community discussion – SoTL workers are often scattered, with only one or two staff with these priorities per discipline in an institution. Research groups usually provide support and discussion environments. At broad national conferences, such as AIP Congress, many types of physics professionals are exposed to discussions about modern physics education.
- Workforce – Postgrads (students and postdocs) are the engine of research work, driven by lead investigators. Postgrads in SoTL have been rare in Australia. Research assistants can fulfil some of this role; this implies funding is vital.
- Opportunities for "experiments" – Implementing teaching developments depends on course offerings and co-operation of colleagues.
- Recognised outputs and impact – Traditional research outputs have very defined audiences. Influencing the more numerous non-teaching-specialist staff is important to achieving widespread change.
- Funding - External funding for this type of research has an uneven history in Australia.

METHOD

We are surveying physics university academics who have an interest in education and best-practice physics teaching. We include academics with teaching-research balanced roles and teaching-focused positions. We are targeting participants who have professed their interest through their membership of the education special interest group of the national physics professional society (more than 300 currently). Non-members are also invited to participate.

A survey instrument has been designed to explore the extent to which science academics engage in scholarly work about effective teaching of tertiary science. This probes their practices and experiences, whether they are doing original research in this area or using the work of others.

FINDINGS

We will present analysis of the survey results for academics in Physics. We expect to uncover issues specific to education-focused positions, and to find broader implications. These may inform a future workshop on useful practices. In supporting a scholarly approach to science education, we expect that findings from this case study will be useful for other science disciplines.

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POSTER 12

STEM GRADUATES AS DIGITAL CREATORS: COMPUTATIONAL THINKING FOR TWENTY-FIRST CENTURY EMPLOYABILITY

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KEYWORDS: Computational thinking, Digital literacy, STEM curriculum

Technology-led disruption of the workforce is a pressing issue for future employability, with up to 47% of the current US workforce (Frey & Osborne, 2013) and 40% of the Australian workforce (CEDA, 2015) at significant risk of automation or mechanisation in the next 20 years. The consequences of mass computerisation and mechanisation of some sectors of the workforce are twofold: firstly, that for graduates to remain employable they must possess both the skills and resilience necessary to adapt and adopt technological advances in their profession; secondly, employers will favour university graduates that possess computational and data analysis skills that transcend extant disciplinary silos. This creates a curricular landscape where technological agility of future graduates is necessary, and thus they develop skills in digital literacy in their chosen profession.

There is a strong sense that our current generation of STEM students have a high level of behavioural utility with technology (Prensky, 2001), though without the cognitive skills necessary to harness this fully for their future employability (Ghaith, 2010). Here we will focus on these cognitive skills and use the term 'computational thinking' to describe an important element of digital literacy. Computational thinking was first coined by Papert (1996), often attributed to Wing (2006; 2008), and was expressed by Aho (2012) as "…the thought processes involved in formulating problems so their solutions can be represented as computational steps and algorithms" (ibid, p 832). Importantly, "the goal is to use computational thinking to forge ideas…" (Papert, 1996, p 116) and is not necessarily to think or behave as a computer scientist (Barba, 2016).

Computational thinking is a key element of future graduates' employability (Barr, Harrison, & Conery, 2011) and an emerging priority in K-12 schools' curricula (Grover & Pea, 2013, Furber, 2012, ACARA, n.d.). To further advance students' potential for computational thinking some universities are offering courses for students from outside traditional STEM disciplines to develop their computational thinking (e.g. Beacock, 2015; Wood & Bix, 2014). However, these courses are often elective and are not well- integrated into the curriculum (Voogt et al., 2013).

We will focus on the application of 'computational thinking' in the chemical sciences, giving relevant examples of its application in our context and charting its development throughout the curriculum. We will also invite you to participate in this research, by helping us collect evidence of validity of our findings, and contribute your ideas about this emerging priority area in our curriculum.

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POSTER 13

BIG DATA - MAXIMISING THE TEACHING AND LEARNING OPPORTUNITIES FOR HIGHER EDUCATION SCIENCE STUDENTS

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KEYWORDS: Data visualisations, Learning Analytics, Pedagogical intent & practice

BACKGROUND

It has become increasingly important to collect institutional data to measure and evaluate teaching and assessment improvements and to evidence quality assurance for both internal policy obligations and external review (TEQSA). However, how this data is presented, reported and targeted to individuals at various levels is of equal importance in ensuring that the correct decisions are made to maximise the student learning experience.

AIMS

The primary aim of this work was to see how best to provide analytic data on subjects and courses at the University of Wollongong to staff and committees for monitoring and quality assurance improvement. This presentation aims to explain how effective this has been and what lessons others can learn from this experience.

DESIGN AND METHODS

The group have targeted the review and presentation of data for quality assurance purposes across the institution, for processes including:

1) Faculty and School assessment committee meetings
2) Subject monitoring reporting
3) Comparative student outcomes
4) Annual and 5 yearly course review processes
5) Annual collaborative partner (third party provider) reviews

Specifically, the group has been looking at the types of data captured, data display formats for different audiences, its timing and method of delivery and how data reports can be targeted to particular end users. The group will also review the process for closing the loop and following-up on outcomes, improvement actions and recommendations.

RESULTS

The group has so far looked at the data needs of 1) assessment committees, and 2) subject monitoring, for internal quality assurance purposes and in relation to the revised Higher Education Standards Framework. In particular the group has focused on what changes are required to ensure all relevant data is captured, the method of delivery of this data (hard vs soft reports), the timing of the data collection and making it available at key points within the academic cycle. These data contain valuable teaching and assessment information for academics, part-time teaching staff and professional staff on students' engagement, motivation and progression in courses of study. The premise behind this work is that the higher the quality of the data provided the more informed will be the quality enhancements.

CONCLUSIONS

Consensus is slowly being obtained for the type and form of data for each of the five processes. This consensus may be challenged as consultation is widened to include more stakeholders. University managers will need to be convinced of the worthiness of this work so as to allocate sufficient resources to make this happen. However, the concepts explained in this presentation have so far been received enthusiastically by all participants and demand for such data reporting is strong.

POSTER 14
EXTENDING AND SUSTAINING WORK-INTEGRATED LEARNING IN SCIENCE

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KEYWORDS: work-integrated learning, curriculum, participation, Faculty strategy

Concerns have been raised about lack of alignment between university science degrees and future employment (Chubb, 2014). Work-integrated learning (WIL) is curriculum that is designed to embed the world of work inside student learning: and is recognised as a key mechanism to build graduate employability (Universities Australia et al. 2015). However, participation in WIL in science is less common than in partner disciplines, such as engineering and agriculture (Edwards, Perkins, Pearce, & Hong, 2015). To rapidly implement change in this crucial area, science faculties need the what, where, when and how of WIL translated to their context. The Australian Council of Deans of Science has led efforts to improve science student participation in WIL through focus on faculty leadership and building capability for science teaching teams. The initial leadership project funded through the Office of the Chief Scientist explored strategies to support faculties. It identified the need for tailored advice and resources recognising that science faculties are at different levels of readiness, ranging from little or no systematic adoption of WIL, through to significant investment and support for WIL strategies (Australian Council of Deans of Science, 2017). The following 'Successful WIL in Science' project draws together complementary strategies to address this complex challenge. It builds upon existing resources to provide targeted advice to Faculties and WIL teachers; includes research to incorporate the voices of students; uses industry consultation to design advice for closer industry partnerships; and draws on the experience of WIL specialists from science and other disciplines. The project is exploring a peer support model co-ordinated at national and local levels. Work so far, suggests that cultural shifts on the part of both staff and students are needed in concert with supporting structures at Faculty and University levels. However, the development of peer-to-peer relationships and expertise through case studies has provided a foundation for good practice: which we seek to extend and sustain through the development of larger communities of practice.

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POSTER 15 (POSTER BITE)

NURSING STUDENTS ARE MORE RELIANT ON ONGOING ASSESSMENT SCORES TO SUCCEED IN BIOSCIENCE AND PHARMACOLOGY THAN PARAMEDIC STUDENTS

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KEYWORDS: nursing and paramedic students, bioscience, pharmacology, ongoing assessment, examinations

BACKGROUND
Ongoing assessment and examinations are often used to test different aspects of learning with examinations testing the assimilation of knowledge and ensuring that the students complete the work themselves. However, the proportional allocation of marks for ongoing assessment and examinations is often made on an arbitrary basis, and the consequences of this are not known.

AIMS
The aim was to determine the success of students in ongoing assessment and examinations. Thus, we determined this for nursing and paramedic students who passed bioscience and pharmacology units in 2014.

DESIGN AND METHODS
In both second year bioscience and pharmacology units for nursing and paramedic students, 40% of total marks were allocated to ongoing assessment and 60% to examinations. The marks for each student who passed the unit in the two components were calculated as a percentage and compared by Students paired test. Students who achieved less than 50% in each component were considered to have failed the component. Failure rates were compared by Odds ratio. In the Table below, significance is at *$P < 0.05$; the number of students is also indicated (n).

RESULTS
Both nursing and paramedic students obtained significantly better marks in ongoing assessment than exams in the bioscience unit. A significantly higher percentage of nursing, but not paramedic, students failed the examination than the ongoing assessment component of the unit. Similar results were obtained in the pharmacology unit for nursing and paramedic students.

CONCLUSIONS
The nursing students who passed the bioscience and pharmacology units were more reliant on scores obtained in ongoing assessment. The students, who passed the unit but not the examinations, may not have assimilated the necessary knowledge to continue in their courses. Additionally, some of the passing students may have succeeded due to work done by others in ongoing assessment.

POSTER 16 (POSTER BITE)

DOES ATTENDING BIOSCIENCE LECTURES MATTER, WHEN LECTURE RECORDINGS ARE READILY AVAILABLE?

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KEYWORDS: bioscience, nursing students, lecture attendance, lecture recordings, academic outcomes

BACKGROUND

Before the introduction of technology into teaching, it was assumed by many teachers that grades were related to lecture attendance; students who attended classes more frequently, obtained better grades. A major review conducted by Credé et al (2010), and two studies of nursing students studying bioscience (Hamen & Kelland, 1994; Brown et al, 1999) supported this. However, there have been no studies of the effects of lecture attendance on academic outcomes for nursing students in bioscience since the extensive use of lecture recordings, which may have led to further reductions in lecture attendance and/or better results for non-attending students.

AIMS

To determine the effect of lecture attendance on academic outcomes in bioscience for nursing students provided with access to lecture recordings. The study was undertaken in 2013/4.

DESIGN AND METHODS

In a first year bioscience class, prior to the start of lectures on gastrointestinal bioscience or microbiology, attending students provided their ID numbers upon submission of a short quiz, as part of another study. The academic outcomes for attending and non-attending students in the tutorial assessment (40%), examinations (60%), and Grade Point Average (GPA) were compared by Student's unpaired t-test with $*P < 0.05$ (Table); the number of students is also indicated (n).

RESULTS

The uptake of lecture recordings and lecture attendance was high at start of the semester, but then declined. Only a third of the nursing students attended the gastrointestinal and microbiology lectures late in the semester. Attending students obtained better outcomes in the tutorial assessment, examinations and GPA.

CONCLUSIONS

As nursing students attending bioscience lectures have better academic outcomes than those that do not attend lectures, this suggests that it is still important to provide face-to-face lectures.

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POSTER 17 (POSTER BITE)

STATISTICAL ANALYSIS OF ACADEMIC RESULTS IN A FIRST-YEAR ON-CAMPUS AND ON-LINE PHYSICS UNIT

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KEYWORDS: online learning, physics teaching, distance education

ABSTRACT

Online education in science has increased dramatically in the past 15 years. The number of online university units taught has also seen an explosion in numbers worldwide. In spite of this, there are relatively few online units in physics offered both in Australia and elsewhere. Deakin University has offered a complete Bachelor of Engineering course in online/distance mode since 1991, one of only four such Australian universities to do so (Long, Joordens and Littlefair, 2014). The course is accredited by Engineers Australia, and is recognized worldwide by the Washington Accord. A key first-year unit in this course is SEP101, Engineering Physics. This unit has been taught to both on-campus and off-campus students since 1996. The unit content and techniques of delivery have undergone significant development over the years, including "flipping the classroom" in the on- campus teaching mode (Long, 2015).

The author's previous presentation to this conference outlined how the advances in distance education were applied to this unit (Long, 2013). In this paper, for the same unit (SEP101 Engineering Physics), we present a statistical analysis of the students' academic performance over a 20-year period. We examine all the assessment associated with the unit – assignments, practicals, and the exam, for over 4000 on-campus and online students. Our current work concludes that as far as final numerical grades are concerned, there is no statistically significant difference between the overall academic performance of on- campus and online students. This work shows that in a first-year physics unit, it is possible to teach to both on-campus and online students, producing the same learning outcomes for both cohorts.

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POSTER 18 (POSTER BITE)

PARTNERSHIP TEACHING IN A FIRST-YEAR LIFE-SCIENCES PHYSICS UNIT

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KEYWORDS: physics teaching, education partnerships

ABSTRACT

Since the 1990's, tertiary education in Australia has seen the rise of private-public partnerships. This trend accelerated after the Rudd Labor government prohibited Australian universities form enrolling full-fee paying domestic students. Typically, a private education provider forms a partnership with a university to teach the first year of a course on a fee-paying basis. Students who complete the program are awarded a tertiary diploma, which they can use as credentials to gain admission to the corresponding course at the parent university, or elsewhere.

Deakin College (formerly the Melbourne Institute of Business and Technology) has had a teaching partnership with Deakin University for many years. Starting with business courses, Deakin College has branched out into science, engineering, IT, and health. Deakin College is owned by the Navitas group, which conducts such partnerships worldwide. The Deakin College Diploma of Science is a one-year fee-paying course that directly articulates into the second year of Deakin University's BSc course. The course caters to both domestic and international students.

One core unit in the Deakin College Diploma of Science and Deakin University's BSc is SEP122, Physics for the Life Sciences. This unit is a one-semester overview of physics for life-science students. It is algebra-based, and covers basic mechanics, fluids, waves, optics, electricity, and modern physics. The syllabus is the same for both institutions, the practicals are identical, but the teaching methods are slightly different. Both institutions offer this unit on two campuses (Melbourne Burwood and Geelong). Deakin College's offerings of this unit are moderated by the corresponding unit leader in Deakin University. Both units are designed to yield the same learning outcomes.

This paper presents a comparison between Deakin University's and Deakin College's offerings of the same unit. The teaching methods, text material, and assessment are presented. We then compare the relative academic performance of the two. We also present the similarities and differences in academic performance of the two cohorts as measured over a six-year period.

POSTER 19 (POSTER BITE)

COMBINED 2ND YEAR PRACTICALS – INNOVATION AND CHANGE WITHIN THE SYSTEM

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KEYWORDS: practicals, molecular biology, curriculum

This poster describes the maturation, challenges and success of our "Pracs ABC system", which represent a common practical component for undergraduate students enrolled in any of the Level II science courses: Biochemistry, Genetics, Microbiology and Immunology. The Pracs ABC system was conceived in response to department mergers and a new building; this brave new world brought with it a reduction in undergraduate teaching laboratory space, triggering the innovative redesign of practical components from multiple courses. Our novel approach was to implement a common practical series, working within existing course structures and without substantial change to learning objectives, and thus with no change to degree structures. By working within the system in this way, we could focus on giving students the best practical experience we could offer to second year students in the subject areas of BIOCHEM, GENETICS, and MICRO. The methodology of these cognate disciplines is based on molecular biological approaches, and thus there is a suite of fundamental technical approaches relevant to students of any of these courses and the majors they contribute to.

Prac A: Fundamental Lab Skills is done by all students enrolled in any course within these three subject areas. Prac A was established to provide a single vehicle for the learning and teaching of essential practical aspects, which include techniques and equipment handling, and also results interpretation and experimental design. The emphasis for Prac A is thus on achieving a solid "practical experience" in the core themes that are essential in the modern practice of each discipline. Students enrolled in more than one of these courses also do Prac B: Applied Lab Skills. Prac B offers breadth and depth beyond the scope of Prac A and aims to deliver an extended molecular biology experience, focusing on additional methodologies to suit students who are engaged with more than one of the disciplines. Prac C: Experimental Design is done only by students enrolled in all three subject areas. These students are committed to majors centred in molecular biology and biomedical science, promoting synthesis of curricula from different courses, since it is only within a Prac C class that all students have a common course enrolment set.

Pracs ABC is a complex, interconnected endeavour with many conflicting pressures and multiple stake-holders. A fitting analogy is that of a large ocean liner: complex to launch but efficient once underway, with substantial momentum and yet requiring continual management, but sluggish to respond to even necessary changes. Here we give an honest presentation of the Pracs ABC system: how we work to satisfy academic equity and logistical issues, and how we implement our pragmatic philosophy of making the most of everything we do, whilst avoiding a crowded curriculum or too-heavy student workload.

POSTER 20 (POSTER BITE)

MAKING ONLINE PRE-WORK ACHIEVABLE AND WORTHWHILE

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KEYWORDS: Pre-work, student engagement, student motivation

In today's tertiary environment, the massification of education and resulting increased pressures on physical teaching spaces has encouraged academics to consider alternate approaches for content delivery. One approach that reduces the number of lectures is the introduction of online pre-work. Online pre-work not only addresses space issues, but also has important educational benefits. For example, removing didactic delivery of content from class time, frees-up the curriculum for greater amounts of active learning (Seery, 2015). Despite the benefits, many academics are left wondering how to maximise student engagement with the pre-class work. Let's face it, if students fail to come to class prepared, it is difficult to move forward with the planned activities. Consequently, when taking a blended approach via the inclusion of pre-work (e.g. flipped classrooms), it is important that the pre- work is designed in such a way that students perceive it be both achievable and worthwhile.

In 2016, we flipped two first year bioscience units, using online pre-work to deliver content to allied health students. By eliminating the didactic content delivery from lectures, we were able to increase our small-group face-to-face time and active learning. Content which was previously didactically delivered in lectures, was provided to students as pre-work in the form of conversational text and short videos (recorded by the teaching staff) and made available to students via a platform on our online learning management system (Moodle lesson). This allowed us to spend more time in class with students while they worked at higher levels of Blooms taxonomy to extend, apply and consolidate their understanding of the online material.

To encourage adequate preparation prior to face-to-face classes, we set a compulsory 80% hurdle requirement on pre-work completion and tested student knowledge at the start of each of our workshops. Students completed a short summative quiz (worth 1% each week) in engineered groups that encouraged collaborative learning and increased their sense of responsibility to engage fully in pre-class materials. Over the course of a semester, 96.5% of students completed their pre-work prior to their first class each week, which we believe led to increased student understanding and engagement in class activities.

Based on evidence gathered from our surveys, student written reflections and focus group discussions, we will present successful strategies that were employed in and out of class to encourage students to engage in pre-work. In addition to this, we will discuss some of the underlying educational theories that we believe may have contributed to the success we experienced.

POSTER 21 (POSTER BITE)

ENGINEERING TECHNOLGY: THE MISSING STEM SUBJECT

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KEYWORDS: STEM Education; Curriculum; Secondary Education; Primary Education

ABSTRACT

Science, Technology, Engineering and Mathematics are represented in the Australian Curriculum, but only English, Mathematics, Science, Health and Physical Education are required to be taught as individual subjects (Australian Curriculum, Assessment and Reporting Authority, 2012). From foundation to year 10, all other topics can be taught in any combination consistent with the guiding principles of an individual school (Victorian Curriculum and Assessment Authority, 2015). Recent interest in Australia and elsewhere for STEM education beyond the traditional topics in mathematics and science (Office of the Chief Scientist, 2013, Office of the Chief Scientist, 2014) has revealed gaps in the Australian curriculum around engineering and technology. This may reflect a systematic weakness in innovation: Australia is ranked 81st in the conversion of raw innovation capability into business outputs related to growing wealth: new knowledge, better products, and creative
industries. While the existing design and digital technologies curricula provide some framework for educating in engineering and technology, the ability for any given school to implement varies widely depending on the facilities available and the proficiency in appropriate pedagogies.

One solution is to create a standalone 'Engineering Technology' subject in years 5-10 based upon three core components:

1. Linking the engineering technology curriculum to the content studied in science and mathematics subjects;
2. Orienting the focus of engineering technology towards the priority research focus areas of Australia and local industry, and
3. Making the engineering technology curriculum directly relatable to the human consequences and outcomes for all content.

We describe the proposed solution in detail, including evidence that such a subject will educate our students in engineering and technology for the 21st century by linking with local industry, and thus making engineering technology relevant for the teachers, students, and the traditional science and mathematics curriculum. The design mirrors that of the Australian Curriculum, avoiding a 'one size fits all' approach to what each school can teach, but guides schools to identify and exploit existing local facilities and partnerships. Particular attention is given the possible benefits in employability in Rural and regional areas.

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POSTER 22 (POSTER BITE)

"I'VE DONE THIS. LET ME SHOW YOU." DEVELOPING STUDENT-DESIGNED RESOURCES FOR TROUBLESOME STEM CONCEPTS.

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KEYWORDS: students as partners, peer facilitation, online learning resources

PROBLEM

In view of the growing demand for high quality STEM graduates, many institutions are explicitly committed to strengthening the STEM learner experience. At QUT, the STIMulate program strives to provide quality support-for-learning opportunities for all coursework students. A key strength of the program is the depth and breadth of STEM expertise in the volunteer Peer Learning Facilitators (PLFs) who provide drop-in assistance to large numbers of students. Social constructivist learning theory suggests that such peer support facilitates the growth of understanding and transfer of learning across contexts (Hunt & Chalmers, 2012) while removing barriers to learning for some students (reviewed in Hilsdon 2014), which, at the institutional level, translates to improved student progression and retention (Thomas, 2012). At present STIMulate primarily delivers support face-to-face during business hours, presenting a significant barrier to participation for some students. Despite targeted PLF recruitment to meet need, and systematic scheduling to improve access, demand occasionally outstrips supply and ongoing expertise is not always available in specific areas.

PLAN

Drawing on the experience of PLFs, this project sought to identify troublesome concepts frequently encountered in the STIMulate drop-in space and to employ a 'Students as Partners' model (Healy et al., 2014) to design and develop a series of short video tutorials to around these themes. Harnessing the student voice and perspective would help create resources that can potentially address the learning needs of a diverse student population, while partnering with academic support staff would potentially assure the quality of the resources and allay concerns of academics around accuracy of content (Croft et al., 2013).

Availability of online resources facilitates a flexible and equitable learning environment, enhancing learning outcomes for consumers (Jordan et al., 2015). A number of studies report that the key beneficiaries of student-generated content are the producers themselves, as participation is in itself an engaging and authentic learning experience (Kearney and Schuck, 2006; Biza and Vande Hey, 2014). Hence this project is expected to improve the learner experience of both producers and consumers.

ACTION

Experienced PLFs identified concepts that they often helped students with, focusing on topics that were relevant to multiple courses and potentially suited to explanation through videos. Seven PLFs were selected from expressions of interest to develop videos in: scientific notation, ordinary differential equations, conditional probability, muscle movement, balancing chemical equations, solution chemistry, and pointers and structures for programming. Each PLF was matched with a staff Member to provide support as required, but PLFs retained leadership in design and production. Final videos were reviewed by library support staff and discipline academics prior to being released on the STIMulate Community Blackboard.

REFLECTION

PLFs utilised different approaches to produce videos which received positive feedback from reviewers. Producers described a deepening of their content knowledge, development of metacognitive skills and learning video production skills. All found that production took significantly longer than expected. During the process, STIMulate academics struggled to identify the level of direction they should provide to ensure quality without silencing the student voice. To allow flexibility, staff adopted a relaxed approach to timeframes, however in follow-up discussions PLFs expressed a preference for explicit deadlines.

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POSTER 23 (POSTER BITE)

AN INVESTIGATION INTO STUDENTS' STRATEGIES AND PITFALLS FOR SOLVING ELECTROPHILIC AROMATIC SUBSTITUTION MECHANISM QUESTIONS

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KEYWORDS: Mechanisms, Undergraduate, Diagnostic test, Problem Solving

BACKGROUND
Organic chemistry is often challenging for students due to the use of mechanism in reaction problems. Students lack deeper understanding of key concepts and will instead rote memorize specific mechanisms often leading to failure when presented with new mechanisms or when they cannot recall information (Bhattacharyya and Bodner, 2005, Kraft, Strickland and Bhattacharyya, 2010).

AIMS
The aim of this study was to investigate the different strategies students' use at different year levels to answer the same electrophilic aromatic substitution mechanism question.

DESIGN AND METHODS
An electrophilic aromatic substitution type question with the acylium ion was presented to level 1, 2 and 3 students enrolled in chemistry units that had all completed first year organic chemistry. Data for level 2 and 3 students was collected mid-way through the semester and data for level 1 students was collected at the end of semester following the organic chemistry lectures. A diagnostic test on the resonance of the acylium ion was administered directly after answering the question on electrophilic aromatic substitution. Some students also participated in semi-structured interviews using the think aloud protocol to understand their thought process when answering the question. Data was analysed by marking the electrophilic aromatic substitution question, generating a mean confidence quotient from diagnostic tests and coding interviews.

RESULTS
Students at lower levels were less successful when attempting mechanism questions than those in upper levels who have more experience and a better understanding of the concepts and chemical reasoning behind each step. Students who understood the resonance structure of the acylium ion and incorporated it in their answers were able to answer the question correctly. Those answers absent of deeper level chemistry knowledge and relying on surface levels of understanding find difficulty to answer the question correctly. Level 2 students were largely unable to answer the question correctly due to the timing in which the question was administered. This indicates students in second year are still not developing deeper understanding of the chemistry behind a mechanism.

CONCLUSIONS
Overall students at lower levels find difficulty in answering mechanism questions. To improve their performance, they must develop proficiency in understanding the key chemistry concepts that allow them to answer mechanism questions, rather than simply relying on rote learning.

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POSTER 24 (POSTER BITE)

A COMPARISON OF TWO SOFTWARE PACKAGES FOR USE AS ELECTRONIC LABORATORY LOGBOOKS – PRELIMINARY FINDINGS

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KEYWORDS: electronic laboratory logbooks, digital record keeping, undergraduate laboratory

BACKGROUND

Over the last decade, electronic laboratory logbooks (ELLs) are increasingly used in the workforce and are an accepted practice in industry (Rudolphi & Goossen, 2012). In 2008, approximately 33% of biopharmaceutical companies reported using at least one ELL (Giles, 2012). In response to changes to industry practice, it is thought to be an ideal time to start using ELLs in undergraduate classes and up-skilling students with electronic recording and data management skills. We need to prepare them for a technological rich workplace and help them develop skills that are easily transferable to any workplace environment, thereby greatly assisting with students' employability.

STUDY DESIGN

A study was conducted to explore the implementation of ELLs in a first year chemistry unit. Phase 1 involved using 12 tablet PCs (six Microsoft Surface 3s and six Lenovo ThinkPads) in two lab classes over two semesters. Half the class volunteered to use an ELL. The remainder of the student cohort utilised paper-based laboratory logbooks (PLL). Microsoft OneNote was used as the software for the ELLs, which is a free software package that offers a classroom version. Phase 2 involved the implementation of 24 tablet PCs in one lab during one semester. It allowed all students in one class to use an ELL. LabArchives was the software used for the ELLs, which is a paid software package that offers a classroom version with a sophisticated classroom management system. Students were provided with a training session at the beginning of the semester before they were required to use the ELLs in class. In both phases, students completed pre-laboratory tasks prior to class and then referred to a laboratory manual that guided them through laboratory activities during class. Students were required to record data, annotate their observations and provide scientific inferences based on their experiments. Students worked in pairs during the laboratory task and sought support from the laboratory demonstrator. The teaching team were also able to view and mark students work online.

PRELIMINARY FINDINGS

One of the aims of this study was to explore students' experiences with using ELLs. This presentation will provide some preliminary findings and a comparison of students' experiences with using the two software packages, Microsoft OneNote and Lab Archives. The experiences of teaching staff will also be presented. We hope that these findings will offer some insight on a preferred software package to use as ELLs in a teaching context. Such information will we useful to anyone interested in implementing ELLs in their undergraduate laboratory classes.

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POSTER 25

UNDERSTANDING STUDENT INITIATED MOBILE-LEARNING IN HIGHER EDUCATION

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KEYWORDS: Mobile-learning, Self-regulated learning strategies, Higher education, Biomedical Sciences

INTRODUCTION

Learning occurs in many forms, and learning through mobile devices (mobile-learning) is becoming increasingly common in higher education (El-Hussein and Cronje, 2010). Students' choices regarding the use of mobile-learning are dependent on intrinsic and extrinsic factors. The extent to which learners engage with technology may be limited by their acceptance and self-efficacy regarding technology. Attributes such as gender, age and experience may affect the attitudes a student holds towards technology (Bao, Xiong, Hu & Kibelloh, 2013). The aim of this study was to determine and evaluate the way mobile learning was employed by second year undergraduate students, and to identify variables that may influence students' use of mobile-learning. Exactly how students utilise their own mobile devices to assist their learning formally and informally, on and off campus, and the factors which influence their choices regarding mobile-learning remain unclear.

METHODS

Participants included second year students in the Bachelor of Physiotherapy (n=128), and Bachelor of Speech Pathology (n=105) programs studying physiology. As part of the course students completed meta-learning assessment tasks (Colthorpe, Sharifirad, Ainscough, Anderson & Zimbardi, 2017).
Responses to the meta-learning questions "In what ways have you used your mobile devices in your previous studies?" and "On a scale of 1-5 (with 1 being 'not at all' and 5 being 'completely') how confident are you in using technology to assist your learning?" were analysed. A Spearman's correlation was performed to determine relationships between mobile device usage, technology self- efficacy, performance and demographic data.

RESULTS

Students (n=154) reported various ways in which they use mobile devices to assist their learning, most commonly saying they used mobile devices for note taking, specifically on their laptops or tablets, and used mobile phones to use Apps, look up concepts and communicate with peers. The most widely used devices were mobile phones (n=131), followed by laptops (n=42), tablets (n=32) and hybrid devices (n=4). Many students reported using more than one device or more than one way in which they had used them. Generally, students were very confident in their ability to use technology to assist their learning, with the majority (76%) of respondents saying that they were very or completely confident. However, almost a quarter of students were moderately or less confident, and these students often said their use of mobile devices for learning was limited. There were no significant relationships between students' technology self-efficacy, exam performance and gender and the extent to which they used their mobile devices for learning.

CONCLUSION

Potentially, there are numerous ways in which students may implement mobile-learning to enhance their learning experiences. When students are free to choose their device and methods, they used differing devices in different ways, although they used their mobile phones to a much greater extent than all other devices. Generally, students are confident using technology, but there are still many who are not, and some students make only limited use of their mobile devices for learning.

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POSTER 26

DEVELOPING CREATIVITY THROUGH AN INNOVATIVE APPROACH TO LABORATORY REPORTS

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KEYWORDS: Assessment, Creativity, Laboratories

PROBLEM

Assessment of and for learning is a core element of education and is acknowledged to drive/guide students. Creativity is an essential element of the practice of science or "being a scientist" which is an innately creative enterprise. Scientists constantly develop creative approaches to discovery, invention, problem solving and inquiry. Laboratory classes, a core component of most science education programs, address a number of core learning outcomes including the ability to think creatively about problems. However written reports, an integral component of laboratory classes, and the most commonly used assessment tool, provide minimal opportunities for students to develop and demonstrate creativity.

PLAN

Videos, a media students are very familiar with, are used routinely in teaching, predominantly as instructional tools. However, an increasing body of work addresses learning "with" videos as opposed to learning "from" videos in which students research a topic and produce videos for the presentation of their research to replace traditional assessment via written or oral presentations. The plan was to replace the traditional assessment of laboratory classes through written laboratory reports with assessment through student produced videos. The aim was that this innovative assessment modality would provide students with enhanced opportunities to develop and demonstrate creativity and critical thinking.

ACTION

A written laboratory report was replaced with a "student produced video report" in a second and third year biochemistry unit. The authors developed new assessment rubrics, video guidelines and an instructional video which provided technical information on how to make a video. Students were informed that this was a new assessment which was designed to develop their creativity while also requiring a stronger emphasis on data analysis and critical thinking. Feedback was provided by the demonstrators who were in the class with the students and assessed the videos (informal/anecdotal) and by the students through a survey.

REFLECTION

Observation of student behaviour during the laboratory classes found students were filming/photographing their experiments and appeared far more engaged with the actual experiments than in previous years. Many student videos demonstrated high levels of creativity and critical thinking. Student perceptions, collected through anonymous surveys showed 53% of students agreed it was an interesting approach to assessment and 63% agreed it allowed them to think creatively. When asked, "What aspects of the practical did you find most enjoyable and interesting?" one student wrote: "The creative process and trying to communicate the results in a way that was understandable to the viewer". However not all students liked the innovative assessment, in fact a small cohort were very unhappy with the introduction of this assessment, in particular with the time commitment.

The student produced videos did provide an opportunity for creative and critical thinking but there are aspects to be improved. Issues to be addressed include: student workload, assessment criteria and technological issues.

POSTER 27

PRACTICING INFORMATION SKILLS IN THE CONTEXT OF THE ENGINEERING CLASSROOM

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KEYWORDS: engineering education, information literacy, blended learning, online learning, digital learning objects

BACKGROUND

The collaboration between Macquarie University Library and Engineering Department to integrate information and academic literacies into the engineering curriculum, via activity based workshops, was presented at ACSME 2015 (LeRoux, Jones, Tse, McGill, Safari & Chakraborty, 2015). The presentation discussed the need to move library workshops into engineering laboratories to make the program sustainable over the long term and scalable for larger cohorts. To this end, librarians trained tutors to facilitate the learning activities supported by online materials.

PROBLEM

After piloting the online content during the second half of 2015, a project was initiated to embed an interactive module into the learning management system. The module, first used in Session 1 2016, included activities that were tied explicitly to a written engineering assessment task and was designed to incorporate formative assessment via quizzes. Summative assessment was achieved via the application of a marking rubric to the assessment task, allowing us to evaluate the success of our intervention in terms of student outcomes.

Evaluation via student surveys indicated positive experiences with the material, and skills quiz results were good. Despite this, analysis of the written assessment task identified gaps in students' understanding and areas of weakness, particularly when considering the quality of both the information sources cited and the execution of the required referencing style.

This presentation will describe the improvements made to activities and materials during 2016 and 2017, and our evaluation of the effectiveness of these changes.

PLAN

Delivery of information literacy content is via a blended approach, pairing a lecture delivered by librarians with a practical in the engineering laboratory in which students work through the interactive module under the guidance of tutors. The activities provide students with the opportunity to learn by doing, practicing skills and receiving feedback on their performance before applying the skills to the assessable written task.

The approach to improving the design and delivery of content has been to reflect upon and respond to evidence gathered via surveys, quizzes and assessments, making incremental changes each session.

ACTION

A turning point in this ongoing project came in Session 2 2016 with the introduction of an "information research process diagram" in the lecture, as a conceptual bridge between engineering and library skills. This innovation was an attempt to build upon students' existing mental models by closely matching unfamiliar information literacy concepts to the engineering design process. The problem of searching for and evaluating discipline specific information and using these sources to compose a written task was broken down into a process with specific steps, and a defined workflow.

In addition, the online module was redesigned for Session 1 2017, with the information research process diagram acting as a scaffold for the new design. Lastly, academic teaching staff and librarians collaborated on rewriting the written assessment task.

REFLECTION

Marking of the new assessment task is in progress, with the expectation of a demonstrable improvement in the information seeking skills utilised by students, and that these will have application beyond the classroom. Further improvements planned include: making the writing process more explicit by adding to this component of the module, the creation of bite-sized videos breaking down the lecture material into smaller concepts, and the further analysis of the written assignments using qualitative data analytics tools.

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CHASING THE UNICORN: A NEW APPROACH TO COURSE DESIGN IN CHEMISTRY TO ENGAGE STUDENTS AND ACHIEVE THRESHOLD LEARNING

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KEYWORDS: Mastery Learning, Core Skills, Assessment

PROBLEM

First year chemistry at UNSW has for many years followed a 'traditional' format, both in terms of teaching structure, assessment items, and student expectations. The inherent assumption of this model is that students having obtained a passing grade will have acquired all of the core knowledge essential for progression to higher years. In reality, we know that a pass grade provides no information on what students have actually learnt: they might pass on excellent results in one syllabus area (e.g. kinetics), while completely lacking understanding in another (e.g. thermodynamics). Ultimately this means we need to re-teach basic concepts in later years before new content can be covered (and that's assuming students turn up to lectures!).

PLAN

We propose a radical new model for teaching and assessing first-year chemistry. The syllabus will be split (50:50) into 'basic' and 'expert' topics. 'Basic' topics will be taught online, and assessed continuously; students will need to demonstrate complete understanding of all of these topics to pass the course. The 'expert' topics will be taught in engaging face-to-face lectures, workshops and tutorials, these will be assessed in the end-of-semester exam for merit grades. By implementing the basic/expert model, the learning outcomes and expectations for students are explicit and their progress is logged across the semester via an individualised knowledge and skills portfolio.

ACTION

The longitudinal study for the basic/expert model began in 2014 with a basic /expert skills assessment approach to laboratory assessment, as of 2017 this initiative has been integrated in all first-year chemistry units and is currently being adopted in higher year courses. A pilot study to introduce the basic/expert model to teaching and assessment was introduced in session 1 2017 in CHEM1811 (a new core unit for engineering students) and continues in session 2 in CHEM1821 (for which CHEM1811 is a prerequisite).

WORKSHOP

Discussion (45 minutes)
We will use this time to showcase some of the interactive learning tools that we have used in the project in order to communicate to participants how we have integrated the basic/expert model into our first- year courses. We will give a 'warts and all' account of the logistical side of the project including adapting the LMS (Moodle), creating online content, converting to digital assessment, workshop development and adapting student support. Finally, we will encourage discussion and debate about this approach and discuss how the students have responded, behaved and interacted with the core-expert approach.

Workshop task (45 minutes):
1.   Assigning basic and expert knowledge. In groups participants will be provided with a small number of common learning outcomes for a first-year chemistry course and asked to categorize the material into core and expert (supplementary materials such as course outline for higher year courses will also be provided). As a whole, we will discuss the approach used by each group to divide the content and compare each group's decisions.

2.   Assigning basic and expert skills in the lab. Using online polling participants will be asked vote for the skills they consider are 'core' for a student in a first year first session course. Using these criteria groups will then be given two practical experiment outline and asked to identify which core and expert skills could be

assessed in each lab. What would be the criteria assigned for competent and non competent demonstration of these skills

MOLYPOLY2: A NEW NOVEL ORGANIC CHEMISTRY INTERACTIVE MODELING TOOL

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KEYWORDS: Organic Chemistry, Interactive Learning Tool, ICT

ABSTRACT
A new interactive application, MolyPoly2, has been developed to build and interact with organic chemistry molecular models using a LeapMotion controller. MolyPoly2 enabled 1st year chemistry students to use hand/finger gestures to select atoms, bond them and rotate the molecule thus giving the student a high impact learning experience. Many researchers have created or used new technologies to enhance the visuospatial ability and those using technologies that increase natural gestures and body movement have found it reduces the abstract relations thus decreasing the number of misconceptions conceived (Chinthammit et al 2015).
Enabling continuous access throughout the semester and the exam period as well as having the application as one of the learning tools integrated within the scheduled learning sessions enabled the student to become familiar with the tool and easily use it for its purpose.
We invite you to trial the tool in a lesson setting and discuss your experience with the system.

WORKSHOP
Duration: 2hrs

During this workshop, participants will have the opportunity to use MolyPoly2 in an introductory lesson as a student with supporting documentation and instruction (1 hr). Following this session will be a discussion about the experience and future development of this tool.

REFERENCES
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NETWORKING FOR STUDENT SUCCESS IN STEM-DEPENDENT DISCIPLINES

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KEYWORDS: networking, STEM, literacy

ABSTRACT

With an economy that has become increasingly reliant on workforce skills in Science, Technology, Engineering and Mathematics (STEM) (Office of the Chief Scientist, 2014) and a wide understanding that STEM literacy is regarded as a prerequisite for reflection, critical thinking and further learning (Zollman, 2012) intensified by concern that the study of science and mathematics at school is at dangerously low levels (Kennedy, Lyons, & Quinn 2014; King & Cattlin 2014) many university educators have become engaged in intentional development and delivery of STEM support-for- learning initiatives.

For some this engagement takes the form of appointments within specialised support programs that are institution-wide (see for example Wilson et. al., 2017) while others in traditional teaching positions are responding innovatively to student needs. Regardless of their specific appointment, these staff are committed to improving access to learning and to facilitating student success.

OBJECTIVES

The objective of the workshop is to provide an opportunity for those engaged in STEM support-for- learning initiatives to share good practice and resources.

WORKSHOP DESCRIPTION

1.5 hrs

The workshop will be interactive with participants encouraged to share and discuss current approaches to support for learning, including pain points and solutions. Recognising that this work is distinct from regular teaching, possibilities for ongoing networking will be discussed.

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AIP PHYSICS EDUCATION GROUP (PEG) DISCIPLINE DAY: INNOVATIVE TEACHING PRACTICES AND SPACES

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KEYWORDS: physics education, teaching practices, flipped classroom

This year our discipline day will focus on innovative teaching practices and teaching spaces. We will start with a brief overview of evidence-based practices in science and mathematics, followed by a brief overview of teaching transformation using Physics and Astronomy Collaborative Environment (PACE) studios at the School of Physics and Astronomy at Monash University, which were designed along the lines of SCALE-UP approach. We will work in groups to discuss how to implement active learning techniques in our courses, and share ideas on developing object-based learning in physics and astronomy education.

ACSME DISCIPLINE DAY CUBENET AND VIBENET (BEAN) WORKSHOP PROPOSAL

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ABSTRACT

The opportunity to share new ideas around curriculum renewal and innovation as well as discipline-based education research is relatively limited. This workshop will invite participants to pitch their ideas and preliminary outcomes around biosciences curriculum innovation, renewal and research in an effort to engage colleagues with expertise to provide valuable guidance and explore opportunities for collaboration. Participants will then be provided the opportunity to workshop a selected number of pitches in a round-table discussion format. This workshop invites discussion and collaboration around biosciences curriculum at a national level.

AIM

To share curriculum and project ideas and preliminary outcomes, invite expert opinion and guidance, and foster collaborations on curriculum renewal and discipline-based education projects in the biosciences.

Duration: 2 hours
Conveners: Dr Tina Hinton and Dr Fiona Bird

The workshop is designed in three parts:
1.   3 minute project/idea/preliminary outcomes pitches
2.   workshopping project/idea pitches
3.   1 min presentation of discussion outcomes

During the 3 minute idea/project pitches, participants will have the opportunity to select their top 3 preferred ideas/projects for further discussion in the workshopping segment.

In the workshopping segment participants will spend 15 minutes per idea/project, rotating between 3 ideas/projects in 45 minutes. The intention is to maximize discussion with many participants

Proposed timeline:
5 min: Brief introduction by workshop conveners including housekeeping
40 min: 3 minute pitch of current ideas/projects including participant
10 min: short break
45 min: workshopping ideas / connecting
20 min: 1 minute presentations of outcomes from discussions then wrap up

ACSME DISCIPLINE DAY CUBENET AND VIBENET (BEAN) WORKSHOP PROPOSAL: PROFESSIONALISM IN BIOMEDICAL SCIENCE DEGREES

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ABSTRACT

This workshop will explore the issues related to biomedical science degrees as pathways to careers in medicine. The workshop will invite participants to discuss the implications this has for i) assessment within the degree program, ii) student behaviours, especially those related to professionalism and iii) our duty of care to Biomedical Science students in terms of career advice and preparation, for careers other than medicine.

AIM

To share experiences relating to biomedical science degree programs as pathway programs for graduate medicine and to use the collective experiences to formulate and guide constructive approaches to relieve student and staff tensions to the three domains of assessments within the degree program, professional behaviours and career advice.   .

Duration: 2 hours
Conveners: Associate Professor Yvonne Hodgson and Julia Choate

The workshop is designed in three parts:
4.   Student stress and the relationship to assessment within the degree program, scoping the environment and experiences of staff teaching in biomedical science degree programs
5.   Some student behaviors resulting from assessment related stress. The issue of professionalism
6.   Student stress and career uncertainty. What is our duty of care to students and what can we do to help?

In each of the workshop sections, qualitative data obtained at Monash University regarding student attitudes and behaviours will be given to set the scene and provoke discussion between participants. Discussion will be outcome focused with an emphasis on seeking realistic solutions and supporting collaboration between universities.

Schedule:
Introduction (15 mins): Setting the scene (Yvonne and Julia). The good, bad and the ugly of our biomed course becoming a formal pathway for our graduate medicine program.
1.   Effect on assessment (25 mins): Student stress and the relationship to assessment within the degree program, scoping the environment and experiences of staff teaching in biomedical science degree programs. Case studies regarding use of CATME and peer assessment.
2.   Effect on student behavior at university (25 mins): Some student behaviors resulting from assessment related stress. The issue of professionalism. Harassment of staff and fraudulent medical certificates. Symptoms of stress and examples of unprofessional behavior. Do students understand their responsibilities at university (A framework for professionalism within a Biomed course)
3.   Our duty of care to students (25 mins): Student stress and career uncertainty. What is our duty of care to students and what can we do to help? Example of embedding a professional development program across a whole biomed degree program, example of embedding WIL in core and elective units within a degree program.
Wrap up (35 mins): Summing up the discussions and planning of collaborative and research projects.

MATHEMATICS NETWORK

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PART 1: 9.00 – 10.30AM
Integers, Integrals and integrity

In this workshop, you will explore resources developed as part of a 2016 La Trobe University project Don't cheat yourself: clarifying collusion confusion, which focussed on educating students about academic integrity in the specific context of mathematics and statistics tasks. First, you will be introduced to what the literature says (and significantly doesn't say) about mathematical tasks. Then, we will get hands-on with the scenario-based resources which draw out a variety of issues around student understandings and motivations, as a means to educate and prevent (the two steps that should be taken before detection and penalty). The resources will be released in the near future as an open educational resource.

The presenter, Associate Professor Katherine Seaton is the Director of Teaching and Learning in the Department of Mathematics and Statistics at La Trobe University, and a member of the Australian Mathematical Society Standing Committee on Mathematics Education. As well as the grant which funded the project being presented in this workshop, she has been awarded a La Trobe University Citation and a Vice-Chancellor's Award for Teaching Excellence. She has published in mathematical physics and more recently in tertiary mathematical education, particularly around task design and feedback. She has over twenty years' experience in tertiary teaching and subject and course coordination.

PART 2: 11.00 – 12.30AM
Issues in mathematics education

As every year, this will be a very good opportunity to network with mathematics colleagues from across the country.

There are several challenges faced by those responsible for teaching mathematics and statistics at undergraduate level. How should we teach mathematics and statistics in the technology rich environment we operate today? How do we better engage students through teaching and learning, and through assessment? Are our graduates equipped with the skills and knowledge required to navigate the world of work? How do we know? How do we inform students about the vast array of jobs that studying mathematics and stats will open them to? Even if this is not their main game, how will mathematics and stats give them an edge?
We will discuss these and other questions that are keeping you awake at night. It will be a great opportunity to exchange approaches you have tried or have seen working elsewhere. If you would like to put a particular issue on the agenda, do not hesitate to contact the workshop leaders.

DEVELOPING TEAMWORK SKILLS IN UNDERGRADUATE SCIENCE STUDENTS: THE ACADEMIC PERSPECTIVE AND PRACTICE

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ABSTRACT

Learning to function as an effective team member is an important skill for science graduates. A science curriculum that supports the development of teamwork skills ensures graduates are equipped with workplace skills that are required in research and other professional careers. This study used a survey to investigate the academic perspective and practice of teaching teamwork within the undergraduate science curriculum in Australian universities. The findings suggest the majority of science academics are positive about the importance of developing teamwork skills in graduates. Fewer academics are confident that teamwork skills are being sufficiently developed through the curriculum. Respondents primarily assigned teamwork activities because it develops interpersonal skills, encourages peer sharing and mimics a real-world environment. Those respondents, who didn't assign teamwork, thought it wasn't suitable to the course, or believed the challenges associated with group dynamics outweighed the benefits of assigning teamwork activities. Current approaches for the development of teamwork skills are varied, with the majority of respondents favouring curriculum-integrated approaches. With a greater understanding of the academic perspective of teaching teamwork, those involved with leading curriculum change can better develop approaches to ensure these valuable skills are fostered in science graduates.

INTRODUCTION

Effective teamwork skills are a highly desirable trait in a science graduate. The benefits of teamwork skills in the STEM disciplines (science, engineering, technology and maths) have been well cited (Baker, Day, & Salas, 2006; Drury, Kay, & Losberg, 2003; Felder & Brent, 2007; Fiore, 2008; Mills, 2003). This is because at every stage of learning through to established workforce practices, collaboration and cooperation are essential (Dunne & Rawlins, 2000). Developing the skills learned through teamwork simultaneously helps to promote the deeper cognition associated with peer interaction, such as dialogue, problem solving and cooperation (Edmondson & Maguire 2001; Tarricone & Luca, 2002). Furthermore, the social nature of teamwork improves student mental health and social competence (Smith 1996, Strom and Strom 2011). This broader diversity of skills and stronger social networks creates a more comprehensive educational experience (Bose, Jarreau, Lawrence, & Snyder 2004, Davies 2009).

Teamwork skills for employability

The common approach for teaching science at undergraduate level is to equip students with the technical aptitudes specific to laboratory work and research (Ge & Helfert, 2014; Tjian, 2015; Venville & Dawson, 2004). Research skills are undoubtedly a priority in a science degree, as they develop many important graduate competencies (Hunter, Laursen, & Seymour, 2007). For example, learning about the scientific research process fosters abstract reasoning and problem solving skills (Rowland, Lawrie, Behrendorff, & Gillam, 2013). However, as a consequence of focusing on research training, the skills of interacting and working with other people are often overlooked in the science curriculum (Tjian, 2015). Not surprisingly, science graduates are noted as lacking in teamwork skills by employers (Curtis & Mckenzie, 2001; Sheldon & Thornthwaite, 2005). For example, a report by Prinsley and Baranyai (2015) finds that STEM graduate's interpersonal skills are poorly rated by employers when compared to non-STEM graduates.

For graduates planning to undertake a research career, teamwork skills will enhance their ability to build research collaborations and work within research teams. This is increasingly important as we see the rise of multidisciplinary research teams, where almost every project will draw upon expertise from a range of areas; often across different disciplines, different institutes and even different countries (Fiore, 2008). A rigorous undergraduate science education should prepare all students for the workforce, not just those destined for a scientific career (Tanner, Chatman, & Allen, 2003). For graduates seeking career pathways beyond science, the ability to work in a team is also highly important (Gibert, Tozer, & Westoby 2017), because many workplaces require cooperation between people and high-level interpersonal skills (Dunne & Rawlins, 2000; Australian Association of Graduate Employers, 2014; Osmani, Weerakkody, Hindi, Al-Esmail, Eldabi, Kapoor & Irani, 2015).

Developing teamwork skills

Assigning teamwork activities has been an approach used within the university curriculum for decades. However, teamwork does not automatically occur as a consequence of putting people together (Lerner, Magrane, & Friedman, 2009). Rather, teamwork is a dynamic skill that requires guidance and mentorship to develop (Cameron-Jones & O'Hara, 1999; Crebert, Bates, Bell, Patrick, & Cragnolini, 2004). Rieb, Girardi, & Whitsed, (2016) outline that the pedagogical approach surrounding teamwork is dependent on a range of interactions including the institutional context, the instructor's experience and the student's perception of undertaking teamwork. They suggest that academics vary widely in their conceptualisation of the pedagogy of teamwork, with many academics placing the emphasis on the final product (output), rather than the skills and attributes (inputs) required to collaboratively work together (Riebe et al., 2016). For example, a common practice is placing student into groups, and leaving them to independently establish how to create a successful and productive team (Dunne & Rawlins, 2000; Tanner et al., 2003). In the context of this study there is a distinction between teaching teamwork (input), and teamwork as an educational objective (output).

It is also important to note that teamwork is defined as distinct from group work, primarily in terms of the cohesion between team and group members. For example, in a group, members will often disperse and go away to work on individual aspects of a project, with very little collaboration actually having taken place. Whereas, in a team, interaction between members regularly takes a much greater significance with the team working collectively towards a common goal, each individual aware of what the others are working on, and with the final product a result of this collaboration (Oakley, Hanna, Kuzmyn, & Felder 2007).

Teamwork skills in science

Although it has been widely advocated that teamwork is an important element in the university curriculum (Dunne & Rawlins, 2000), little is understood about the approaches for teaching teamwork within science degrees. The development of teamwork skills has been frequently considered from the student perspective within disciplines beyond science (Burdett, 2003; Pfaff & Huddleston, 2003; Walker, 2001), and in the more closely related health sciences and engineering disciplines (Black, Blue, Davidson, & McCormack, 2016; Oakley et al., 2007; Pogge, 2013). To the author's knowledge, teamwork skills within science degrees have been given scant attention (but see Bose et al., 2004; Garcia-Bayonas & Gottschall 2008; Gibert et al., 2017; Rahman, Sarkar, Gomes, & Mojumder, 2010; Shibley 2002). For example, in a recent review on teamwork pedagogy, no science-focused studies are cited (Riebe et al., 2016). Fewer studies look at the academic perspective on developing teamwork skills (but see Johnson, Al-Mahmood, & Maier 2012). To gain a complete picture of the complex dynamics of teaching teamwork, the student perceptions must also be considered. In light of this, a further paper investigating the student's perspective of teamwork in science was undertaken simultaneously with this research by Wilson, Ho and Brookes (submitted).

At a time when universities are under increasing pressure to develop work-ready graduates, an understanding of how science academics conceptualise teamwork teaching approaches provides important insights. This may enhance the current practices of teaching teamwork skills and highlight where teaching teamwork in the science undergraduate curriculum is afforded or constrained.

This study investigates the academic perspective and practices on the development of teamwork skills through the undergraduate science curriculum. Specifically, it is asked:

- What are the perspectives of academics about the value of teamwork skills for science students?
- What are the practices of these academics within the undergraduate science curriculum?

METHODOLOGY

This research used a mixed-methodological approach comprising both quantitative and qualitative data (Sadan, 2014). The quantitative data was gathered using online survey responses with Likert-attitude scale question responses of one (least important) to seven (most important). The qualitative data consisted of ranked responses, and open-ended comments. Open-ended questions were used to gain a more nuanced understanding of the quantitative data and so that respondents could express their thoughts more freely (Bogdan & Biklen, 1998). Relying on a survey for the data collection enabled a larger number of academics from a broad range of universities to be included within the study.

Survey procedures

The survey questioned academic and professional staff about their opinion and professional practice related to teaching teamwork in the undergraduate science curriculum. Before proceeding with the survey, respondents needed to confirm they had been actively teaching within the last year. To interrogate the difference between teamwork being focused on the product (outcome) and teamwork teaching (input), the

survey questions made a distinction between *teaching* teamwork (e.g. '*Teaching teamwork actively occurs in your faculty, choose an answer…*') and *assigning* teamwork activities (e.g. '*do you assign teamwork activities within the units or courses that you teach?*').

A suitable survey instrument could not be established from the existing literature to use in this study. Therefore, where possible aspects of the survey were based upon prior literature on teamwork in higher education. For instance, rank-list questions interrogating the reasons teamwork skills were taught were derived from Walker (2001) and questions about the current practices for teaching teamwork were developed by drawing upon key themes discussed by Davies (2009).

Prior to administering the survey, the draft survey questions were piloted by five actively teaching science academics. Amendments were made to the order and wording of the existing questions and further questions were added based upon the feedback from groups. Respondents were invited to complete an anonymous online survey during March–May 2016. The survey was distributed either by direct survey invite, newsletter advertisement, or via snowballing, where existing participants recruited further participants from their networks. The data was collected using the online survey tool *SurveyMonkey*. The survey was comprised of 33 questions with sections on demographic information (e.g. university, academic role, length of teaching experience), how much respondents valued teamwork as a skill and their opinion about current teaching approaches. The survey required 10 to 15 minutes to complete. The Monash University Human Ethics Research Committee provided approval for the research approach #CF16/728 – 2016000356.

Data analysis
A total of 70 respondents from 13 higher education (HE) institutions in Australia completed the survey (Fig. 1). The respondents represented a broad range of roles and scientific disciplines (Figs. 2 & 3). Survey responses were analysised via one of two main methods. The qualitative responses were coded using *NVivo 10* (QSR International Pty Ltd., 2012) with open coding to establish dominant themes. The quantitative survey data were summarised and presented as a frequency. For the purpose of analysis, scores of 2 and 3 were counted as 'agree,' and scores of 5 and 6 were counted as 'disagree'. A single-factor non-parametric analysis of variance (Kruskal-Wallis test) was conducted to test for significant differences in the questions with ranked order responses (Allan & Seaman, 2007). These questions related to the value of teamwork skills at university and the best way to integrate teamwork into the curriculum. The significance threshold was set at 0.05. These tests were followed by a post-hoc Dunn's test with a Bonferroni correction to contrast the different responses.

Responses were also compared among disciplines and academic roles (e.g. teaching associate, professor), using single-factor analysis of variance (ANOVA) in Excel (Version 15.16). The significance threshold was set at 0.05, wherein a P value of <0.05 shows a statistically significant result. As no significant difference among participants' scientific disciplines and academic roles was identified (F values ranging 0.058–0.280, and P values ranging 0.893–0.997), the survey results across scientific disciplines were subsequently aggregated.
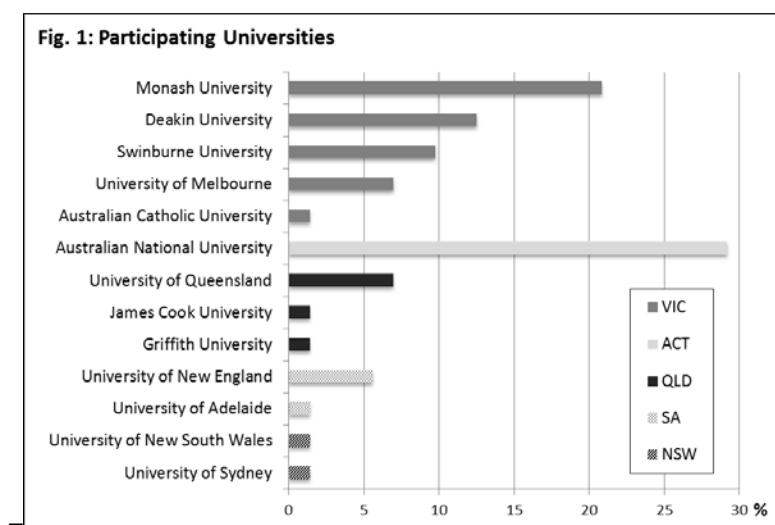
Figure 1: Summary of participating universities. Figure legend acronyms: VIC = Victoria; ACT = Australian Capital Territory; QLD = Queensland; SA – South Australia; NSW = New South Wales.
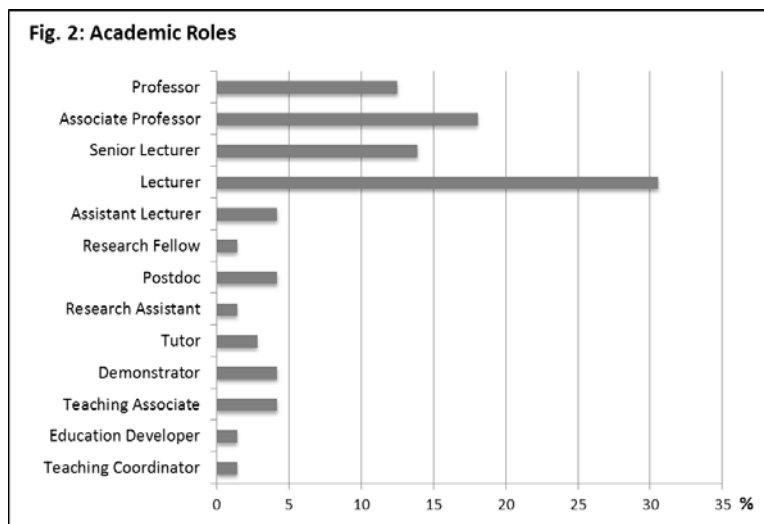
Figure 2: Distribution of roles held by survey respondents.
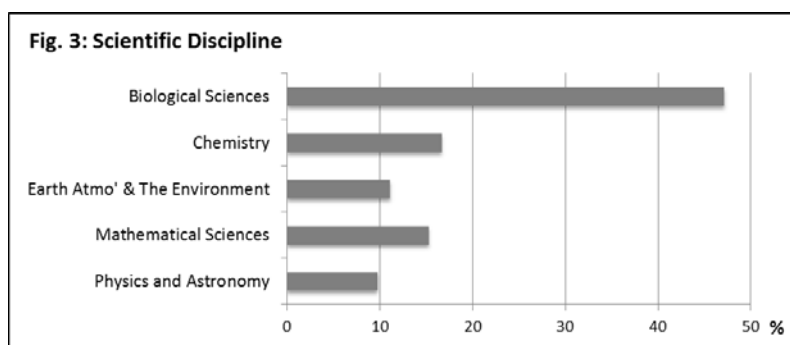
Figure 3: Respondent's science disciplines.

RESULTS

The academic perspective of teaching teamwork

The majority of respondents indicated a positive attitude about the value of teamwork for science graduates. A higher number of respondents agreed, or strongly agreed, that teamwork was an essential skills for both science and non-science careers (Table 1). In addition, respondents believed that universities have a responsibility to ensure science students are graduating with the teamwork skills needed for employment (Table 1). Markedly fewer respondents agreed, or strongly agreed, that students are currently graduating from university well equipped with teamwork skills (Table 1).

Table 1: Summary of responses about the value of teaching teamwork. 'SA' = Strongly agree, 'A' = Agree, 'N' = Neutral, 'D' = Disagree and 'SD' = Strongly disagree. *n = 70*

Survey Question	SA *n/(%)*	A *n/(%)*	N *n/(%)*	D *n/(%)*	SD *n/(%)*
Teamwork is an essential skill for science graduates in preparation for future research, or employment in SCIENCE based careers.	33/(47)	24/(34)	4/(6)	8(11)	1(1)
Teamwork is an essential skill for science graduates in preparation for future employment in NON-SCIENCE careers.	37/(53)	23/(33)	2/(3)	7/(10)	1(1)
University undergraduate science degrees should be ensuring students are graduating with the teamwork skills needed for employment.	31/(44)	27/(38)	3/(4)	6/(8)	3/(4)
In your experience, science students are graduating well equipped with the team skills needed for their future careers, in science or otherwise.	2/(3)	21/(30)	27/(38)	16/(23)	4/(6)

Reasons for including teamwork

Respondents were asked to rank the reasons why they believed teamwork was an important skill for students to learn from a range of attributes (1 = most important, 7 = least important). Following a Kruskal-Wallis test, it was found that the medians within each group of attributes varied significantly ($P < 0.05$). Respondents valued teamwork for *'promoting the sharing of ideas and expertise'* more highly than all other reasons except *'helping to develop interpersonal communication skills'* and *'mimicking a real working environment'* (Dunn's test P values ranging from < 0.05 to < 0.0001). Respondents least-valued teamwork for *'distributing the workload,'* which was rated lower than *'promoting the sharing of ideas and expertise'*, *'developing interpersonal communication skills'* and *'promoting working towards a common goal'* (Dunn's test $P < 0.0001$; Fig. 4).

When respondents were asked in an open-ended question, "*Do you have any additional reasons why students should be learning teamwork skills at university?"* several dominant themes emerged (Fig. 5). These themes largely supported the ranked data. Again, the most frequently cited benefit of including teamwork activities was its importance for facilitating sharing of ideas and expertise (cited by 16% of respondents; Fig. 5). Responses included comments such as: *"Best way to learn is to teach. They work together, explain things to each other, understand the material better themselves.* And: *"Learning that each person has skills and knowledge that together can complement the rest... 'the whole is greater than the sum of its parts.'"*

Many respondents recalled the importance of teaching teamwork for the promotion of communication and creating authentic learning (cited by 13% of respondents for both themes; Fig. 5). A physics and astronomy respondent commented about the development of communication skills: *"It helps students understand that perspectives on the same matter can vary considerably. Ideally, they'd get a taste of conflict resolution."* In discussing the importance of developing teamwork skills in biological sciences, a respondent stated: *"It's a critical workplace skill. We should be teaching it for that reason alone."*
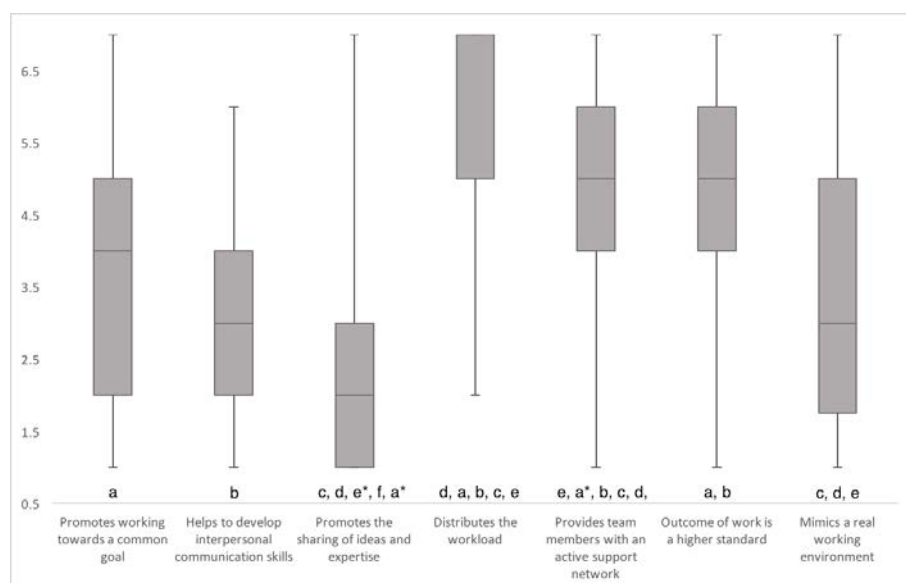
Figure 4: Box plot showing ranking of responses to the statement *'teamwork is an important skill for students to learn while they at university because:'*. The lines inside the boxes denote the medians. The boxes mark the interval between the 25th and 75th percentiles. The whiskers denote the interval between the 10th and 90th percentiles. Common letters show a statistical difference between median scores of the groups ($P < 0.001$). When the letter is followed by *, the difference between medians is $P < 0.05$.

Teamwork was also valued because it teaches students how to work collaboratively towards a common goal (7% of survey respondents). For example, one respondent from mathematics noted: *"It teaches them the value of working with people with diverse backgrounds and develops skills for collaboration."* Other themes that were represented included peer-to-peer learning (6%), the promotion of collegiality (6%), and exposure to working with a diverse range of people (6%; Fig. 5).
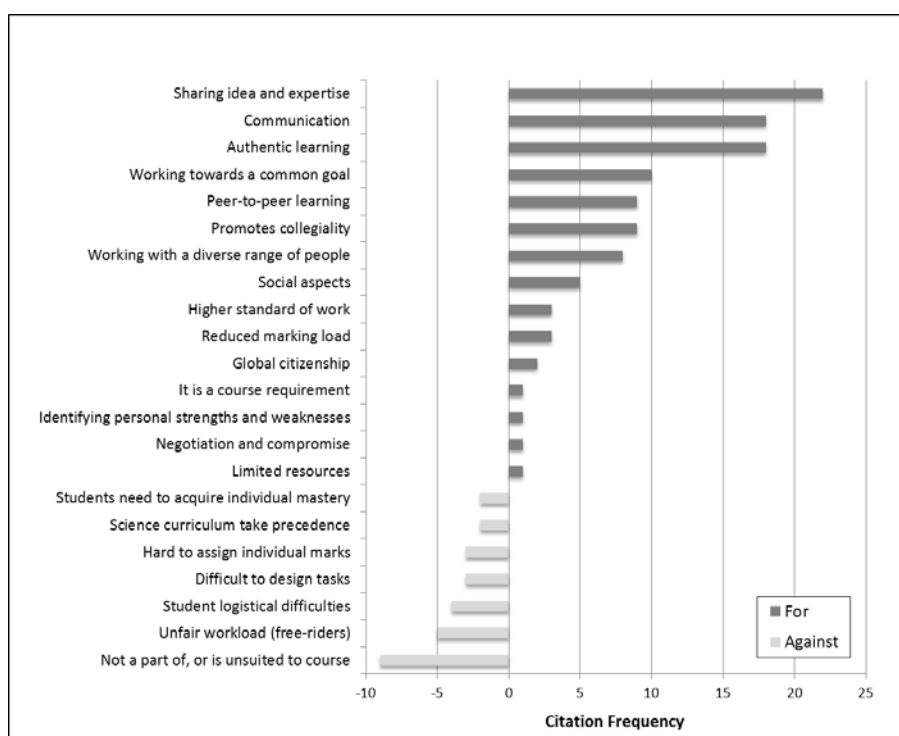
Figure 5. Citation frequency showing themes from coding of open-ended questions asking, '*please list any additional reasons why students should be learning teamwork skills'* and '*please explain why you do not assign group/teamwork tasks*'.

Reasons for not including teamwork

When asked in an open-ended question '*why they don't assign teamwork activities'*, a minority of respondents (*n* = 25) discussed their reasons for not teaching teamwork (Fig. 5). The most frequently cited reason was its unsuitability to the discipline in question (12%), followed by the notion of 'free-riders' (e.g. students not completing an fair amount of work), (4%), student logistical difficulties (3%) and the challenges associated with equitable marking (3%). Comments were included such as: *"Students always complain about students who don't contribute their share."* And: *"I don't use them for assessment, as it can lead to mismatches in effort and some students getting marks that don't reflect their work."*

And:

"It is a terrible teaching method, as many students fail to learn how to complete tasks themselves. It is an even worse assessment method. For poor students, it teaches laziness and encourages incompetence. For good students it has little benefit, since they would do most of the work themselves in any event."

Comments on various organisational difficulties, such as student logistics (3% of respondents), task design (2% of respondents) and assignments of individual marks (2% of respondents) were also received. Those included: *"I allow students to collaborate, but it's essential that they individually demonstrate mastery of the material, and this is not possible in group work."* And: *"Not all tasks are best suited to teamwork. Some lab based experiments that learn skills are best done individually."*

Teaching teamwork
Respondents were asked to provide insight into the ways teamwork was currently taught in their faculty. The majority selected *'Yes, as an integrated part of the science curriculum'* (49%), 12% selected *'Yes, but as a supplementary or external program'*, 15% selected *'No'* and 24% selected *'Don't know'* (*n* = 66).

When asked if teamwork activities were assigned in their units or courses, 74% responded that they assigned teamwork and 26% responded that they did not assign teamwork activities. When asked to select where teamwork activities took place in their units or course, 66% of respondents selected during workshops or laboratories, 58% selected assessments undertaken out of class, 52% selected during tutorial sessions and 50% selected during in-class sessions (lectures).

When asked to rank the following statement *'To include teamwork in the curriculum is important, and it is good practice to dedicate some curriculum time to this'*, 78% of respondents agreed or strongly agreed, 17% were neutral and 5% disagreed, or strongly disagreed.

Respondents were asked to rank '*The best way to integrate teamwork into the curriculum'*, from a range of options including curricular and extra-curricular approaches. A Kruskal-Wallis test showed that the medians of the responses varied significantly (*P* <0.001; Fig. 6). Respondents selected that *'teamwork 'should be developed through participation in teamwork activities (though not explicitly taught)'* more frequently than students should be *'taught teamwork through separate 'bolt-on' courses'*, or *'in extracurricular classes'* (*P* = 0.0001). *'Teaching teamwork as an integrated part of the curriculum'* was also a highly-valued approach, however this approach was only statically different from *'students learning teamwork as an extracurricular class'* (*P* = 0.0001). The lowest median scores for the best way to integrate teamwork were *'teamwork being taught as a separate 'bolt-on' part of the academic program'* and *'students learning teamwork within extracurricular classes'*.

An open-ended question prompted respondents to elaborate on their own teamwork teaching approaches. These comments varied from people actively teaching teamwork, such as:

"In our first-year Biology class, we actively teach the students about the nature and practice of teamwork using a recently released MOOC for one of their major assessment tasks. This is then followed with various opportunities in 2nd and 3rd level classes."
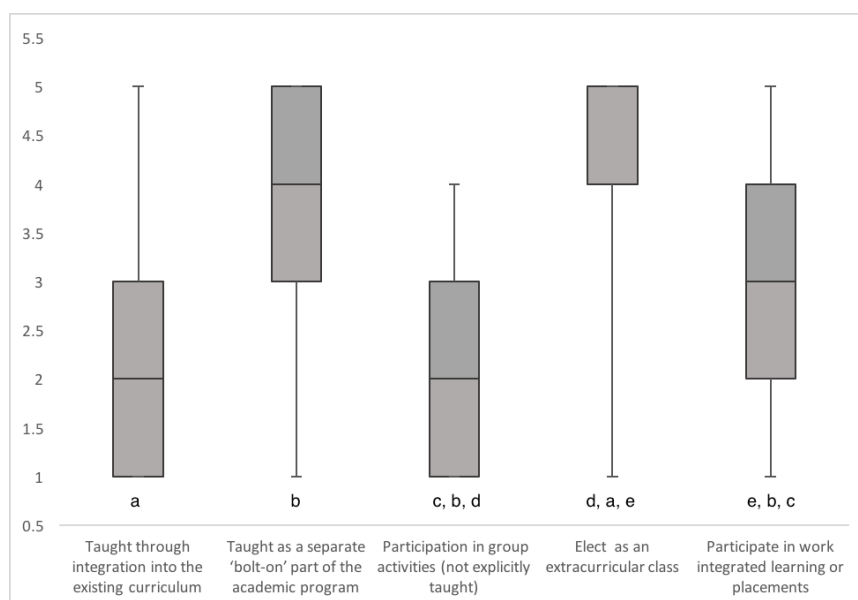
Figure 6: Box plot showing ranking of responses to the statement *'The best way to integrate teamwork into the curriculum is:'.* **The lines inside the boxes denote the medians. The boxes mark the interval between the 25th and 75th percentiles. Common letters show a statistical difference between median scores of the groups (*P* <0.001).**

Through to those academics simply assigning teamwork activities: *"While often expected to work in teams, students are not taught how to do this, they are simply put in teams and expected to get on with their task."*

A few respondents commented about why they did not explicitly teach teamwork, such as:

"Our focus is on teaching the technical skills and concepts, not the soft skills that accompany them. While acknowledging that these are valuable to develop, I'm skeptical of a pedagogy of teamwork." And: *"I do not teach sociology! I let teamwork skills develop naturally, as in the past 5000 years of human culture."*

And:

"Not really. There are certainly team-based activities, most notably in laboratories, and in a learn-by-doing sense students should be learning some teamwork skills. However, it would be a stretch to say we are "actively" teaching students how to work in teams."

When asked to rank whether they believed *'their current approaches for teaching teamwork sufficiently prepared students for employment'*, 48% of the respondents agreed or strongly agreed, 27% were neutral and 25% respondents indicated they disagreed, or strongly disagreed, that they were adequately preparing graduates with teamwork skills (*n = 59*).

Respondents were asked '*would you be happy to alter your current methodology to include a greater focus on the development of team skills'*. Slightly more than half (57%) indicating they were positive, or strongly positive, about their willingness to alter their current approaches.

Respondents were asked to suggest ways to integrate teamwork skills into a science curriculum to enhance employability. These included suggestions ranging from taking a course-wide approach, through to greater resourcing (Table 2).

Table 2: Selected responses on ways to integrate teamwork skills into a science curriculum.

Approach	Suggestions: *'Based upon your own experience, in what ways could the university better integrate teamwork into the curriculum with a view for preparing graduates for employment'?*
Pedagogical approach	*"Providing students with a way to assess their skills so that they could approach a group knowing what skills they are most suitable for."* – A/Prof., Earth, Atmosphere and Environment *"I think teamwork activities are reasonably embedded into the current curriculum, most notably in the laboratory program. I think what is lacking is explicit teaching of teamwork skills and associated metacognitive skills like reflection."* – Senior Lecturer, Physics and Astronomy
Course-wide approach	*"Develop plans for assessment across programs rather than in individual courses. This can be applied to other generic skills, as well as teamwork."* – A/Prof., Biological Sciences *"A good start would be to measure the outcomes - what specifically are the team-work skills of incoming and outgoing students, and what specifically are the missing skills in our graduates. Then lots of experimentation to find out what approaches work best to remedy these. Teamwork skills are diverse, and some are surely not teachable - simply having more team exercises may make no difference."* – A/Prof., Physics and Astronomy
Academic development	*"Getting academics to have improving student outcomes as their first priority would be a good first step. Most academics seem to teach under sufferance and then only as a means to get the best students to do graduate work in their lab. They are disinterested in the vast majority of students who will not ultimately become research scientists"* – Lecturer, Biological Sciences *"Start by training the academics--particularly in terms of emotional intelligence, which I often find lacking amongst the higher-ups in research. Many of us think we're good at teamwork but are actually fairly ineffective at ensuring our teams achieve their highest potential."* – ARC Fellow, Physics and Astronomy
Transferable skills	*"I think that in general degrees it is extremely difficult to prepare students with specific skills for specific employment since their destinations are so varied. I think what is important is to identify the core principles for team work and ensure students learn those in a way that enables them to transfer that learning to new contexts, such as in the workplace. Much of the design of undergraduate classes primarily focusses on learning the discipline - student learning needs to take priority over specific workplace skills, but should at the same time equip students with important principles and practices which they can then transfer to new contexts."* – Lecturer, Biological Sciences
Contextualisation	*"We could probably do better at explaining/promoting the 'philosophy of teamwork'. Top notch scientific developments are almost always now the result of significant team work."* Prof., Chemistry
Beyond undergraduate curriculum	*"A higher objective should be to improve the general standard of graduates. Teamwork, either official or de facto, is an essential requirement at Honours level doing research in technical faculties and can/should be left till then.*" – Prof., Chemistry
Work integrated learning	*"While moves are occurring, I think we need a greater emphasis on students being embedded within prospective employers and greater emphasis on bringing students together from different faculties."* – A/Prof., Earth, Atmosphere and Environment
Teaching spaces Assessment	*"Better teaching spaces"* – Lecturer, Mathematical Sciences *"Improving the culture of the way students approach assessment.*" – Lecturer, Mathematical Sciences *"The current ways in which teamwork skills are assessed are somewhat naïve and don't consider the human elements of the students' behaviour. For example, if grades are important, then teamwork will be sacrificed and the project/task will be undertaken in a way which is not conducive to team work but will achieve a higher mark. How one goes about fairly assessing group assignments is difficult."* – Tutor, Physics and Astronomy
Resources	*"Make available more resources for people trying to develop this component into existing units."* – Senior Lecturer, Physics and Astronomy

DISCUSSION

This study shows that many academics value the importance of teamwork skills for science undergraduates. Yet, fewer believe that science graduates are equipped with the teamwork skills needed for future employment. These results are consistent with prior studies demonstrating that both science graduates and their employers believe teamwork skills need greater development (Prinsley & Baranyai, 2015; Sarkar et al., 2016). To ensure science students have adequate team skills upon graduation, it is important to look more closely at the science curriculum, assessment and pedagogical approaches.

Teamwork skills were valued because of the importance of sharing ideas and expertise between students, the development of communication skills and the authentic learning environment teamwork activities created. These views echo the reasons why teamwork is highly valued in other disciplines (Lerner et al., 2009, Lingard, 2010) and within the workplace (Dunne & Rawlins, 2000; Prinsley & Baranyai, 2015). This suggests that the majority of science academics clearly have a strong understanding of the benefits of teamwork, the skills that are acquired through teamwork and it's importance in the workplace.

A small number of respondents strongly believed that teaching teamwork was not appropriate for their science discipline. The most common reasons for this view was that teamwork skills were not appropriate for the discipline and because of the difficulty of managing 'free riders' in groups. 'Free-riders' are those students who contribute very little, or lower amounts of work, than the rest of the team. In the eyes of some researchers, there is a notion that teaching 'soft-skills', such as teamwork, may undermine the purity and orthodoxy of academia. For example, Zakaria & Iksan, (2007) finds opposition to the idea of explicitly teaching team skills on the grounds that this inclusion will require significant extra preparation. Whereas, Bellanca & Brandt, (2010) noted in their study a concern that teaching teamwork comes at the expense of important subject content. Furthermore, Johnson et al., (2012) identified that some science academics have a strong opinion that teamwork is a skill that should be acquired through practice rather than explicitly teaching it in the science undergraduate curriculum. They found that academics thought that resilient teams naturally evolve through prolonged exposure to the authentic research laboratory (Johnson, et al., 2012).

Most respondents were already teaching teamwork skills as an integrated part of the science curriculum (49%). Integrating teamwork into the curriculum is ideal as it provides students the opportunity to develop these skills within the context of their discipline. Experiential learning, where the student is immersed in an activity that simulates the real world, helps students acquire the knowledge, skills and attitudes in a powerful learning environment (Banerjee, Slagle, Mercaldo, Booker, Miller, France, Rawn & Weinger 2016). Even if experiential learning is not possible, a curriculum-integrated approach will provide opportunities for immediate application and reinforcement of the skills. It is important to note, that this integration of soft skills does not need to come at the expense of discipline content, as both can be taught simultaneously. A greater number of academics explicitly teaching teamwork may also support students, by not only better fostering valuable skills, but also ensuring a more positive experience. This is because many studies indicate one of the biggest factors impacting a positive teamwork experience for students is the scheduling of time to work together due to study timetables and work commitments (Burdett, 2003; Garcia-Bayonas & Gottschall, 2008).

When asked what the best way was to develop teamwork skills, respondent's equally valued approaches where teamwork was explicitly taught, as well as when it was solely acquired through undertaking teamwork activities without guidance (Fig. 6). These two approaches may achieve significantly different outcomes for students. Without receiving instruction about how to effectively approach teamwork processes, students are often found lacking in the very skills needed to negotiate teamwork challenges (Huxham & Land, 2000). Despite the reported benefits of working in a team, this lack of skills development may be a significant contributor to why teamwork and group tasks are not always viewed positively by students (Burdett, 2003). Previous research shows that to work together effectively, members of a team need to know what each other are doing, possess knowledge of both their own and their teammates responsibilities, communicate ideas and results, and understand the strengths and limitations of individuals in the team (Baker et al., 2006; Herrmann, 2013). Working in a team at university is often a lesson in professionalism and poses many of the challenges that students will face during work with regards to collaboration and interpersonal relationships (Tarricone & Luca, 2002).

Without guidance, there is no guarantee that the teamwork experience will be one that will be accompanied by positive learning outcomes. Commonly students assign themselves individual subtasks within the group, and then they go away and approach each element as a separate endeavour, not interacting again until completion and thus eliminating the requirement to develop many of the other fundamental teamwork skills (Felder and Brent (2007). This 'jigsaw' approach also can result in significant knowledge gaps for each individual team member with each student only learning about their area of specialization (Pfaff &

Huddleston, 2003). This approach can pose a substantial issue with regards to developing an understanding of the entire project and means that students to not gain the secondary skills of communication, negotiation and peer learning related to teamwork. In most cases, students may learn teamwork skills through exposure to tasks that require group cohesion. Johnson, Johnson and Smith (1998) suggest that operating successfully as a team is not always fundamentally obvious to students, and often it is through trial and error that they learn these skills. To ensure development of these skills, a teamwork activity should ideally instruct the students on both the product required from the assignment, and the process that the students can follow to get there. To accomplish this, greater application of explicitly teaching teamwork skills in the science curriculum is needed.

Limitations

This study investigates the academic perspective of *teaching* teamwork. Whilst the questions specifically probed about practices related to *teaching* teamwork, some academics may have interpreted these questions as the practice of assigning students into groups for assignments without explicitly teaching teamwork skills. Should this misinterpretation have been made, this may have inflated some results. For example, 48% of respondents thought that their current approach to *teaching* teamwork was sufficient. However, some of these respondents may be basing their responses on just allocating teamwork assignments rather than *teaching* teamwork.

CONCLUSION

Developing teamwork skills for undergraduate science students is clearly not new. However, based upon reports from employers and the students themselves, teamwork skills of science undergraduate students need strengthening. This study shows strong academic support for teamwork as an important graduate outcome for science students and a broad willingness for a greater introduction of approaches where teamwork is taught in the science undergraduate curriculum. However, many academics indicate they are not confident that their institutes, or their current approaches, sufficiently support teamwork skills in graduates. These insights suggest a greater need for Science Faculties to encourage stronger practices for teaching teamwork skills with their educational staff.

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DO ACCELERATED STUDENTS IN NURSING BENEFIT FROM FACE-TO-FACE SUPPORT WHEN ONLINE SUPPORT IS AVAILABLE?

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KEYWORDS: accelerated nursing students, bioscience, face-to-face support, online support, pharmacology

ABSTRACT

We have demonstrated that the diploma-entry accelerated students in a nursing program need additional support at the start of their studies in bioscience and pharmacology to prevent high rates of attrition. This support consists of a formative, online activity of resource notes and quizzes covering key concepts in bioscience and pharmacology, and a face-to-face workshop addressing academic skills and reviewing bioscience material, presented to the students in orientation week. Subsequently, we developed an online eBook: Getting Started in Bioscience, Pharmacology and Microbiology; https://sites.google.com/site/gettingstartedinbioscience/ The aim of the present study was to determine whether it was necessary to provide both the face-to-face workshop/review lectures and the eBook, as support for nursing students undertaking the biosciences and pharmacology. In order to do this, firstly, we evaluated the eBook showing it was well received by the both accelerated and traditional students. Secondly, we evaluated the face-to-face workshop/review lectures in 2016, when the students had access to the eBook, and this showed high appreciation by the students. Finally, we compared the analysis of the face-to-face workshop/review lectures in 2016 with the analysis in 2011, which was prior to the eBook, and showed that the students' appreciation of the face-to-face workshop/review lectures was not altered by the introduction of the eBook. Thus, continuing face-to-face support for nursing students prior to studying bioscience and pharmacology, despite the introduction of an eBook, may be worthwhile.

INTRODUCTION

Since the transfer of nursing education into the higher education domain in the 1970s it has been documented that the bioscience subjects pose a challenge for commencing nursing students in some countries. In the UK, the traditional nursing students find bioscience and pharmacology among the most difficult to learn, mainly due to their poor science background (reviewed in McVicar, Clancy, & Mayes, 2010). In Australia, diploma students are given academic credit to enter the Bachelor of Nursing at second year level and these students also struggle with the biosciences (reviewed by Ralph, Birks, Chapman, Muldoon, & McPherson, 2013). At QUT, accelerated entry into the second year of a nursing degree is given to diploma students, and domestic and international graduates. Of these accelerated students, only the diploma-entry students have higher attrition rates in bioscience and pharmacology than the traditional students (Doggrell & Polkinghorne, 2015; Doggrell & Schaffer, 2016a). Thus, diploma-entry students may need support to succeed in these disciplines.

THE STORY SO FAR

At QUT, we introduced a strategy to prepare the diploma nurses for the pharmacology and bioscience units of a nursing degree, from 2010-2013. This strategy included a formative, online activity consisting of resource notes and quizzes covering key concepts in bioscience and pharmacology, which was made available to the diploma students on Blackboard. A second part of this strategy involved a face-to-face workshop addressing academic skills and reviewing bioscience material, and was presented to the students in orientation week. The strategy was well received by the students, and was associated with reduced attrition of the diploma students at QUT (Doggrell & Polkinghorne, 2015; Doggrell & Schaffer, 2016a).

After a change to the nursing curriculum at QUT, it was considered that the support strategy for diploma students may no longer be needed, and it was not offered in 2014/15. However, in response to requests from both diploma-entry and traditional students for support in pharmacology, in the middle of semester 2 in 2014, a peer leader-led revision skills workshop was held for all students. This peer leader workshop highlighted revision methods to better understand concepts in pharmacology. All of the attending students agreed or strongly agreed that there was a need for support in pharmacology. The unit outcomes for the attending students were the same as for the whole class (Doggrell, Menzies & Bakon, 2015).

A comparative analysis of the withdrawal and failure rates of diploma-entry and traditional students in 2014, showed the combined withdrawal and failure rates were higher for diploma-entry (21%) than traditional nursing (8%) students at the main campus at QUT (Doggrell & Schaffer, 2016b). At the QUT regional campus, the withdrawal and failure rates were high for both traditional (24%) and diploma-entry students, 20% (Doggrell & Schaffer, 2016b). This suggested that, despite the change in nursing curriculum, diploma-entry students still required support in bioscience/pharmacology, and that the traditional students at the QUT regional campus may also require support.

In 2015, we developed an eBook based on the strategy we had previously used to support the diploma-entry students. The objectives of the eBook were as follows: to provide a "Formative" activity testing key bioscience concepts; to provide the students with "Review" lectures covering first year bioscience material; to provide students with some information about academic skills ("Academic Self-Assessment") needed for university studies; and to identify key university services and support available for students. We subsequently made the eBook available to the students on Blackboard for semester 2, 2015. From 2016, we provided both the traditional and diploma-entry students with both a face-to-face workshop and the eBook online: Getting Started in Bioscience, Pharmacology and Microbiology; https://sites.google.com/site/gettingstartedinbioscience/

AIMS

The aim of the present study was to determine whether it was necessary to provide both the face-to-face workshop/review lectures and the eBook, as support for nursing students undertaking the biosciences and pharmacology. In order to do this we completed the following: (i) an evaluation of the eBook in the pharmacology unit in 2015 and in the bioscience unit in 2016; (ii) an evaluation of the face-to-face workshop/review lectures in 2016, when the students had access to the eBook and (iii) a comparison of the analysis of the face-to-face workshop/review lectures in 2016 with 2011, which was prior to the creation of the online eBook.

METHODS

Discussions with the QUT Human Ethics Committee indicated that ethical review by the committee was not required for this project, provided students were not identifiable, and the study was conducted in accordance with the Australian Government National Statement of Ethical Conduct in Human Research; these conditions were met by the study.

The evaluations involved questionnaires using a Likert scale; they were completed by the students voluntarily.

 (i) Evaluation of eBook; Getting Started in Bioscience, Pharmacology and Microbiology

The students studying pharmacology evaluated the eBook in semester 2, 2015, when the diploma and traditional students were in their second and fourth semesters of university, respectively. A different cohort of diploma-entry and domestic and international graduates studying bioscience in their first semester at university evaluated the eBook in semester 1, 2016. Evaluations were undertaken in tutorials for the pharmacology unit and practicals for the bioscience unit. The questionnaire included the following:

1. The "Formative" material was presented in a clear and organized manner.
2. The "Academic Self-Assessment Literary" tool directed me to learning support.
3. The "Review" lectures were presented in a clear and organized manner.
4. Undertaking the "Quizzes" made me more confident of my future learning.

In addition, those that had attended the face-to-face workshop/review lectures, were asked to consider whether they required both the workshop and the eBook.

 (ii) Evaluation of face-to-face workshop/review lectures

The diploma-entry and domestic and international graduate students studying bioscience in their first semester at university evaluated the workshop in semester 1, 2016. The students completed the evaluation at the end of the workshop. The questionnaire included the following:

1. The demonstration of the community website was informative and valuable.
2. The library and learning skills were presented in an informative manner.
3. The information presented in the bioscience review lecture was informative and appropriate.

4. The information presented in the microbiology review lecture was informative and appropriate.
5. The interview with a previous accelerated student was informative and valuable.
6. Overall, the workshop was informative and valuable.

The students were also asked to comment on ways to improve the workshop and to suggest other useful topics or support services.

    (iii)   Comparison of the evaluation of face-to-face workshop/review lectures before and after the availability of the eBook

Questions 2-5 in section (ii) were included in the workshop evaluation in 2011, which was prior to the introduction of the eBook, and in 2016 after the introduction of the eBook.

Analysis of data

The percentage responses to the 5 points on the Likert scale surveys were determined for both the evaluation of the eBook and workshop. Comparisons between cohorts were made using the Odds ratio (OR) calculator https://www.medcalc.org/calc/odds_ratio.php with $P < 0.05$ being considered significant.

RESULTS

Evaluation of eBook; Getting Started in Bioscience, Pharmacology and Microbiology
The eBook has been evaluated twice; firstly in the bioscience unit in 2016, when the accelerated students were in their first semester at university, and secondly in the pharmacology unit in 2015, when the accelerated students were in their second semester of university, but had not had access to the eBook previously.

In the first semester of 2016, there were 229 students in the bioscience unit, which was specifically designed for accelerated students in their first semester at university; 162 students attended the practicals in week 3 and responded to the survey. Of these, 95 (59%) had used the eBook, and the majority of these students strongly agreed or agreed with the 4 statements on the eBook (see (i) Evaluation of eBook; Getting Started in Bioscience, Pharmacology and Microbiology) (Figure 1). Ninety-one percent of the accelerated students who used the eBook in the bioscience unit would recommend it to other students. Ninety of the students had used the eBook and attended the face-to-face workshop/ review lectures, and 84 of these considered it necessary to have both.

Figure 1: Evaluation of eBook: Bioscience in 1st semester

Figure 2: Evaluation of eBook: Pharmacology in 2nd semester
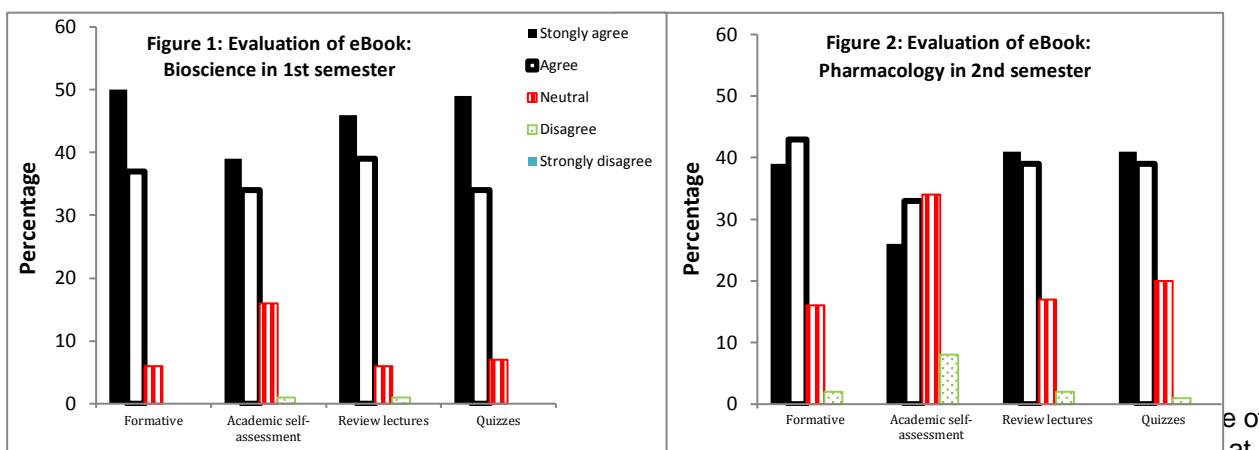
university. All of the students responded to the survey, and of these, 199 (50%) had used the eBook, with use being higher for the accelerated (57%) than the traditional students (45%). For the eBook users, most of the students strongly agreed or agreed that the "Formative" activity and the "Review" lectures were presented in a clear and organized manner, and that undertaking the "Quizzes" made them more confident for the future (Figure 2). Furthermore, 92% of the students who used the eBook would recommend it to other students.

In comparing the two surveys evaluating the eBook (Figures 1 and 2), more than 80% of bioscience and pharmacology students strongly agreed or agreed with the statements regarding the "Formative" material, "Review lectures" and "Quizzes". The percentage of students who strongly agreed with the four statements (see (i) Evaluation of eBook; Getting Started in Bioscience, Pharmacology and Microbiology) was

significantly higher for the bioscience students in their first semester of university than for the pharmacology students in their second/forth semester of university, for questions 1, 2 and 4 (P < 0.05 from OR). Similar percentages of students in the two cohorts strongly agreed or agreed with question 3 regarding the "Review lectures".

When the data for accelerated and traditional students in the pharmacology unit were compared, the combined strongly agreeing and agreeing percentages were higher for the accelerated than traditional students (data not shown). Thus, the percentages were 89% for the accelerated vs 61% for the traditional students on the "Formative" activity (OR = 0.1933, P < 0.0001); 69% vs 47% for the "Academic self-assessment" (OR = 0.3984, P = 0.0018), 87% vs 68% (OR = 0.3175, P = 0.0018) for the "Review" lectures, and 86% vs 72% for "Quizzes" (OR = 0.4186, P = 0.0168), respectively.

Additionally, on comparison, the combined strongly agreeing or agreeing percentages for the accelerated students in both the bioscience and pharmacology units were not significantly different. Thus, the percentages were 89% for the accelerated students in pharmacology vs 87% for the accelerated students in bioscience for the "Formative" activity; 69% vs 73% for the "Academic self-assessment", 87% vs 85% for the "Review" lectures, and 86% vs 83% for "Quizzes" respectively.

Evaluation of face-to-face Workshop and Review Lectures

In the first semester in 2016, 100 students from the bioscience unit (44%), attended the workshop; of these 76 students completed the workshop evaluation. More than 80% of the completing students agreed or strongly agreed with all the statements (see (ii) Evaluation of face-to-face workshop/review lectures) included in the questionnaire (Figure 3).

Figure 3: Evaluation of face-to-face workshop and review lectures in 2016

Figure 4: Comparison of the evaluation of face-to-face workshop/review lectures before and after the availability of the eBook

Comparison of the evaluation of face-to-face workshop/review lectures before and after the availability of the eBook

A comparison of the responses to the statements asked in 2011, which was prior to the introduction of the eBook, and after the introduction of the eBook in 2016 (see (ii) Evaluation of face-to-f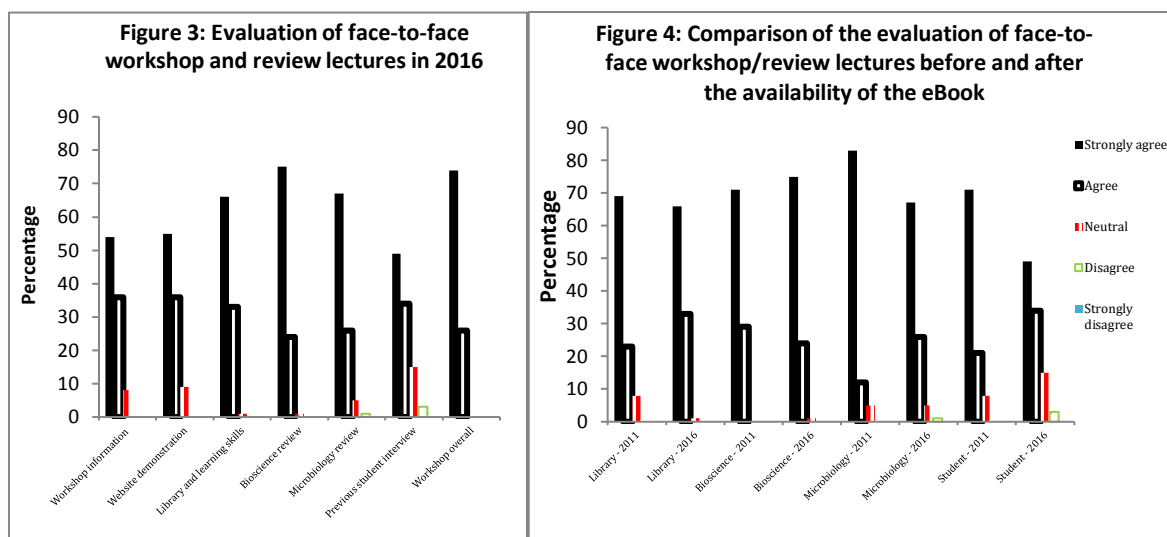ace workshop/review lectures, statements 2-5 inclusive) is given in Figure 4. In comparing the two evaluations, more than 80% of bioscience and pharmacology students strongly agreed or agreed with the statements regarding the "Library and learning skills" material, "Review lectures" and "Previous Student" before and after of the availability of the eBook. Analysis showed that the combined strongly agree and agree percentage was not significantly different for the Bioscience review (100% in 2011 vs 99% in 2016) or Microbiology review (95% vs 91%) before or after the availability of the eBook. A higher percentage of students strongly agreed or agreed with the statement regarding the "Library and learning skills" in 2016 than 2011 (99% vs 92%, P = 0.04), whereas fewer students appreciated the "Previous Student" in 2016 than 2011 (83% vs 92%, P = 0.04).

DISCUSSION

We have previously shown that, a strategy to support accelerated nursing students, reduced the attrition of diploma students (Doggrell & Polkinghorne, 2015; Doggrell & Schaffer, 2016a). Subsequently, we developed an eBook based on this strategy (Doggrell & Schaffer, 2016b). This study shows that the eBook, Getting Started in Bioscience, Pharmacology and Microbiology was well received by both the accelerated nursing students in a first semester bioscience and second year pharmacology unit.

We made the eBook available to both accelerated and traditional students, as we have recent evidence that some of the traditional nursing students also need support in bioscience and pharmacology (Doggrell, Menzies & Bakon, 2015; Doggrell & Schaffer, 2016b). Although the eBook was not specifically designed for the traditional students, and they were not so appreciative of the eBook as the accelerated students, there were a high percentage of traditional students strongly agreeing or agreeing with components of the eBook; ≥ 60%, for the "Formative" activity, "Review" lectures, and "Quizzes". Thus, it seems worthwhile that the eBook be made available to traditional students. Alternatively or additionally, tailor-made support for traditional students who are struggling with bioscience or pharmacology may be needed, and we do this at QUT with the STIMulate program (Devine & Doggrell, 2016).

One of the reasons for creating the eBook was to replace the face-to-face support. However, the student evaluation of the face-to-face workshops and review lectures was very favourable in 2016, despite the introduction of the eBook. Indeed, the student evaluation for the face-to-face lecture resources was very similar before and after the introduction of the eBook; with more that 80% of the students strongly agreeing or agreeing with the statements relating to these lectures. There was a small difference in the support for the "Library and learning skills" in favour of 2016 (99%) over 2011 (92%), which is unlikely to relate to the introduction of the eBook. The difference is more likely to relate to the different presenters, but suggests that both presenters were highly appreciated. There was also a difference for the interview with a "Previous student", which was less appreciated in 2016 than 2011. This is probably due to there being a different previous accelerated student for the workshops in 2011 and 2016 with, in our opinion, the 2011 student being more enthusiastic about their experience than the 2016 student.

One of the most interesting findings of this study was that most of the students who attended the face-to-face workshop/lecture resources had also used the eBook and would recommend both, and considered it important to have both. Thus, we have decided to continue face-to-face support for nursing students prior to studying bioscience and pharmacology, as the students are strongly supportive of this. However, the main limitation of our study is that we do not know whether it is the eBook or the face-to-face support alone or both that are needed to reduce the attrition of accelerated and traditional students.

Another reason for writing the eBook was to make this support available to nursing students at other universities, as the problem of accelerated students struggling with bioscience and pharmacology is a common problem in universities in UK and Australia. Thus, the eBook has been made available on a standalone Google site; https://sites.google.com/site/gettingstartedinbioscience/ which is freely available.

ACKNOWLEDGEMENTS

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DEVIATION FROM STEM PEERS AND EMPLOYERS IN EMPLOYABILITY FOCUSES: THE CASE OF MATHS, STATS, PHYSICS AND ASTRONOMY STUDENTS

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ABSTRACT

STEM employability is a non-homogenous phenomenon with mixed outcomes for graduates from different disciplines. A myriad of factors may contribute to the diverse employability. We examine the heterogeneity of career and employability development focuses among different STEM student cohorts and employers within a curricular context. A structured framework of Career Information Literacy (CIL) was utilised to map STEM students' and employers' focuses on career and employability. This paper presents findings from the Mathematics, Statistics, Physics and Astronomy cohort.

Data was collected from final year capstone unit students at a STEM faculty in an Australian university (n=517, response rate 44%). Of which, Maths, Stats, Physics and Astronomy (MSPA) students were analysed as a cohort (n=80, response rate 73%). Concurrent data collection took place with STEM employers and industry stakeholders who engaged this faculty in recruitment and employability activities (n=62, response rate 78%). Upon comparing student cohorts' focuses on career and employability development with their peers and employers, we found MSPA students differ from both their STEM peers and employers. Most other STEM student cohorts differ from employers, but not their peers. The implications point to a different career development need of this cohort to fully realise the benefits of their education.

BACKGROUND

STEM employability is an intriguing phenomenon attracting global attention from policy makers, educators, employers and industry stakeholders (Office of the Chief Scientist, 2012, 2013). Propelled by graduate expectations, industry demands and governmental agendas, concerned parties have studied STEM employability from various empirical and strategic angles, including gender balance, racial representations, labour market demands and supply, varying graduate outcomes, professional identity, and curriculum design (Broadley, 2015; Petocz & Reid, 2010, Riegle-Crumb et al., 2010; Xue & Larsen, 2015), to name a few. The breadth of topics covered in the STEM employability studies reflects a grave concern of meeting current and future workforce needs through STEM education.

Specifically, despite the strong demand for STEM graduates, many STEM students still face underemployment and unemployment. Recent analyses on mixed STEM graduate outcomes based on fields of work and study (Xue & Larson, 2015) signalled a need to examine the heterogeneity of STEM employability. However, two significant challenges exist. Firstly, to date, a multitude of industry reports, academic papers and government publications have produced wish-lists of skills for STEM students upon completion of degrees. However, little attention is paid to the structural embedment of career and employability development within the curriculum. Secondly, there is also a lack of knowledge of and studies on STEM students' predispositions towards career and employability development. The complexity of the heterogeneous STEM employability is poorly understood.

Addressing issues of STEM employability will mean addressing STEM students' career needs throughout students' university learning journey (Rayner & Papakonstantinou, 2016; Sarkar et al., 2016). It is time we adopt a structural approach to explore the intricacy of integrating generic, discipline-specific and personal career preparation learning into university programs of study. Furthermore, differences between student cohort and employer needs should be identified within that investigation.

AIMS

To afford structural, holistic thinking of generic, discipline-based, and personal/professional development learning within the curriculum, and to identify student cohorts' and employers' needs, a conceptual tool was created to juxtapose key types of learning and gauge to which extent students and employers value or focus on them. A two-year project spanning across disciplines in a comprehensive STEM faculty in an Australian university produced the Career Information Literacy Learning Framework (CILLF) (Figure 1). The CILLF unites three key theoretical frameworks of learning approaches, career development learning and information literacy. It is informed by and tested with academic, employer, and student inputs and data (Lin-Stephens et al., 2016, 2017).

Figure 1. The Career Information Literacy Learning Framework (Version 2.0) (Lin-Stephens, et al. 2017)
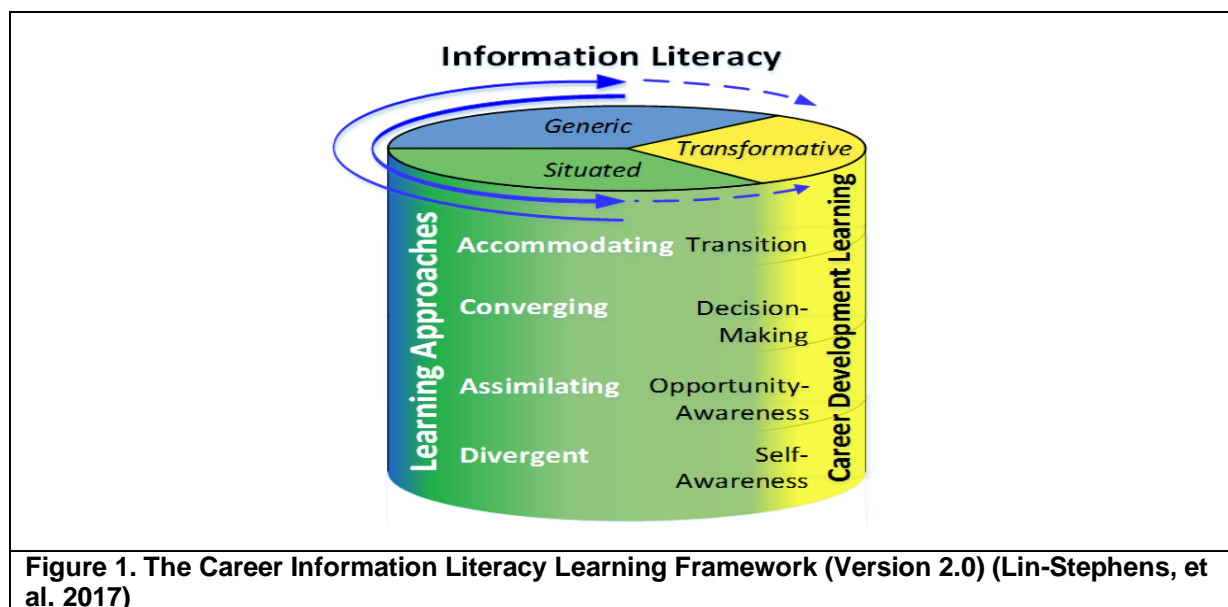
The Career Information Literacy Learning Framework is used here to:
- delineate the relationship between key aspects of university learning, including generic, discipline-based learning, transformative, and career development learning
- capture varying focuses in aspects of learning held by academics, students and employers; thus furthering our understanding about heterogeneity in STEM employability

In this paper, we report the use of this framework to map students' and employers' focuses on career and employability development within university learning. In particular, we present the comparison between the cohort of Mathematics, Statistics, Physics and Astronomy (MSPA) students and their STEM peers, as well as the comparison between the MSPA cohort and STEM employers.

METHOD

Applying the Career Information Literacy Learning Framework (CILLF)

The Career Information Literacy Learning Framework (Lin-Stephens et al., 2016, 2017) integrates three theoretical frameworks: learning approaches (Kolb and Kolb, 2015), career development learning (Watts, 2006) and information literacy (Lupton, 2008) (Figure 1 & Table 1). It associates career development learning with fundamental learning approaches by highlighting career development learning as a function of learning approaches. The framework posits learning as an ability to work with information and specify three relevant domains in the higher education context: Generic (cross-discipline), Situated (discipline-specific) and Transformative (trans-discipline).

Table 1. CILLF Codes				
Learning Approaches	***Career Development Learning***	***Information Literacy***		
		Generic	Situated	Transformative
Diverging	Self-Awareness	***DSG***	***DSS***	***DST***
Assimilating	Opportunity Awareness	***AOG***	***AOS***	***AOT***
Converging	Decision Making	***CDG***	***CDS***	***CDT***
Accommodating	Transition Learning	***ATG***	***ATS***	***ATT***

The CILLF was previously used to code data collected from academics with success (Lin-Stephens et al., 2016). Subsequently, Career Information Literacy (CIL) survey instruments were devised for data collection from students and employers (Lin-Stephens et al., 2017). The CIL survey contains answer items for students and employers to map their focuses on career and employability development. Choice items were devised to denote conceptions/values in the CILLF according to Table 1.

We posed two research questions to test the heterogeneity of the STEM employability being studied. Here we report findings from the Mathematics, Statistics, Physics and Astronomy (MSPA) cohort.
RQ1: Does the MSPA student cohort share the same focuses on career and employability development as their STEM peers?

RQ2: Does the MSPA student cohort share the same focuses on career and employability development as STEM employers?

Applying Profile Analysis and Hotelling's T^2 test
Profile analysis and Hotelling's T^2 test were used to study the similarity of score profiles, particularly the significance of the various patterns or effects. We tested two hypotheses for the means of the groups being compared:
- Parallelism - If the groups' profiles are not parallel between variables, the two groups are considered different across the key measurements. If they are parallel, the groups exhibit similar trends in scores across the dimensions, but not necessarily the same values. Hence the next step to test coincidence.
- Coincidence - If the groups' profiles are at equal levels across variables, they are coincident as having the same value for each dimension. If not, the two groups are different.

Standard ordinal regression was used to confirm the results obtained. Specifically, the validity of the results was confirmed by controlling for demographic covariates and checking for linearity of the ordinal scale.

Data Collection
The CIL survey was administered to students in the 34 capstone units in the STEM faculty being studied (n=517, N=1176, response rate 44%) at the end of semesters in one academic calendar year, primarily face to face. Web survey links were provided to those who could not attend lectures in person. Six final year capstone units resided in Mathematics, Statistics, Physics and Astronomy (n=80, N= 110, response rate 73%).

In the same period, data was collected from STEM employers who approached this STEM faculty to engage students in recruitment and employability activities, for example participation in careers fairs, employer presentations, etc. to attract students to work in relevant STEM opportunities (n=62, N=80, response rate 78%).

RESULTS
Demographic and activity-based characteristics of the MSPA cohort and the whole of STEM cohort are summarised in Table 2. Employer/industry stakeholder respondent characteristics are presented in Table 3.

We compared the characteristics of the MSPA cohort and whole of STEM cohort. Chi-square tests did not find any significant difference between the MSPA and the whole of STEM cohort at $p<.05$. We found no significant difference between the MSPA cohort and the general STEM cohort in terms of gender, age, or residency composition. Nor were there any statistical remarkable differences in terms of activities completed in the past 12 months, total work and unpaid work history, and plans within one year of degree completion. The Cronbach's alpha value for the MSPA cohort was high (0.82), giving us confidence in the internal consistency of the student responses.

Table 2. CIL Capstone Unit Student Respondents' Characteristics Math, Stats, Physics & Astronomy Cohort vs. Whole of STEM Faculty		
	MSPA cohort	STEM whole faculty
Total number of responses (n)	80	517
Total number of enrolments (N)	110	1176
Response rate	73%	44%
Male	60%	67%
Female	30%	32%
Domestic	63%	67%
International	6%	8%
NA	31%	25%
Age		
19 or under	0%	0.4%

**Table 2. CIL Capstone Unit Student Respondents' Characteristics
Math, Stats, Physics & Astronomy Cohort vs. Whole of STEM Faculty**

	MSPA cohort	STEM whole faculty
20-25	84%	81%
26-30	11%	10%
31-40	5%	6%
41+	0%	3%
Activities in the past 12 months		
Part time work	79%	75%
Job search	35%	49%
Student groups/societies	25%	28%
Unpaid work experience	18%	28%
Volunteer or community work	28%	30%
Project work involving external clients	34%	21%
Full-time work	10%	11%
Professional association involvement & networks	3%	8%
Overseas exchanges or studies	4%	6%
Average total paid work history	4 years	4 years 2 months
Average total unpaid work history	9 months	10 months
Plan within 1 year of completing degree		
Work	76%	73%
Further study	33%	37%
Other	5%	10%

Table 3. CIL STEM Employer/Industry Stakeholder Survey Respondents' Characteristics

	Frequency	Percentage
Organisation type (n=62, N=80, response rate 78%)		
Large enterprise (200+)	28	46%
Small/Medium Enterprise (< 200)	25	41%
Government	5	8%
Not for profit	4	7%
Male	24	39%
Female	38	62%
Length of time		
Average experience in workforce	13 years 3 months	
Average experience in hiring	7 years 5 months	

Despite the similarity between MSPA student characteristics and their STEM peers (Table 2), Profile analysis and Hotellings T² test showed that MSPA cohort's CIL profile differs from their STEM peers (Figure 2 and 3). Hotelling's T² tests show that the profiles are parallel but not coincident (Table 4 and 5). Therefore, for RQ1, the MSPA student cohort differ from their STEM peers in their career and employability development. The MSPA cohort rated the CIL items consistently lower than their STEM peers.
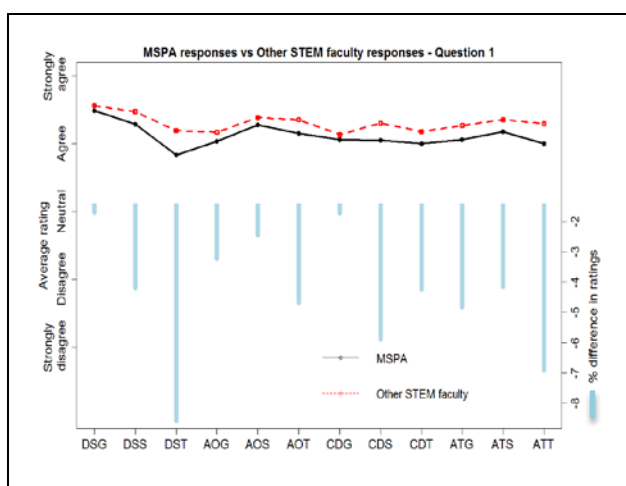
**Figure 2. Q1 Responses
MSPA Cohort vs. Other STEM Peers**

**Figure 3. Q2 Responses
MSPA Cohort vs. Other STEM Peers**

**Table 4. Hotelling's T² Test Result Q1
(MSPA cohort vs. STEM peers)**

Hypothesis	Hotelling's T²	Critical value	P-value
Parallel	14.79	20.28	0.28
Coincident	9.94	3.86	<0.01

**Table 5. Hotelling's T² Test Result Q2
(MSPA cohort vs. STEM peers)**

Hypothesis	Hotelling's T²	Critical Value	P-Value
Parallel	5.93	9.61	0.32
Coincident	6.33	3.86	<0.01

For RQ2, we performed the same procedure on the MSPA cohort and STEM employers. We found even greater differences between the MSPA cohort and STEM employers (Figure 4 and 5). MSPA students' and employers' scores across the measures are distinctly different as confirmed by Hotelling's T² Test (Table 6 and 7).
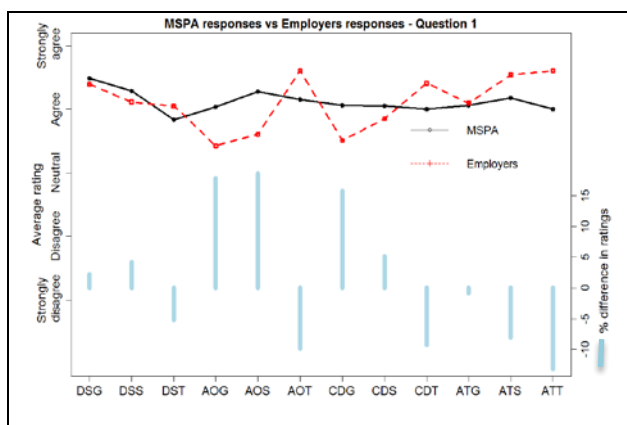
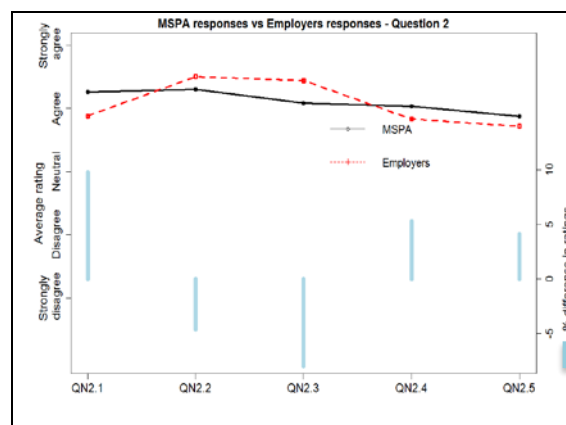**Figure 4. Q1 Responses
MSPA Cohort vs. STEM Employers**

**Figure 5. Q2 Responses
MSPA Cohort vs. STEM Employers**

**Table 6. Hotelling's T² Test Result Q1
MSPA Cohort vs. STEM Employers**

Hypothesis	Hotelling's T²	Critical value	P-value
Parallel	124.74	22.08	4.009E-13

**Table 7. Hotelling's T² Test Result Q2
MSPA Cohort vs. STEM Employers**

Hypothesis	Hotelling's T²	Critical Value	P-Value
Parallel	25.55	9.96	0.000329962

We used CILLF to map student cohort and employer results (Table 8 and 9) and found that MSPA students focus on their discipline-based learning most while employers highly value the transformative learning. The transformative items refer to critical reflective abilities and actions (challenging the status quo), meaning-seeking behaviour, and outside-of-the-box thinking.

Table 8. CIL Scores of MSPA Students

Learning Approaches	Career Development Learning	Information Literacy		
		Generic	Situated	Transformative
Diverging	Self-Awareness	DSG 4.48	DSS 4.28	DST 3.83
Assimilating	Opportunity Awareness	AOG 4.04	AOS 4.28	AOT 4.16
Converging	Decision Making	CDG 4.07	CDS 4.05	CDT 4.01
Accommodating	Transition Learning	ATG 4.06	ATS 4.17	ATT 4.00
	Average	4.16	4.20	4.00

Table 9. CIL Scores of STEM Employers/Industry Stakeholders

Learning Approaches	Career Development Learning	Information Literacy		
		Generic	Situated	Transformative
Diverging	Self-Awareness	DSG 4.39	DSS 4.11	DST 4.05
Assimilating	Opportunity Awareness	AOG 3.43	AOS 3.61	AOT 4.61
Converging	Decision Making	CDG 3.51	CDS 3.85	CDT 4.41
Accommodating	Transition Learning	ATG 4.10	ATS 4.54	ATT 4.61
	Average	3.86	4.03	4.42

Wilcoxon Rank Sum Tests were used to compare information literacy groups and determined that MSPA students focused on situated (discipline-based) items most and rated transformative items significantly lower than the generic and situated items (Table 10). There was no significant difference between the generic and situated learning focuses. In contrast, for employers, generic, situated and transformative learnings are distinctly different. The transformative items are particularly emphasised by employers (Table 11).

Table 10. Wilcoxon Rank Sum Test Results- MSPA Student

Intra-category comparison p-value matrix	Average scores	Career Information Literacy		
		Generic	Situated	Transformative
Generic	4.16	-	0.88	0.0117
Situated	**4.20**	-	-	0.003
Transformative	4.00	-	-	-

Table 11. Wilcoxon Rank Sum Test Results- STEM Employers Results

Intra-category comparison p-value matrix	Average scores	Career Information Literacy		
		Generic	Situated	Transformative
Generic	3.86	-	0.013	<0.001
Situated	4.03	-	-	<0.001
Transformative	**4.42**	-	-	-

CONCLUSIONS

In this paper, we present the Career Information Literacy Learning Framework which structures several key university learnings in one single framework. In addition, we successfully demonstrated the use of this framework in gauging student and employer career and employability development focuses. We found the MSPA cohort differ from their STEM peers and identified a gap between the MSPA cohort and employers. These findings further our understanding of the heterogeneity of STEM employability.

As this is part of a larger study we are able to see that most other STEM student cohorts share similar focuses (Lin-Stephens, forthcoming). The fact that the MSPA cohort CIL profile deviates from that of their STEM peers suggests that the MSPA students may have different needs in career and employability development. Whilst their degrees may satisfy their aptitude for acquiring specific technical skills and knowledge, MSPA students may benefit greatly from curricular facilitation which incorporates industry and employer perspectives. Mathematics, Statistics, Physics and Astronomy are a key cluster of STEM disciplines that provide students with strong numeric and quantitative thinking skills. Strengthening their employability will mean a direct contribution to a stronger STEM workforce.

We note that due to sample size this study is limited to analysing the MSPA capstone unit students as a cohort only, despite the high response rate. Likewise, the STEM employer sample is based on proactive employers only; therefore may not be representative of all STEM employers.

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PERCEPTIONS OF MATHEMATICS AMONG UNDERGRADUATE BIOMEDICINE STUDENTS

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ABSTRACT

Mathematics plays an important role in 21st century biology, but is its importance recognised by students? How do students of the biological and health sciences view the role of mathematics in these disciplines, and the relevance of mathematics in their courses? These considerations may be important as undergraduate biology and biomedicine curricula increasingly incorporate specialised biology-oriented mathematics subjects. In this paper we investigate perceptions amongst undergraduate biomedicine students of the role of mathematics in biomedical science, and the relevance of mathematics in the undergraduate biomedicine curriculum. Student attitudes were found to be generally positive regarding the role of mathematics in biomedical science and its relevance in the curriculum, and persisted throughout the degree programme. Themes arising from student survey responses included whether mathematics is relevant to all or only to some disciplines or careers, and the value of specific mathematical content versus generic skills.

BACKGROUND

Mathematics plays an important role in 21st century biology and health sciences (National Research Council, 2003). This is increasingly being reflected in the curricula of undergraduate Australian biology and biomedicine programmes, for instance (Matthews, Adams, & Goos 2010; Poladian 2013; Carnie & Morphett 2017). The importance of mathematics in these fields is certainly accepted by practitioners in these areas, but is it recognised by undergraduate students? How do undergraduate students in the life and health sciences feel about studying mathematics as part of their course – especially specialised, biology-focussed mathematics subjects?

Matthews, Adams and Goos (2010, 2009) investigated biology students' attitudes towards mathematics and computer programming, following an interdisciplinary first-year science subject incorporating mathematics and programming. They observed high agreement that mathematics was important, and high enthusiasm about mathematics, but lower levels of intention to study further mathematics. Although these students recognised that mathematics was important in biology, this did not translate into a strong impetus for them to choose additional mathematics courses in their degree. They also identified that higher-achieving students are more able to draw links between mathematics and other sciences than lower-achieving students, and noted that students' experiences from school mathematics can shape their beliefs about mathematics in science.

Poladian (2013) reported on a redesign of a mathematics subject aimed at life science students, and the resulting impact on student motivation and perceptions of the relevance of mathematics. He found that the addition of authentic biological examples to the subject increased students' perceptions of the subject's relevance, but noted that the personalities or experiences of individual students seem to strongly influence such perceptions.

CONTEXT

The population of students under consideration are those enrolled in the 3-year undergraduate Bachelor of Biomedicine degree programme at a large research-intensive Australian university. Students in the programme complete a fixed sequence of core subjects and subjects leading to a major (specialisation) such as immunology, genetics or biotechnology, and elective science and non-science subjects. The core subjects include first-year biology, chemistry, physics, mathematics and statistics, and second- and third-year physiology, biochemistry and cellular biology. Many students aspire to study postgraduate medicine or other professional health qualifications after their undergraduate degree, though the programme also offers pathways to research or to graduate study in other areas such as bioengineering. The enrolment in the programme is approximately 500 students each year, of which about 65% are domestic Australian students and 35% are international students. Entry to the programme is competitive and (for domestic students) most entrants are drawn from the top 3-4 percentiles of secondary school graduates.

The core first-year subjects in the programme include one statistics and one mathematics subject. Both subjects are compulsory for most students in the programme (except for bioengineering and health informatics majors who replace one or both of these with standard calculus or computing subjects) and are not available to students from other degree programmes. The mathematics subject teaches mathematical concepts and modelling in biomedical contexts. The mathematical content includes difference equations, ordinary differential equations (ODEs) and systems of ODEs. The mathematical concepts and techniques are motivated and introduced through authentic mathematical models from population genetics, chemistry and epidemiology, and the process of modelling and the role of models are discussed extensively through the course. A more detailed description of the subject, and its development, is given by Carnie & Morphett (2017). The core statistics subject includes study design, introductory descriptive and inferential statistics, and use of statistical software.

FIRST-YEAR STUDENT ATTITUDES TOWARDS MATHEMATICS

To investigate biomedicine student attitudes towards mathematics at the start of their degree programme, an online survey was administered to all students enrolled in the core mathematics subject at the start of semester, over 3 semesters' offerings of the subject (2015S2, 2016S1, 2016S2). The total enrolment across these semesters was 686 students, and there were 250 responses (36% response rate). The survey was run in the week before semester commenced. In this time, students had access to some subject materials via the LMS but had not yet attended any classes. Questions 1-4 of the survey asked students about various potential roles of mathematics in biomedical science. Question 5 asked students about the relevance of studying mathematics in the Bachelor of Biomedicine. Question 6 asked students whether they were interested in studying additional mathematics in the future. All questions used a 5-point Likert scale, and question 5 also had an open-response section asking students to comment on their answer. The questions and summarised results are shown in Table 1. The survey was repeated at the end of the semester after the last lecture.

The design of the survey was informed by a pilot study conducted in semester 1, 2015. The pilot survey used a single Likert-scale question "I feel that mathematics is important in the discipline of biomedical science" with an open-response section instead of questions 1-4. The written comments from the pilot phase suggested that some students did not appear to distinguish between mathematics as a discipline, and 'mathematics' as the subject in which they were enrolled. Because of this, the question was replaced with questions 1-4 in subsequent semesters, which were intended to address different aspects of the role of mathematics in biomedical science.

Table 1: Survey questions and results of pre-semester surveys of first-year students. %A/SA = percentage of respondents who agree or strongly agree, N = number of responses.

Question	%A/SA	N
1. Mathematics is important in biomedical science as a tool for performing calculations.	92%	250
2. Mathematics is useful to help interpret data from experiments.	96%	249
3. Mathematics can help us understand natural phenomena in biomedical science.	79%	250
4. Mathematics can help guide decision making in medicine and health.	87%	249
5. Studying mathematics in the Bachelor of Biomedicine is relevant to me.	78%	250
6. I am interested in studying more mathematics in the future (for instance, as a selective).	41%	250

QUANTITATIVE RESULTS

Questions 1-4 of the survey were intended to investigate student perceptions of the role of mathematics in biomedical science. We see that a strong majority of students agree that mathematics has a positive role in biomedical science. Perhaps unsurprisingly, agreement is strongest for question 2, which addresses a role of mathematics which is likely to be familiar to students from secondary school, and weakest for question 3, for which students are less likely to have encountered examples previously. Questions 5 and 6 were intended to investigate student perceptions of the relevance of mathematics in undergraduate biomedical science programmes. Question 5 asked students directly whether studying mathematics is relevant to them. Most respondents (78%) agreed that studying mathematics in their Biomedicine degree programme was relevant to them. We note that the level of agreement with question 5, which concerns the relevance of studying mathematics, although high, is lower than that of questions 1-4, which concern the role of mathematics in biomedical science. Some students appear to believe that mathematics is important in biomedical science, but that studying it is not relevant. The open response comments suggest an explanation for this: some students feel that mathematics is relevant only for certain disciplines or career paths, and in particular is less relevant for students pursuing a career in medical practice. This is discussed further below.

Question 6 investigated students' intentions to study additional mathematics. This question was intended as an indirect measure of student perception of the relevance of mathematics, as it was expected that a perception that mathematics is relevant would translate to a greater interest in studying additional mathematics. Despite high rates of agreement that mathematics has a positive role in biomedical science and is relevant to their course, only 41% of respondents agreed that they were interested in studying more mathematics in the future. This indicates that a perception that mathematics is important and relevant is not sufficient to motivate students to study additional mathematics. The survey did not provide a space for written comments for question 6, so we do not have evidence to explain this. However, we can suggest some possible explanations. Perhaps students feel that the compulsory one-semester mathematics subject is sufficient, and do not see a need for additional mathematics studies beyond this. Or perhaps motivation to study additional mathematics is more influenced by pre-existing personal attitudes towards mathematics, such as a 'love' or 'dislike' of mathematics, than by any perceived benefits of additional mathematics, as noted by Poladian (2013). The overall level of interest seen here agrees with Matthews et al. (2010), who found similar levels of intention to study more mathematics after an interdisciplinary mathematics and quantitative modelling subject.

We omit any discussion of the quantitative results of the post-semester survey in this paper.

QUALITATIVE RESULTS

Further insights into student perceptions of the role and relevance of mathematics can be obtained from the open response comments. The written responses were analysed by the author using a conventional content analysis methodology (Hseih & Shannon, 2005). Preliminary qualitative analysis found the same themes present in both the pre-semester and post-semester survey responses. Hence, for the content analysis, the comments from all pre- and post-semester surveys were pooled, including those from the pilot phase. In total, 240 responses included written comments (158 from pre-semester surveys and 82 from post-semester surveys). In this section we describe some common themes identified from these comments. We do not mean to suggest that any of the opinions described below are held by a majority of the cohort, but rather to illustrate some common views and the diversity of attitudes encountered in the study.

One notable theme was the opinion that mathematics is relevant for some fields of biomedical science but it is not relevant for all disciplines or careers. Twenty-seven responses were classified in this category (14 from pre-semester, 13 post-semester). In particular, studying mathematics was often seen as important for a career in research, but less important for a career in medical practice. Some typical comments illustrating this are:

'It has made me appreciate the uses of maths in biomedicine within the contexts that we studied, however I don't feel it was very relevant or interesting for me personally, as I want to study medicine and practice as a doctor, where such detailed maths (I don't believe) will be required on a daily basis.' (2015S1 post-semester)

'It depends on what you want out of the Biomedicine bachelor. If one were to become a doctor [...] their [sic] really is no use for mathematics in their undergraduate degree.... However, for research mathematics is important.' (2016S1 pre-semester)

Similar attitudes were seen previously, amongst students in the same degree programme, by Familari, Elliott, Watson & Matthews (2012). Medical educators commonly agree that mathematics is required for postgraduate medicine. The American Association of Medical Colleges (AAMC-HHMI Committee, 2009) lists the ability to "apply quantitative reasoning and appropriate mathematics to describe or explain phenomena in the natural world" as one of the competencies expected of students entering medical school. A view such as those expressed in the comments above might therefore be problematic for the student as they progress to postgraduate medical studies. One approach to counter such attitudes could be to explicitly highlight the role of mathematics in medical practice, for instance by using practice-oriented examples when teaching aspiring medical students. Another approach may be to emphasise the transferrable skills developed by studying mathematics, discussed further below.

On the other hand, some (3 respondents: 2 pre-semester, 1 post-semester) explicitly state that mathematics is useful for medical practice: '*I believe Mathematics will be useful in many careers in the future, even in medicine*' (2015S1 pre-semester). Others (22 responses: 13 pre-, 9 post-semester) feel that mathematics is generally useful for all fields of science: '*Mathematics is the key underlying principle for most of science*' (2016S1 pre-semester). Another common attitude (22 responses: 17 pre-, 5 post-semester) was that mathematics is indirectly useful as it aids in scientific understanding: '*Even though mathematics may not be*

required in our eventual professions, it is needed to understand the basic core concepts that we use in our profession.' (2016S1 pre-semester)

This leads to another theme identified from the comments: the importance of specific mathematical content versus generic skills. Does the value of studying mathematics for biology or health sciences lie in the specific *content* taught in the subject, for instance the mathematical concepts or techniques mastered, or in the *generic skills* it develops, for instance problem-solving, communication or critical thinking? Here the views of students are mixed. Some (11 respondents: 8 pre-, 3 post-semester) clearly identify generic skills as an important outcome:

'The critical thinking and problem solving needed for maths also applies to many other subjects' (2016S2 pre-semester)

'Studying maths definitely help me improve my problem-solving skills and interpret information logically and methodically.' (2015S2 post-semester)

Others (17 respondents: 3 pre-, 14 post-semester) feel the value of studying mathematics lies only in the specific content:

'Allows for an understanding of modern genetics, modelling for disease spread etc. thus broadening outlook on future careers.' (2016S1 post-semester)

'It just seems that unless I intend on studying population genetics/disease modelling/biochemistry (which I do not) then most of what I have learnt in [the core mathematics subject] isn't very helpful.' (2015S2 post-semester)

These commenters have focussed on specific contexts explored in the mathematics subject – genetics, reaction kinetics and infectious disease modelling – and do not appear to see the skills or concepts developed in the subject as transferrable to other contexts. In this case, the development of transferrable general skills was an aim of the core mathematics subject (Carnie & Morphett, 2017), but this was not greatly emphasised to students. Perhaps being explicit with students about the intended skills to be developed, and how they transfer to other areas, may help students better recognise and appreciate this aspect of their learning.

The same themes were seen in both pre- and post-semester responses, and with broadly similar prevalence in terms of the frequency of responses. (The exception is the last theme, which was far more common in the post-semester responses. This is understandable considering the pre-semester respondents had not yet been exposed to most of the specific content of the subject.) In broad terms, except for an increased focus on the specific content of their mathematics studies, there does not appear to be much qualitative shift in student attitudes over the course of a biomedicine-focussed mathematics subject. Does this change as students progress through the later years of their course?

LATER-YEAR STUDENT ATTITUDES TOWARDS MATHEMATICS
In the context of engineering, Coupland, Gardner & Carmody (2008) noted that engineering students' perceptions of the relevance of statistics and mathematics can change over the course of their degree programme, as its utility became apparent in their later-year subjects and projects. To investigate whether biomedicine student attitudes towards mathematics change over the course of their degree programme, the online survey was repeated for final-year students of the Biomedicine programme. The survey consisted of questions 1-5 from Table 1 (except that Q5 was expressed in the past rather than present tense). Students enrolled in a core third-year subject of the Bachelor of Biomedicine were surveyed in August 2015 and in April 2017 (865 students in total). The response rate was 20% (172 responses). Most of the students surveyed took the core mathematics subject in their first year. Responses from 9 students who took the Bioengineering Systems major were excluded from this analysis, as they took a series of standard calculus and linear algebra subjects instead of the core Biomedicine mathematics subject, and are likely to have different attitudes towards mathematics due to the mathematically intensive nature of their chosen specialisation.

QUANTITATIVE RESULTS
Results from the survey are shown in Figure 1, alongside the results of the pre-semester survey of first-year students for comparison. None of the differences in levels of agreement differed significantly (Fisher exact test, α = 0.05).
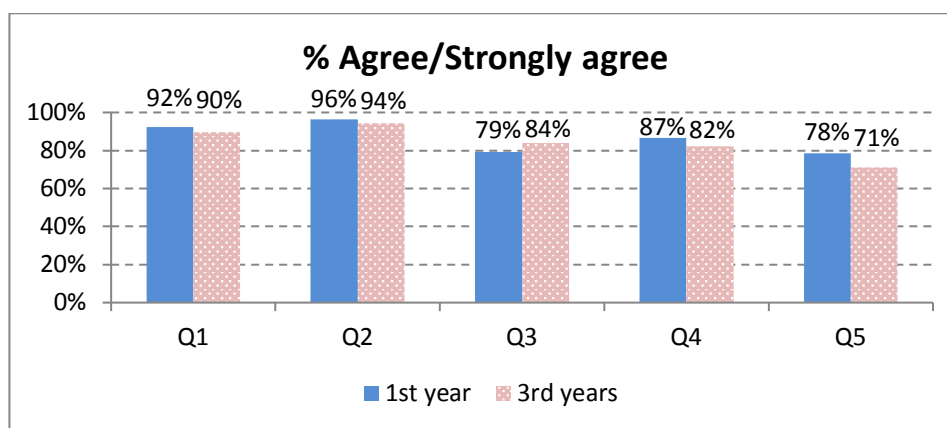
Figure 1: Comparison of levels of agreement with each question between pre-semester first-year students and third-year students. The number of later-year respondents were N = 163 for Q1, Q4, Q5, and N = 162 for Q2, Q3.

These results give little evidence of any quantitative change in student attitudes regarding the role and relevance of mathematics over the course of their studies, and the generally high levels of agreement persist throughout the programme.

QUALITATIVE RESULTS

Written comments were given by 80 respondents (out of 163). Some familiar themes were still present in the third-year student responses. The view that mathematics is more relevant for research than for other career paths was seen in 5 comments (6%), though it was less common than in the first-year responses (11% of responses). The question of specific content versus generic skills was again apparent in the third-year responses. Some students (11 comments) appeared to focus primarily on the content of the first-year mathematics and statistics subjects they studied:

'Only a small number of concepts I learnt in [mathematics and statistics] subjects have been relevant to me throughout my course. I believe some aspects of the subjects were useful in helping me understand concepts in other subjects (significance of data, types of studies, confounding factors, Michaelis-Menten kinetics for example), but I cannot recall much else, which to me indicates that other concepts learnt in [mathematics and statistics] subjects have not recurred in my degree and may not be relevant.'

'the content [of first-year mathematics] was great and relevant.'

Others (4 comments) explicitly mentioned transferrable skills as an outcome of these subjects:

'Very relatable skills, use maths as tool to assess biological questions.'

One notable attitude seen in the comments (12 responses) was the view that statistics is more relevant than mathematics: *'[introductory statistics] had much greater relevance to understanding scientific research papers and being able to comprehend them'.* This attitude could be a reflection on the curriculum: despite its increasing importance in biomedical research, perhaps mathematical modelling has not yet been incorporated into the core second- and third-year biomedicine curriculum to the same extent as statistics. However, the strong focus noted above by students on content may provide another possible explanation for this. Perhaps mathematical skills, where they are used in the students' later-year studies, tend to be in the form of generic skills rather than the application of specific mathematical concepts or techniques, and are thus less likely to be recognised by students, whereas the use of statistical techniques are often explicit and clearly visible to students in research articles or lab activities.

CONCLUSION

We have seen that a majority of biomedicine students see mathematics as having an important role in biomedical science and as being relevant to their studies. These views generally persisted throughout the degree programme. Some students see mathematics as relevant only for certain scientific disciplines or careers, however, and high levels of positive perceptions of the role and relevance of mathematics did not translate into similarly high levels of interest in studying additional mathematics subjects. Another point of difference among student views was the value of mathematics for developing generic skills. Some students saw mathematics as a source of valuable transferrable skills; others saw the value of studying mathematics

mainly in the particular content covered. These observations suggest several considerations for academics designing or teaching mathematics in biomedicine programmes. The use of practice-oriented examples may help students see the relevance of particular content for medical practice, and being explicit about the generic or transferrable skills intended to be developed in a subject may make students more aware of this aspect of their learning and better recognise its applicability in later studies.

We close with some quotes showing positive perceptions of a biomedicine-specific mathematics subject in the Bachelor of Biomedicine programme:

'I thought the content [of the biomedicine-specific mathematics subject] was great and relevant. It aided in the genetics component of 1st and 2nd year biology and genetics subjects. Enzyme kinetics and epidemiology was also very relevant to understanding my 2nd year subjects. I think the subject definitely benefited me more than just a basic calculus subject with no biology context attached.' (3rd-year)

'[The core biomedicine-specific mathematics subject] has most definitely changed my perception of the role of mathematics in biomedical sciences. Previously, I had thought that mathematics played only a minor role in biomedical sciences. However, having seen its various uses in biomedicine (such as modelling the spread of infectious diseases and predicting future population sizes of particular species), I now know just how important and significant mathematics is in biomedical sciences.' (2015S1 post-semester)

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